ALFA BK UNIVERSITY
FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
FACULTY O F COMPUTER SCIENCE
ALFATECH
Proceedings of Conference

UDK: 711.45:004.7
005.94:004.9
COBISS.SR-ID 148858889
DOI: 10.5281/zenodo.12615087
Original scientific paper

THE USE OF BUSINESS INTELLIGENCE IN THE DEVELOPMENT AND MANAGEMENT OF SMART CITIES

Miloš Ilić[75]*; Vladimir Mikić*[76]

Abstract

In recent years, smart cities, as well as their development and management, have become a popular study topic among researchers. Smart cities, through the use of different technologies, produce vast amounts of data. Business intelligence (BI) is a set of techniques and procedures used for collecting and analyzing data and turning it into useful insights that can assist in decision-making. For these purposes, BI employs various tools to process data and display analytical findings with some kind of visualization, such as reports, charts, or different gauges. This paper aims to show how essential BI can be for the development and management of smart cities. The integration of smart cities and BI technology can bring great benefits for residents and city officials since it may provide them with valuable information that can address complex issues.

Keywords: *Business intelligence, Smart cities, Databases, BI tools, Data mining*

Introduction

Urban environments play a pivotal role in shaping social and economic aspects on a global scale. The infrastructure of these environments exudes attractiveness for individuals seeking the benefits of urbanization in various contexts. Consequently, urban environments encounter various challenges and strains on their infrastructure and resources. To overcome these challenges and improve deficiencies, there's a growing trend of utilizing information and communication technologies within accessible infrastructures to optimize resources [1]. This marked the inception of the smart cities concept, aimed at ensuring that urban areas worldwide evolve into sustainable environments capable of enhancing quality of life and

[75] Miloš Ilić, 1991, teaching assistant, Faculty of Information Technology, Alfa BK University, Palmira Toljatija 3, Belgrade, Serbia, milos.ilic@alfa.edu.rs https://orcid.org/0000-0003-1190-1181
[76] Vladimir Mikić, 1996, teaching assistant, Faculty of Information Technology, Alfa BK University, Palmira Toljatija 3, Belgrade, Serbia, vladimir.mikic@alfa.edu.rs https://orcid.org/0000-0003-3971-8725

ISBN: 978-86-6461-074-2

fostering prosperity through socio-economic development [2]. This topic has garnered significant interest, prompting researchers to concentrate on aspects that can contribute to making urban environments "smarter". These include sustainability, mobility, quality of life, ecology, governance, technological infrastructure, and advanced technologies. Advancements in modern technologies have facilitated the implementation of various tools within the contexts of the mentioned segments of the smart city concept. Sensors [3], advanced communication networks [4], and software [5] have all played crucial roles in overcoming the challenges posed within each segment.

The deployment of modern technology necessitates substantial quantities of high-quality data, a challenge less pronounced in the realm of smart cities due to the extensive coverage of various topics and aspects. To effectively process the generated data and extract valuable insights, various analytical approaches incorporating techniques like artificial intelligence (AI) [6] and business intelligence (BI) [7] have become firmly established in this field. In our paper, we provide an overview of smart city aspects, the BI concept, different BI tools, and features that BI tools utilize. We also provide perspective on the integration of BI and smart cities and our viewpoint of what the main roles of BI can be in smart cities. In this regard, the following research questions are addressed:

- RQ1. What are the most prominent BI tools on the market, and what are their main features?
- RQ2. What are the main roles of BI in smart cities, and how can the integration of BI and smart cities benefit residents and city officials?

The paper is structured in such a fashion that, after the introduction, the following section describes the background of the mentioned concepts of smart cities and BI. The next section addresses and discusses the results of the conducted survey and draws insights and implications related to the research topic and proposed research questions. Finally, the last section concludes the paper and provides suggestions for future work.

Background

Smart cities

As the population of urban areas continues to rise, there's a growing demand for fresh, cutting-edge strategies to handle the intricate nature of city ecosystems. In recent years, the smart city concept has surged in popularity, ultimately aiding urban residents in fulfilling their needs regarding aspects such as infrastructure, transportation, energy, and housing. This concept aims to ensure that the city evolves into a sustainable area capable of enhancing quality of life and fostering prosperity within the context of economic development [8]. Certainly, some of the primary objectives of modern smart cities are geared towards optimizing the utilization of public resources and enhancing the quality of services offered to residents, all while alleviating economic strain and streamlining administration. The majority of publications delving into the literature in their efforts to define the concept of smart cities predominantly concentrate on technological aspects. Some define smart cities as urban centers that harness sets of advanced technologies like smartphones, wireless sensors,

ISBN: 978-86-6461-074-2

autonomous vehicles, and sophisticated communication networks [9]. Others argue that smart cities are environments founded on the integration of information and communication technologies utilized to effectively manage city resources [10]. Although, in terms of political and business discourse, smart cities represent the cities of the future, there are some obstacles that make the implementation of this concept challenging. The difficulties faced relate to excessively costly investments in advanced technologies, the deployment of these technologies in complex scenarios, the lack of implemented solutions, and the development of infrastructure [11]. In the realm of modern technologies, the concept of smart cities serves as the foundation for the availability of a diverse array of data types. Analyzing this data can aid in crafting effective strategies to benefit the city and facilitate the ongoing implementation of new approaches.

Business inteligence

BI is a set of techniques and procedures used for collecting and analyzing data and turning it into useful insights that can assist in decision-making [12]. For this purpose, companies are collecting a vast amount of data from different sources that needs to be transformed and placed into a single database in order to enable BI to run effectively. This process is known as extract, transform, and load (ETL). Operating that single database only through some database management system, such as SQL Server Management Studio or Oracle SQL Developer [13], is insufficient; thus, BI tools are required for further data analysis. BI tools can be successfully utilized for reporting, creating dashboards, and visualizing results [14].
AI has had a huge impact on BI in recent years, automating many tasks and increasing the efficiency of the BI process in general. AI assists in identifying various trends and patterns that would otherwise be impossible to detect through traditional data analysis and reporting [15]. As a result, AI-assisted BI can process a large amount of data quickly, provide users with intelligent insights and findings, and ensure accurate reports [16]. In this manner, organizations can utilize AI-assisted BI capabilities to make informed decisions to accomplish the intended objectives.

Results and discussion

This section is going to address and discuss the results of the survey and provide answers to two research questions.

RQ1. What are the most prominent BI tools on the market, and what are their main features?

BI tools are used for the collection and analysis of data, with the goal of converting and transforming unprocessed data into usable information [17]. They usually offer a rich user interface with intuitive controls, as do many other applications [18]. The main goal of these tools is to assist users in identifying trends and patterns in order to draw conclusions for better decision-making.

ISBN: 978-86-6461-074-2

The most known BI tools are:

1. Power BI – developed by Microsoft, represents one of the leading BI tools on the market.
2. Tableau – represents a sophisticated, powerful, and flexible BI tool for data analysis and visualization.
3. Looker Studio – formerly known as Data Studio, is a BI tool owned by Google that enables the integration of different sources for the purpose of creating reports and dashboards.
4. Domo – advanced BI tool that provides reports, dashboards, and AI-generated insights for users.
5. SQL Server Data Tools – represents a Microsoft product that works within Visual Studio [19], offering reporting services, integration services, and analysis services.

There are six main features that can be incorporated and utilized in BI tools, and those are: reporting, OLAP (online analytical processing), dashboards, ETL, predictive analytics, and data mining. BI tools with these features can help organizations achieve their goals and desired outcomes. Table 1 presents a matrix table of the most prominent BI tools and the main features they support.

Table 1: BI tools and main features

	Power BI	Tableau	Looker Studio	Domo	SQL Server Data Tools
Reporting	x	x	x	x	x
OLAP		x		x	x
Dashboards	x	x	x	x	
ETL	x	x		x	x
Predictive analytics	x		x	x	
Data mining		x		x	x

BI tools can be available on three different platforms: as a desktop application, a mobile application, or via the cloud. Table 2 presents a matrix table of the BI tools and platforms they are available on.

Table 2: BI tools and platforms

	Power BI	Tableau	Looker Studio	Domo	SQL Server Data Tools
Desktop	x	x			x
Mobile	x	x	x		
Cloud	x	x	x	x	

RQ2. What are the main roles of BI in smart cities, and how can the integration of BI and smart cities benefit residents and city officials?

ISBN: 978-86-6461-074-2

BI can have a significant role in the development and management of smart cities. Smart cities, through the use of different technologies, produce vast amounts of data. In order to function effectively, smart cities require some type of analytics, which BI can enable [20]. BI can process and analyze smart city data to generate valuable insights for city officials to use in order to make the right decisions and take appropriate actions.
The main roles of BI in smart cities are:

1. Integration of data
2. Analysis of data
3. Predicting future trends
4. Supporting decision-making
5. Improving public services

The integration of data from different smart city devices can be a difficult and challenging task [21]. That is why this is the most important role of BI in smart cities, as they generate huge amounts of data through IoT sensors and different electronic devices. BI can be crucial for the integration of this data through the ETL process into a single database.
Analysis, reporting, and visualizing data through dashboards can turn smart city data into valuable information [22]. In this way, BI can derive meaningful insights that can be used for different purposes. For example, it is possible to optimize transportation routes, thus reducing traffic, which can lead to better air quality [23].
Predicting future trends can be crucial in smart city management. By discovering patterns and trends in the data, it is possible to predict energy usage, maintenance needs, or traffic flow. Analyzing patterns of energy usage, for example, can result in better energy distribution and preservation approaches that are more practical and effective [24]. Having insight into this kind of data can help city officials with resource optimization and allocation.
The BI can provide insights that help in decision-making. Based on information from reports, predictive analytics, and data mining, city officials can make data-driven decisions that are essential for society [25]. Also, urban planners can make decisions on city development initiatives with the assistance of BI. By examining different kinds of patterns, they can identify potential development sites, estimate future expansion, etc.
BI can also be the key to improving public services. Citizens in smart cities often fill out surveys, participate in forums, or discuss various aspects on social networks. Interpreting public opinions and citizen feedback using BI can help in recognizing areas that need enhancement. Based on those results, it is possible to provide customized solutions suited to citizens' preferences and requirements [26]. Gaining useful insights using BI can help the authorities improve the lives of the residents [27].
Smart cities can solve the intricate problems of urbanization and improve the standard of living for their residents by exploiting data with BI. Through the integration and analysis of data, using predictive analytics and data mining to facilitate decision-making, BI is seen as a necessity for smart cities and their normal functioning [28]. That is why the integration of BI and smart cities has become an essential need for urban planning, development, and management.

ISBN: 978-86-6461-074-2

Conclusion and Future work

The utilization of the BI concept and its tools represents a promising perspective aimed at improving the development and management of smart cities. Through this research, the potential of BI tools for leveraging data from urban areas in order to optimize resources and decision-making processes has been highlighted. Through the integration of data from different sources and the derivation of data-driven insights, BI can potentially enhance the sustainability of smart city initiatives and foster better governance transparency. Future studies on this topic should focus on evaluating the effectiveness of this concept in real-life scenarios and assessing the impact of these analytical techniques on addressing challenges such as technological infrastructure limitations and limited resource scenarios. Such endeavors not only promise to deepen our understanding of BI's role in smart city development but also hold the potential to inform the refinement of strategic imperatives essential for navigating the evolving landscape of urban living.

References

[1] Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research - An information systems perspective. *International journal of information management*, *47*, pp. 88-100.
[2] Mishra, P., & Singh, G. (2023). *Sustainable Smart Cities: Enabling Technologies, Energy Trends and Potential Applications*. Springer Nature.
[3] Ramírez-Moreno Mauricio A., et al. (2021). Sensors for sustainable smart cities: A review. *Applied Sciences*, *11*(17), pp. 1-29.
[4] Ilić, M., Mikić, V., Zakić, A., & Zlatković, D. (2021). A survey of energy-efficient solutions for 5g networks. In *11th International Conference on Applied Information and Internet Technologies – AIIT 2021*, Zrenjanin, pp. 70-73.
[5] Mikić, V., Ilić, M., Zakić, A., & Zlatković, D. (2021). Green Cloud Computing in the purpose of energy efficiency. In *11th International Conference on Applied Information and Internet Technologies – AIIT 2021*, Zrenjanin, pp. 190-193.
[6] Ilić M., Mikić V., Kopanja L., & Vesin B. (2023) Intelligent techniques in e-learning: a literature review, *Artificial Intelligence Review*, *56*(12), pp. 14907–14953, https://doi.org/10.1007/s10462-023-10508-1
[7] Tavera Romero, C. A., Ortiz, J. H., Khalaf, O. I., & Ríos Prado, A. (2021). Business intelligence: business evolution after industry 4.0. *Sustainability*, *13*(18), pp. 1-12.
[8] Zubizarreta, I., Seravalli, A., & Arrizabalaga, S. (2016). Smart city concept: What it is and what it should be. *Journal of Urban Planning and Development*, *142*(1), pp. 1-8.
[9] Belli, Laura, et al. (2020). IoT-enabled smart sustainable cities: Challenges and approaches. *Smart Cities*, *3*(3), pp. 1039-1071.

ISBN: 978-86-6461-074-2

[10] Javed, A. R., Shahzad, F., ur Rehman, S., Zikria, Y. B., Razzak, I., Jalil, Z., & Xu, G. (2022). Future smart cities: Requirements, emerging technologies, applications, challenges, and future aspects. *Cities*, *129*, pp. 1-50.
[11] Syed, A. S., Sierra-Sosa, D., Kumar, A., & Elmaghraby, A. (2021). IoT in smart cities: A survey of technologies, practices and challenges. *Smart Cities*, *4*(2), pp. 429-475.
[12] Al-Okaily, A., Teoh, A. P., & Al-Okaily, M. (2023). Evaluation of data analytics-oriented business intelligence technology effectiveness: an enterprise-level analysis. *Business Process Management Journal*, *29*(3), pp. 777-800.
[13] Ilić, M., Kopanja, L., Zlatković, D., Trajković, M., & Ćurguz, D. (2021). Microsoft Sql Server and Oracle: Comparative performance analysis. In *The 7th International conference Knowledge management and informatics*, pp. 33-40.
[14] Kumar, S. M., & Belwal, M. (2017). Performance dashboard: Cutting-edge business intelligence and data visualization. In *2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, pp. 1201-1207. IEEE.
[15] Bharadiya, J. P. (2023). Machine learning and AI in business intelligence: Trends and opportunities. *International Journal of Computer (IJC)*, *48*(1), pp. 123-134.
[16] Bharadiya, J. P. (2022). Driving business growth with artificial intelligence and business intelligence. *International Journal Of Computer Science And Technology*, *6*(4), pp. 28-44.
[17] Badgujar, A. D., Kadam, S. S., Zambare, M. M., & Kulkarni, S. R. (2022). A comparative study: Business intelligence tools. *International Journal of Research in Engineering, Science and Management*, *5*(1), pp. 116-118.

[18] Ilić M., Mikić V., Kopanja L., Vesin B. Gamification Effectiveness in e-Learning Systems. (2022). *In 12th International Conference on Applied Information and Internet Technologies - AIIT 2022*, Zrenjanin, pp. 136-142.

[19] Ilić M., Mikić V., Gligorijević M., Zlatković D. (2023). Performance analysis of C# programming language in Visual Studio 2017, 2019, and 2022. In *The 9th conference with International Participation on Knowledge management and informatics*, pp. 69-73.

[20] Xu, H., & Geng, X. (2019). People-centric service intelligence for smart cities. *Smart Cities*, *2*(2), pp. 135-152.
[21] Mikić V., Ilić M., Kopanja L., Vesin B. (2022). The Use of Scaffolding Approach in Technology-Enhanced Learning: A Literature Review. In *12th International Conference on Applied Information and Internet Technologies - AIIT 2022*, Zrenjanin, pp. 124-129.
[22] Farmanbar, M., & Rong, C. (2020). Triangulum city dashboard: an interactive data analytic platform for visualizing smart city performance. *Processes*, *8*(2), pp. 1-22.
[23] Takić Lj., Ketin S., Marjanović R., Preljević A., & Šacirović S. (2018). Comparison of maximum range of pollutants. *Fresenius Environmental Bulletin*, *27*(2), pp. 1157-1163.
[24] Ibrahim, H., Ilinca, A., & Perron, J. (2008). Energy storage systems—Characteristics and comparisons. *Renewable and sustainable energy reviews*, *12*(5), pp. 1221-1250.
[25] Shahat Osman, A. M., & Elragal, A. (2021). Smart cities and big data analytics: a data-driven decision-making use case. *Smart Cities*, *4*(1), pp. 286-313.

ISBN: 978-86-6461-074-2

[26] Mikić, V., Ilić, M., Kopanja, L., & Vesin, B. (2022). Personalisation methods in e-learning-A literature review. *Computer Applications in Engineering Education*, *30*(6), pp. 1931-1958.
[27] Hashem, I. A. T., et al. (2016). The role of big data in smart city. *International Journal of information management*, *36*(5), 748-758.
[28] Silva, B. N., et al. (2018). Urban planning and smart city decision management empowered by real-time data processing using big data analytics. *Sensors*, *18*(9), pp. 1-19.

ISBN: 978-86-6461-074-2