

SOFTWARE TOOLS FOR ONLINE ANALYTICAL PROCESSING- FROM DATA TO STRATEGIC DECISIONS IN THE DIGITAL ECONOMY

Софтуерни средства за онлайн аналитична обработка- от данни към
стратегически решения в дигиталната икономика

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Abstract

Digitalization in the modern world is causing fundamental transformations in the economy as a whole. For this reason, the digital economy is not just a trend, but an inevitable reality that determines the competitiveness and development of businesses over time. Data is becoming an increasingly strategic resource, allowing organizations to optimize their processes and offer personalized solutions, and software tools for online analytical processing are key tools for their effective management and analysis. The report examines the evolution of software tools for online analytical processing - from traditional to modern cloud platforms with artificial intelligence integration. Emphasis is placed on defining the criteria for selecting an appropriate solution for online analytical processing according to the size and needs of enterprises, and a model of logically related indicators is proposed, including: functional, technological and economic aspects of implementation. Based on this, a comparative analysis of the leading products for online analytical processing is carried out, selected due to their widespread distribution, different approach to data processing and market leadership in the BI industry. The comparison is made based on predefined criteria such as scalability, ease of integration, analytical capabilities, price and accessibility. Trends for the future development of online analytical processing are presented, which transform these systems from analysis tools into an engine of strategic management decisions and a catalyst for the digital transformation of business.

Keywords: digital economy, online analytics software, business intelligence, data analysis

JEL: O33, C88, L86

Резюме

Дигитализацията в съвременния свят предизвиква фундаментални трансформации в икономиката, като цяло. Поради тази причина, дигиталната икономика не е само тенденция, а неизбежна реалност, която определя конкурентноспособността и развитието на бизнеса във времето. Данните се превръщат във все по-голям стратегически ресурс, позволявайки на организациите да оптимизират процесите си и да предлагат персонални решения, а софтуерните средства за онлайн аналитична обработка са ключови инструменти за тяхното ефективно управление и анализ. Докладът разглежда еволюцията на софтуерните средства за онлайн аналитична обработка - от традиционните до съвременните облачни платформи с интеграция на изкуствен интелект. Акцент е поставен върху дефинирането на критериите за избор на подходящо решение за онлайн аналитична обработка според големината и нуждите на предприятията, като е предложен модел от логически обвързани показатели, включващи: функционални, технологични и икономически аспекти на внедряване. Оповавайки се на тази основа се извършва сравнителен анализ на водещите продукти за онлайн аналитична обработка, избрани поради тяхното широко разпространение, различен подход към обработката на данни и пазарно лидерство в BI индустрията. Сравнението се извършва на база предварително определени критерии като мащабируемост, лесна интеграция, аналитични

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възможности, цена и достъпност. Представени са тенденции за бъдещото развитие на онлайн аналитичната обработка, които трансформират тези системи от инструменти за анализ в двигател на стратегически управленски решения и катализатор на цифровата трансформация на бизнеса.

Introduction

The entry of online analytical processing software into the economy is a new beginning in the corporate world. In recent years, online analytical processing software in the digital economy has witnessed an extraordinary transformation in the way companies analyze the data they collect, be it from social networks, customers, markets. The process of implementing OLAP software in the economy, in particular the digital economy, leads to a natural increase in the quality of data processing. The integration of online analytics technologies not only fundamentally transforms the analysis process, but also outlines key roles for a number of improvements in the way data is presented in general. Online analytical processing software is becoming a powerful tool used by enterprises and corporations around the world to present a modernized way of data analysis to ordinary people. Modern online analytical processing software is responsible for how data analysis occurs and its presentation to the participants in the process. Due to the dynamic development of digitalization and the growing demands of business, data analysis needs a profound transformation that will allow online analytical processing software tools to adapt and effectively support management decision-making. This transformation is the result of continuous progress in the field of information and communication technologies, which lay the foundation for more effective and intelligent data analysis solutions.

The essence of software tools for online analytical processing and the digital economy

Software tools for online analytical processing

They are software tools that are responsible for organizing data into multidimensional structures (so-called cubes). They facilitate interactive analysis of the provided data from different perspectives. OLAP software is widely used in BI, serving as a tool for users to extract, summarize and visualize information necessary for making management decisions [1].

Digital economy

It encompasses economic activities carried out through digital means. It is based on the use of the Internet, information systems, digital technologies, which contribute to the transformation of the ways of production, consumption, communication, trade. The digital economy is characterized by high-level automation, global connectivity and innovation. In this way, the digital economy places data and technology at the center of economic value. It changes traditional business models, accelerates innovation and creates new forms of employment and consumption [2].

Evolution of software tools for online analytical processing

When did online analytical processing software tools emerge?

The emergence of online analytical processing software is due to the need for faster and more flexible data analysis for the corporate world. In the late 1970s and early 1980s, the first online analytical processing software appeared, their development was influenced by the concepts of relational databases and multidimensional analysis. This concept allows for data processing according to various criteria such as time, product, region. The first online analytical processing (OLAP) software was Express, developed by Information Resources Inc. (IRI). It uses a multidimensional structure for storing and processing data, which allows for fast aggregation, filtering and visualization. It was initially designed to work on server platforms, and later a version for personal computers appeared. In 1995, Express was acquired by Oracle, which led to the development of Oracle OLAP- a platform combining relational and multidimensional models [6][7][11].

Traditional OLAP systems

They are based on locally installed architectures that use relational databases and multidimensional structures, also called "cubes". These systems provide opportunities for data analysis using various criteria- temporal, categorical, geographical regions and others. Although traditional OLAP systems were effective for their time, they are characterized by limited scalability, high maintenance costs and difficulties in integrating with dynamically changing business environments in the era of the digital economy [11].

OLAP with visualization and interactivity

With the development of graphical user interfaces and the growing needs of the business industry, after the emergence of the digital economy, there is a need for accessible analytical tools. This leads to the emergence of platforms such as Tableau, QlikView, Power BI, etc. These software's offer the possibility of interactive analysis, intuitive data visualization and easy report creation. They integrate with multiple data sources and allow users to extract detailed information without the need for deep technical knowledge. Their functionality is extended through dynamic dashboards, filters and automated reports.

Artificial intelligence integration

The latest stage in the development of software tools for online analytical processing has been reached, including the integration of artificial intelligence and machine learning. Artificial intelligence significantly improves the efficiency of analytical processes. Platforms such as Microsoft Azure Synapse and IBM Watson Analytics provide intelligent recommendations, personalized analysis and anomaly detection that facilitate strategic decision-making in real time. Integration with artificial intelligence allows for a transition from descriptive to predictive and prescriptive analysis.

Where AI changes the functionalities of OLAP software

In the modern digital economy, there are more and more ways to change the functionality of OLAP software. Artificial intelligence (AI) is increasingly changing the way OLAP (online analytical processing) systems operate, transforming them from traditional data analysis tools into intelligent decision-making platforms. Thanks to AI-assisted analysis automation, patterns, dependencies, and anomalies in data are automatically detected, which significantly reduces the need for manual intervention and speeds up the process of extracting useful information. In addition, by applying machine learning (ML), OLAP systems gain the ability not only to analyze past events, but also to predict future trends, even recommending optimal solutions based on accumulated data. An important role in this transformation is also played by natural language processing (NLP), which allows users to interact with the system more intuitively, asking questions in natural language and receiving automatically generated analyses and visualizations. In addition, AI enables intelligent optimization of OLAP processes – indexes and aggregates are dynamically adjusted according to the load, which leads to faster queries and more efficient work with large volumes of data. In addition, systems become more secure, as artificial intelligence allows for timely detection of anomalies, fraud and potential security threats. Ultimately, the integration of artificial intelligence into OLAP environments transforms analytical processes into more intelligent, adaptive and predictive systems that help businesses achieve more accurate, faster and more informed decisions [5][12].

Applications of OLAP software in the digital economy

Online analytical processing (OLAP) software plays a key role in the digital economy, supporting informed decision-making through multidimensional analysis of large volumes of data generated from various sources. One of their main applications is related to the analysis of user behavior in online platforms, where user interactions create a valuable information base for discovering trends and patterns. Through criteria such as device type, traffic source and geolocation, businesses can identify behavioral patterns and personalize content according to the needs of a specific user. Thanks to OLAP cubes, fast data aggregation and filtration is ensured, which is especially important for highly dynamic platforms such as online stores, social networks and streaming services. In addition, OLAP systems

also support the monetization processes of digital services, allowing detailed analysis of the user life cycle and revenues by various criteria - type of service, time period, region and market niche. This allows for optimization of pricing strategies, improvement of revenue forecasts and identification of channels with the highest return. In addition, OLAP software is also important in the optimization of digital marketing campaigns, where data serves as a key tool for evaluating and managing performance. Through in-depth multidimensional analysis, specialists can calculate return on investment, compare results across time periods, platforms, and users, and formulate more precise marketing strategies. In addition, OLAP tools are also actively used in the financial analysis of digital assets, providing the ability to track indicators such as value, transaction volume, volatility, and liquidity. In this way, OLAP software is establishing itself as an indispensable element in data management and analysis in the digital economy, providing a high degree of transparency, efficiency, and strategic predictability.

Criteria for selecting OLAP software based on digital business needs

The criteria for selecting OLAP software in the context of the digital economy are formulated to ensure an optimal match between analytical needs and the scale of the business. They include indicators such as the size of the digital business, scalability, ease of integration, analytical capabilities, price and accessibility, which reflect the key factors for effective data management and analysis. Scalability and integration determine the ability of the system to adapt to growing volumes of data and connect to other corporate systems, while analytical capabilities reveal the degree of depth in information processing - from basic visualizations to predictive analytics and artificial intelligence models. Price and accessibility, in turn, ensure economic sustainability and operational flexibility through cloud and hybrid solutions. These criteria achieve a balanced approach to choosing an OLAP system, ensuring that the organization's technological resources are aligned with its capacity, strategic goals and level of digital maturity [11].

Table 1. Criteria for choosing OLAP software based on the size of the digital business

Digital Business Size	Scalability	Easy integration	Analytical capabilities	Price	Accessibility
Small Digital Business	Low to medium - suitable for limited data volume and users	High- easy integration with popular digital tools	Basic- visualizations, dashboards, reports, KPI analysis	Low- freemium and subscription models available	Very high - access via the cloud without the need for infrastructure
Medium Digital Business	Medium to high - support for growing data volumes and more users	Medium- integration with CRM, ERP and marketing systems	Advanced- drill-down, AI insights, scenario analysis	Medium- subscription plans with flexible upgrades	High - cloud + hybrid solutions, accessible via browser
Large Digital Business	Very high - real-time processing of large and distributed data	High- deep integration with corporate systems (SAP, Oracle, Salesforce, Big Data)	Advanced- predictive analytics, AI/ML models, OLAP cubes, real-time insights	High- enterprise licenses, but with high ROI	Medium - requires technical infrastructure and BI team

Source: Author's research

Logical indicator model

The logical indicator model is chosen because it provides a structured and systematic approach to evaluating OLAP software that allows for simultaneous consideration of functional, technological, and

economic aspects of solutions. It shows the extent to which different platforms meet complex business requirements, including depth and flexibility of analysis, self-service analytics capabilities, scalability, integration with enterprise systems, security, and financial metrics. The use of logical indicators provides an objective framework for comparison and evaluation that supports informed decision-making by showing the strengths and weaknesses of OLAP solutions in the context of different business needs and organizational budgets [9].

Table 2. Logical indicator model

Category	Indicator	Goal of the indicator	Evaluation criteria
Functional	Scope of analytical capabilities;	To assess the depth and flexibility of the analysis	Support for OLAP cubes, drill-down, slice/dice, predictive analysis, AI/ML functions
	Visualization and user interface	To assess the accessibility and intuitiveness of the platform	Availability of drag-and-drop, interactive charts, mobile compatibility
	Self-service support	To assess whether end users can analyze on their own	Ability to create reports without programming, templates, automatic recommendations
Technological	Scalability	To assess the ability to grow and process big data	Support for Big Data, cloud architecture, parallel processing
	Integration with existing systems	To assess compatibility with other platforms	API, connectors to ERP, CRM, databases, cloud services
	Security and data protection	To ensure confidentiality and compliance with standards	Encryption, access control, GDPR, ISO 27001 compliance
Economic	Total implementation costs	To assess the financial investment	Licenses, training, support, infrastructure
	Return on investment (ROI)	To assess the efficiency in relation to the resources invested	Reduced costs, accelerated decision-making, improved productivity
	Pricing model flexibility	To assess the adaptability to the organization's budget	Availability of free versions, subscription plans, pay-as-you-go

Source: Author's research

A figure is also presented that illustrates the hierarchy of indicators in an organization, showing how information is transformed from raw operational data to strategic decisions.

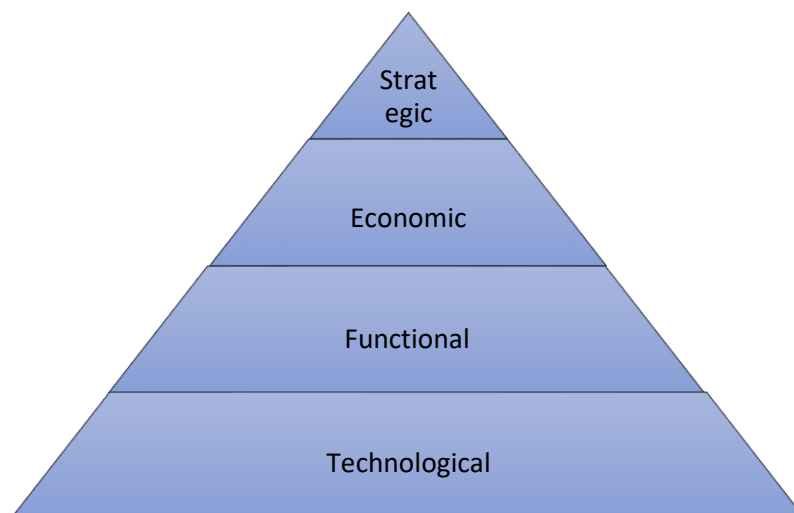


Figure 2. From data to strategic decisions

Comparative analysis of OLAP software

This comparative analysis is designed to provide an objective assessment of leading OLAP solutions across key criteria – data processing, functionality, technology features and cost-effectiveness – and to demonstrate how different platforms meet diverse business needs and scales. The selected solutions are based on Gartner’s Magic Quadrant, which ranks market leaders based on vision and ability to execute, demonstrating robustness, innovation and diverse approaches to visualization, self-service analytics, integration and cloud technologies. The analysis supports informed decision-making by demonstrating best practices and technology approaches adapted to different scales, functional requirements and budget constraints in the digital economy [3][8][10][4].

Table 3. Comparative analysis of OLAP software

OLAP solution	Data processing approach	Functional benefits	Technology Features	Economic aspects
Microsoft Power BI	Combines ROLAP and in-memory analytics via VertiPaq;	Intuitive interface, strong self-service BI, AI Copilot	Cloud Scalability, Easy Integration with Microsoft 365	Low license cost, excellent ROI, high availability
Tableau	full integration with Azure	Highest level of visualizations and drag-and-drop analysis	Integration with Salesforce Data Cloud, Extensions via API	Mid-to-high cost, suitable for medium/large businesses
Google Looker / Looker Studio	In-memory OLAP with a focus on visualization and storytelling	Web-based model, strong integration with Google Data Cloud	Scalability, Security, Big Data Support	Primarily SaaS model, flexible pricing, high efficiency
Qlik Sense	Cloud-native model (ROLAP) via LookML and BigQuery	Automatic data connections, AI insights, storytelling	Multi-Source Support, High Security	Mid-cost, good price-performance ratio
Oracle Analytics Cloud	Associative OLAP (in-memory engine)	Strong predictive and planning features	Integration with Oracle DB, ERP, ML Models	High price, aimed at corporate customers

Source: Author’s research

Trends for future development of OLAP software in the digital economy

In the future, the development of OLAP software in the digital economy will be closely linked to the introduction of new technologies and the need for faster and smarter data analysis. It is expected that the integration with artificial intelligence (AI) and machine learning (ML) will be significantly improved and expanded, which will allow for automatic pattern discovery, behavior prediction and generation of recommendations in real time. Cloud-based OLAP solutions will be increasingly important, providing flexibility, accessibility and scalability, especially for newly created digital businesses that process large volumes of data. In parallel, improvements will be observed in Real-Time OLAP, which will provide the opportunity for immediate analysis of accurate and up-to-date data, supporting automatic reactions to market changes or technical difficulties. User interfaces and visualizations will also be improved, offering intuitive and interactive dashboards, graphs and maps for faster and more effective decision-making. Integration with Big Data technologies will allow the processing and analysis of unstructured data, expanding the analytical capabilities of digital enterprises. Self-Service Analytics solutions will also become increasingly popular, allowing employees to perform analyses and create visualizations without the need for specialized technical knowledge, which will speed up business processes and reduce dependence on IT specialists. In addition, attention will be paid to data security and protection by implementing stricter protection mechanisms adapted to the dynamic development of technologies. The development of voice integration is expected, which, through the use of natural language processing (NLP) technologies, will make data analysis more accessible, intuitive and effective in the modern digital environment.

Conclusion

In the modern digital economy, online analytical processing software tools occupy a key position as strategic tools for data management and decision-making. Their ability to process multidimensional data provides enterprises with the opportunity to perform in-depth analyses of key indicators that are of strategic importance for business development. The introduction of artificial intelligence and machine learning into these systems further expands their potential, enabling automated forecasting, personalized recommendations and anomaly detection - functions that make them indispensable in conditions of dynamically changing markets and increasing competition. A variety of OLAP solutions, adapted to different scales and budgets, demonstrate their applicability in all economic sectors and for enterprises of different sizes. Real-time analytics, cloud architectures and advanced user interfaces contribute to wider access to these technologies, even for users without specialized technical knowledge. As a result, online analytics software tools play a significant role in the transformation of data-driven business models and are establishing themselves as a core component of the digital economy, where information is a key resource for strategic development, sustainability, and innovation.

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