УДК 681.3; 621.3

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REVIEW OF OLAP-MODELING APPLICATION IN THE ECONOMIC INDUSTRY OF UKRAINE

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Анотація. Проведено аналіз можливості застосування OLAP-моделювання для забезпечення діяльності фінансових установ і підтримки функціонування бізнес-процесів, прийняття ефективних рішень на всіх рівнях управління організацією (виробничих, маркетингових, і кадрових рішень; рішень, які зачіпають ціни, знижки), які в кінцевому підсумку приведуть до успіху всієї організації в цілому, може бути реалізована за допомогою застосування OLAP-технологій і OLAP-систем. Результати дослідження можуть бути апробовані шляхом впровадження відповідних проектів, зумовлених викликами та тенденціями фінансової галузі, ринковими та регуляторними змінами.
Ключові слова: OLAP-моделювання; бізнес-процес, OLAP-технологія, OLAP-система.
Abstract. The analysis of the possibility of using OLAP-modeling that support the activities of financial institutions and support the functioning of business processes, the adoption of effective solutions at all levels of organization management (production, marketing, and personnel decisions, decisions affecting prices, discounts), which in the final the result will lead that the success of the entire organization as a whole, can be implemented through the use of OLAP technologies and OLAP systems. The results of the study can be tested through the implementation of relevant projects driven by challenges and trends in the financial industry, and market and regulatory changes.
Keywords: OLAP modeling; business process, OLAP technology, OLAP system

DOI: 10.31649/1681-7893-2022-44-2-5-12

INTRODUCTION

The problem of social information analysis to identify regularities, building models, and forecast the development of society was a reference point and a driving force in the creation of special mechanisms for data processing and analysis in the form of software products. Yes, Data methods Mining is successfully used to solve business problems in banking, insurance, industrial production, marketing research, trade, scientific research, etc.

1. CONCEPT OF OLAP TECHNOLOGIES AND DATA MINING

Informatization and promising OLAP technologies ensure fast and accessible dissemination of scientific knowledge and advanced technologies in society, increasing the general level of its intellectualization. In these conditions, not only people's abilities to perceive new methods and work tools are in demand, but also the ability to create and generate new knowledge about the world as products obtained as a result of informational intellectual activity.

Most modern content analysis programs are limited to text processing, but their capabilities are much broader. An example of a technology of this generation is the technology of "mining" data or Text Mining. In general, cloud technologies and methods became the result of the natural evolution of information technologies: classification, clustering, and forecasting; and technologies such: Data Mining, Text Mining, Web Mining, and OLAP-intelligent data analysis. The reasons for their popularity were the rapid accumulation of data; general

computerization; penetration of the global computer network into all spheres of activity; progress in the field of information technologies (improvement of DBMS and data warehouses); progress in the field of production technologies (increase in productivity of computers, volumes of drives, implementation of Grid systems).

Despite the number of Data methods Mining preference is given to logical if-then data search algorithms, which solve the problems of prediction, classification, pattern recognition, segmentation of databases, extraction of hidden knowledge from data, interpretation of data, the establishment of associations in databases, etc. The results of such algorithms are efficient and easy to interpret. But the main problem with logical methods of detecting regularities is the problem of sorting through options in a limited time. These methods artificially limit such selection and build decision trees with fundamental limitations on the effectiveness of searching if-then rules.

The main feature of Data Mining is a combination of mathematical tools with the latest achievements in the field of information technology. In Data technology Mining harmoniously combined strictly formalized methods and methods of informal analysis, i.e. quantitative and qualitative data analysis.

Most of the analytical methods used in Data technology Mining are known as mathematical algorithms and methods. The new thing is that they can be used to solve certain specific problems. This is due to new properties of technical and software tools.

Algorithms of traditional mathematical statistics have long supported the concept of averaging from a sample, which is reduced to operations on fictitious values. The methods of mathematical statistics proved to be useful mainly for checking pre-formulated hypotheses (verification-driven data mining) and for «rough» intelligence analysis, which forms the basis of operational analytical data processing (online analytical processing, OLAP).

To tasks Data Mining includes [2, 3, 4]:

1. Classification. It consists in ordering according to some principle a set of objects that have similar qualifying features, which are chosen to determine the similarity or difference between the objects of comparison [5].
2. Forecasting. A method that uses both the accumulated experience of the past and current assumptions about the future to determine it.
3. Clustering. It consists in identifying classes of initially undefined objects and, as a final result, dividing objects into classes.
4. Sequence is the establishment of regularities between events that are connected in time.
5. Estimation is the prediction of continuous values of a feature.
6. Relationship analysis is finding dependencies in a data set.
7. Visualization – the use of graphic methods that show the presence of regularities.

The software product market is currently represented by universal statistical packages that are equipped with a set of methods of intelligent data analysis, for example, SPSS (SPSS, Clementine), Statistica (StatSoft), SAS Institute (SAS Enterprise Miner), Deductor (Base Group Labs).

IAD methods and algorithms include the following: artificial neural networks, decision trees, symbolic rules, nearest neighbor and k-nearest neighbor methods, support vector method, Bayesian networks, linear regression, correlation-regression analysis; hierarchical methods of cluster analysis, non-hierarchical methods of cluster analysis, in particular, k-means and k-median algorithms; methods of finding associative rules, in particular, the Apriori algorithm; method of limited enumeration, evolutionary programming and genetic algorithms, various methods of data visualization and many other methods. It is worth noting that most of the methods of intellectual data analysis were developed within the framework of the theory of artificial intelligence. There is no consensus on which tasks should be included in intelligent data analysis. Most authoritative sources list the following: classification, clustering, prediction, association, visualization, anomaly detection analysis, evaluation, relationship analysis, and summarization. Let's consider some of them [3].

Neural networks belong to the class of nonlinear adaptive systems with an architecture that conditionally imitates the nervous tissue consisting of neurons [1].

Self-organizing Kohonen maps are one of the varieties of neural networks, the difference of which is the use of unsupervised learning.

Decision trees are a method of structuring a task in the form of a tree graph, the vertices of which correspond to productive rules, which allows data classification or analysis of the consequences of decisions.

Autocorrelation is the calculation of sample correlation.

Associative rules – consist in finding regularities between related events, for example, often the buyer buys not one product, but several related products, which in most cases are interconnected.

Classification (Classification). This is the simplest and most common task of intelligent data analysis. As a result of solving the classification problem, signs are revealed that characterize groups of objects of the studied data set – classes; based on these features, a new object can be assigned to one or another class. The following

methods can be used to solve the classification problem: nearest neighbor (Nearest Neighbor); k-nearest neighbor (k-Nearest Neighbor); Bayesian networks (Bayesian Networks); induction of decision trees; neural networks (neural networks).

Clustering (Clustering). Clustering is a logical continuation of the idea of classification. The peculiarity of clustering is that object classes are not initially defined. The result of clustering is the division of objects into groups. An example of a clustering task method is a special type of neural network (Kohonen maps) that self-organize without a teacher.

Association (Associations). In the process of solving the task of finding associative rules, patterns of interconnected events in the data set are sought. The difference of association from the two previous tasks of intelligent data analysis: the search for regularities is not based on the properties of the object being analyzed, but between several events that occur simultaneously. The most famous algorithm for solving the problem of finding associative rules is the Apriori algorithm.

Sequence (Sequence), or sequential association (sequential association). Consistency allows you to find temporal patterns between transactions. The sequencing problem is similar to the association problem, but its goal is to establish regularities not between simultaneously occurring events, but between events that are related in time (that is, occurring with some definite interval in time. This problem of intelligent data analysis is also called the problem of finding sequential patterns (sequential patterns). Sequence rule: event X will be followed by event Y after a certain time.

Forecasting (Forecasting). As a result of solving the problem of forecasting based on the features of the existing data, missed or future values of target numerical indicators are estimated. To solve such problems, the methods of mathematical statistics, neural networks, etc. are widely used.

Visualization (Visualization, Graph Mining). As a result of visualization, a graphic image of the analyzed data is created. To solve the problem of visualization, graphic methods are used, which show the presence of regularities in the data. An example of visualization methods is the representation of data in 2D and 3D measurements.

Summarization is a task whose purpose is to describe specific groups of objects from the analyzed data set, etc. [4, 10, 11].

Data mining tasks, depending on the models used, can be descriptive and predictive. As a result of solving descriptive problems, the analyst receives templates that describe data that are amenable to interpretation. These tasks describe the general concept of the analyzed data and determine the informative, summary, and distinctive features of the data.

Predictive tasks are based on data analysis, model creation, forecasting trends or new properties or unknown data.

Intelligent data analysis can consist of two or three stages [4, 12, 13]:

Stage 1. Identification of regularities (free search).

Stage 2. Using the identified regularities to forecast unknown values (predictive modeling).

Stage 3. Analysis of exceptions is a stage designed to identify and explain anomalies found in regularities.

Free Search (Discovery). At the stage of free search, the data set is studied to find hidden patterns. Preliminary hypotheses regarding the type of regularities are not defined here. Regularity (law) is an essential and constantly repeating relationship that determines the stages and forms of the process of formation, and development of various phenomena or processes.

The system of intelligent data analysis at this stage defines templates, for obtaining which in OLAP systems, for example, the analyst needs to consider and create a set of queries. Here the analyst is freed from such work – the system searches for templates for him. The application of this approach is especially useful in very large databases, where it is quite difficult to catch a regularity by creating queries, for this, it is required to try many different options. Free search is provided by the following actions [6, 14, 15]:

- detection of regularities of conditional logic (conditional logical);
- detection of regularities of associative logic (associations and affinities);
- detection of trends and fluctuations (trends and variations).

The described actions within the free search stage are performed using:

- induction of conditional logic rules (tasks of classification and clustering, description in a compact form of close or similar groups of objects);
- induction of rules of associative logic (tasks of association and sequence, extracting information using them);
- determination of trends and fluctuations (the initial stage of the forecasting task).

At the stage of free search, regularities should also be validated, that is, their reliability should be checked for parts of the data that did not participate in the formation of regularities.

Predictive modeling (Predictive Modeling). The second stage of intelligent data analysis – predictive modeling – uses the results of the first stage. The patterns found here are used directly for forecasting. Predictive modeling includes the following activities:

- prediction of unknown values (outcome prediction);
- forecasting the development of processes (forecasting).

In the process of prognostic modeling, the tasks of classification and forecasting are solved.

When solving a classification problem, the results of the first stage (induction of rules) are used to assign a new object with some certainty to one of the known, predefined classes based on known values.

When solving the forecasting problem, the results of the first stage (identification of the trend or fluctuations) are used to forecast the unknown (missing or future) values of the target variable(s).

The regularities obtained at this stage are formed from partial to general. As a result, some general knowledge about a certain class of objects is obtained based on the study of individual representatives of this class.

Predictive modeling, on the contrary, is deductive. The regularities obtained at this stage are formed from the general to the partial. Here, new knowledge about an object or a group of objects is obtained based on:

- knowledge of the class to which the studied objects belong;
- knowledge of the general rule operating within this class of objects.

Exception analysis (forensic analysis). In the third stage of intelligent data analysis, exceptions or anomalies found in the found patterns are analyzed. The action performed at this stage is the detection of deviations detection). To detect deviations, it is necessary to determine the norm, which is calculated at the stage of free search. The exception analysis stage can be used as data cleaning [4].

2. APPLICATION OF OLAP TECHNOLOGY

Over the past ten years, the information industry has seen a steady increase in interest in data analysis technologies and decision support systems based on these technologies[1]. The term Data, which has already become common in English-language literature, has taken root in this entire area of Mining or Knowledge Discovery or «intelligent data analysis».

Taking into account the variety of forms of data presentation and the algorithms used, as well as the fields of application, intelligent data analysis can be carried out with the help of software products of the following classes [4, 16, 17]:

- specialized «boxed» software products for intellectual analysis;
- mathematical packages;
- spreadsheets and various add-ons over them;
- tools integrated into database management systems (DBMS);
- other software products.

Modern requirements have led from simple search and statistical processing of data to more complex analysis of accumulated information. OLAP (Online Analytical Processing) technologies and Data Mining, the main purpose of which is to provide end users with a methodology for structuring large volumes of data, analyzing the corporation's work in real-time, building reports of any complexity, and obtaining new knowledge using artificial intelligence methods. The use of these technologies requires high-performance computing to process large volumes of data and the use of special software tools.

OLAP is a technology of operational analytical data processing that uses methods and tools for collecting, storing, and analyzing multidimensional data to support decision-making processes. The main purpose of OLAP systems is to support analytical activities and arbitrary requests of analytical users.

Let's consider the temporal aspects of the data warehouse and their impact on the OLAP environment (On-Line Analytical Processing) [8, 18].

A data warehouse can be characterized as an object-oriented, integrated, supporting temporary factor and a long-term (non-destructive) set of data for use in information systems. In addition to the data warehouse, various decision-support applications can be used in decision-support information systems. The use of OLAP technology for multidimensional data analysis allows for supplementing the standard data storage tools for preparing various reports with means of analysis and interactive access to data. It is proposed to expand existing data environments with OLAP tools for operating temporal data. To do this, additional information about such data must be contained in a metadata repository, preserving the basic schema of the data warehouse.

An OLAP server must be able to perform temporal queries. When using this type of query, some events may occur.

Data in the data warehouse can belong to different operating systems and be supplemented with data from the external environment. For their presentation, a multidimensional model is required, an important feature of which is the division of data into facts and dimensions. Facts (also called metrics or quantitative data) are numerical values that describe dimensions (called qualitative data) of user data. If, for example, sales at an enterprise are modeled, the number of goods sold is a fact, while time, branches, and products are dimensions (measurements). Facts and dimensions form a hypercube. To provide information with a sufficient degree of detail, hierarchies of dimensions are formed. Elements with the same level of detail are called dimension levels. Assume the simultaneous task of several hierarchies.

Using a hypercube, you can implement interactive data analysis. This process is known as an OLAP process, and the user can specify both a data specification process (called detailing) and an inverse process called convolution.

The generalized environment (architecture) of OLAP includes three levels: the client (intended for the user interface), which receives user requests; a server that processes information (data); a data storage component consisting of a data store (Date Warehouse, DWH) and metadata repositories and provides information about facts, dimensions, and hierarchies.

The OLAP server accepts the request and receives meta-information about the selected cube and the corresponding hierarchies (steps 2, 3), writes the request to the data store (step 4), receives the result (step 5), and returns it to the client (step 6), which then transmits the result to the user. In further analysis (step 7), the OLAP server uses metadata.

Navigational access is performed using the ROLL-UP and DRILL-DOWN commands, and changes occur in the selected hierarchy according to the level of detail. Presentation of the results can be both in two-dimensional form (table) and in three-dimensional form (nested tables). Elements of dimensions have a photo database property. The smallest granularity of the «time» dimension should be taken as a unit of the interval boundaries. At the same time, the parent vertices of the tree are rows, the children are columns, and the elements of the corresponding matrix are intervals.

OLAP (online analytical processing) – a set of technologies for operational data processing, including dynamic construction of reports in various sections, data analysis, monitoring, and forecasting of key business indicators. The basis of OLAP technologies is the presentation of data in the form of OLAP cubes.

OLAP cubes contain business indicators, used for analysis and management decisions, for example, profit, product profitability, total funds (assets), own funds, loan funds, etc. Due to the detailed structuring of data, OLAP cubes allow you to quickly perform data analysis and generate reports in various sections and with a depth of detail. Reports can be created by analysts, managers, financiers, and department heads.

The OLAP system is an information and analytical system built based on OLAP technologies.

OLAP systems integrate already existing accounting systems, providing the user with tools for analyzing large volumes of data in real-time.

OLAP systems effectively solve the following analytical tasks:

- sales analysis;
- procurement analysis ;
- price analysis;
- marketing;
- cash flow;
- storage.

Solutions based on OLAP technologies allow you to analyze trends and optimize the operation of the retail network:

- data consolidation (it is possible to consolidate information from territorially distributed units and enrich the system with information from many data sources);
- analytical reporting;
- forecasting and optimization of stocks (OLAP systems implement the most modern algorithms, statistical, econometric, and expert programming mechanisms. They allow you to build adaptive models, automatically find seasonality and trends, and take into account the complex influence of multiple external factors);
- loyalty programs (with the help of methods of deep data analysis, it is possible to understand the peculiarities of customer consumption and the attitude of customers to marketing programs. This will make it possible to build effective loyalty programs that are not simply reduced to providing discounts, but offer all customers what they are interested in);
- stimulating demand.

When using OLAP technologies, it becomes possible to automate the processes of making decisions for bank clients, find patterns in huge volumes of data, and effectively manage risks:

- data consolidation;
- analytical reporting;
- credit scoring (allows you to conduct a credit policy and reduce the level of overdue debt);
- underwriting (allows several times to reduce the time of consideration of applications);
- forecast of account balances.

The wide distribution and popularity of OLAP technologies and OLAP systems are explained by the fact that they allow overcoming the limitations of traditional information systems, designing reports without the participation of programmers, analyzing data in real-time by any categories and business indicators at any level of detail, producing monitoring and forecasting key business indicators. As a result, the management receives a completely clear vision of the situation and a single mechanism of accounting, control, and analysis, as well as due to the automation of internal business processes and the improvement of employee productivity, the need for human resources is reduced. This allows for an increase in the company's profit, which in turn is the main goal of economic activity.

It is possible to conventionally divide banking IT systems into transactional Online systems Transaction Processing (hereinafter OLTP) and analytical Online Analytical Processing (hereinafter OLAP). In general, OLTP systems provide raw data for data warehouses, while OLAP systems help to analyze them. Cloud technologies can equally be used for both OLTP and OLAP technologies in banking information systems.

In table 1 shows the main differences between OLTP and OLAP technologies when building a banking information system using cloud technologies. The greatest benefits of using cloud computing can be obtained by implementing OLAP Servers based on cloud technologies [9].

Table 1

Comparative characteristics of OLTP and OLAP

Sign	OLTP (operational transaction processing, operating systems)	OLAP (operational analytical processing, data warehouses)
Data source	Operational data, OLTP systems are the primary source of data	Consolidated data OLAP data comes from different OLTP databases
Appointment	To control and manage key business tasks	Assists with the planning, problem-solving, and decision support
What means	Displays a slice of current business processes	Multidimensional showcases of various types of business activities
Inserts and updates	Short and fast insertions and updates initiated by end users	Periodic long-term days for batch data updates
Requests	Relatively standardized and simple queries with relatively few records	Often complex queries involving aggregation
Processing speed	Usually very fast	Depending on the amount of data; batch data updates and complex queries can take several hours
Space requirements	May be small if historical data is archived	Larger due to the existence of aggregation and historical data; requires more indexes than OLTP
Database structure	Highly normalized with a large number of tables	Usually de-normalized with fewer tables. Using a star and/or snowflake pattern
Backup and recovery	Backup is mandatory; the loss of operational data is critical to the business and will most likely result in significant monetary losses and legal liability	Instead of regular backups, some environments may consider simply reloading the OLTP data as a recovery method

OLAP is implemented in a multi-user client/server mode and offers fast responses to queries, regardless of database size and complexity. OLAP helps the user synthesize enterprise information through a comparative, personalized view, as well as through the analysis of historical and forecasted data in a variety of "what-if" scenarios of the data model. This is achieved by using OLAP Server.

OLAP Server is a specially designed multi-user, high-performance data manipulation engine for supporting multidimensional data structures. Multidimensional structures are arranged in such a way that each data item and access to it is localized based on the intersection of the measurement items that define that item. The server design and data structures are optimized for fast information retrieval, as well as for fast, flexible calculation and transformation of output data based on template relationships. OLAP Server can either physically

deliver processed multidimensional information to provide fast response times to end users, populate its data structures in real-time from relational databases, or offer a combination of both techniques. Considering the current state of technology and end-user requirements for fast response time, putting multidimensional data into OLAP Server is the most optimal method.

MS SQL Server Business environment Intelligence (SSBI). It is used to create and modify business intelligence solutions. The following service projects can be created using SSBI:

- SSAS (SQL Server Analysis Services) – placement of tabular models, hypercubes, as well as models of intelligent data analysis;
- SSIS (SQL Server Integration Services) – development of ETL processes (extraction, transformation, loading of data from various sources);
- SSRS (SQL Server Reporting Services) – development, construction, viewing of reports... Data enters the hypercube from various sources, the main of which is the central database. Information technologies in culture, art, education, science, economy, and business. In the SSAS environment, it is also possible to implement calculations of various indicators according to OLAP technology.

CONCLUSIONS

Systems of intelligent data analysis are used as a mass product for business applications and as tools for conducting unique research.

Leaders in intelligent data analysis associate the future of these systems with their use as intelligent applications embedded in corporate data warehouses.

Despite the sufficient number of methods of intelligent data analysis, the priority is gradually shifting towards logical algorithms for searching causal rules in data. With their help, the tasks of forecasting, classification, pattern recognition, database segmentation, extraction of «hidden» knowledge from data, data interpretation, the establishment of associations in databases, etc. are solved. The results of such algorithms are efficient and easy to interpret.

In addition, the main problem of logical methods for detecting regularities is the problem of sorting through options in an acceptable time. Known methods either artificially limit such sorting (KORA, WizWhy algorithms), or build decision trees (CART, CHAID, ID3, See5, Spina, etc. algorithms), which have fundamental limitations in the effectiveness of searching for causal rules. Other problems are related to the fact that the known methods of searching for logical rules do not support the function of generalizing the above rules and the function of finding the optimal composition of such rules. A successful solution to these problems can be the basis of new methods of intelligent data analysis and corresponding developments.

The problems of using clustering occupy an important place in data analysis since the results of cluster analysis significantly influence the formation of the strategy of actions of enterprises. It is known that there is no single correct clustering algorithm.

When using any clustering algorithm, it is important to analyze its positive and negative aspects, choose the most suitable algorithms, and evaluate the role of a neural network as a tool for cluster analysis of data.

Despite the achievements of modern statistics, as a result of the rapid development of computer technologies and database science, the volume of information is constantly growing. Modern statistical methods are no longer capable of adequately processing large data sets. Intelligent data analysis makes it possible to detect hidden connections in large arrays of information.

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Надійшла до редакції12.09.2022р.

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