IOP Conf. Series: Journal of Physics: Conf. Series **803** (2017) 012183 doi:10.1088/1742-6596/803/1/012183

The application of OLAP technology in the automated risk assessment system for oil and gas fields

D A Zavyalov

Tomsk Polytechnic University, 30, Lenina Ave., Tomsk, 634050, Russia

E-mail: zda@tpu.ru

Abstract. The article shows the advantages of using OLAP technology in the engineering of fields' development and its application in the automated risk assessment system.

1. Introduction

Data analysis is an integral part of every stage of engineering of field development. These data represent a different scale arrays, which can be organized into multidimensional hirarcies with different levels of nesting. In addition, the engineering of field development is an iterative process because a lot of variations of geological, hydrodynamic and economic models of fields should be reviewed and analyzed. Therefore, there is a problem of optimization of data storage and data processing for the purpose of narrowing the range of possible solutions and improving development efficiency.

2. Problem

Engineering and maintenance of field development assumes the storage of large volumes of data in the electronic form and on paper. That, along with the multi-variant engineering process and the heterogeneity of the data used creates a number of problems:

- large amounts of data;
- incomplete data, sometimes there is a need to use an analogies;
- non-uniformity, the regularity and frequency of data may be different;
- non-aligned formats and forms of data storage;
- lots of data are not digitized, there are only hard copies;
- outdated, irrelevant or lost data.

Most of these problems can be solved by an expert on the basis of personal experience or the experience of engineering of similar fields.

In addition, parameters of fields are constantly changing in time on the basis of the revised data and new researches. An analysis of the history of these changes indicates the reliability of the data and the chosen development strategy, as well as it is an auxiliary tool in correction of the strategy.

3. The use of OLAP technology

To solve the problem, it is proposed to use OLAP technology, which is a tool for storage, processing and analysis of multidimensional multiscale and multi-temporal data and their visualization. OLAP systems provide opportunities for multivariate data analysis and for rapid analysis.

OLAP allows one to organize the information and helps to make analytical conclusions using different slices of data (figure 1). For example, performing the cut by one of the parameters, one can obtain fields group's statistics (figure 2).

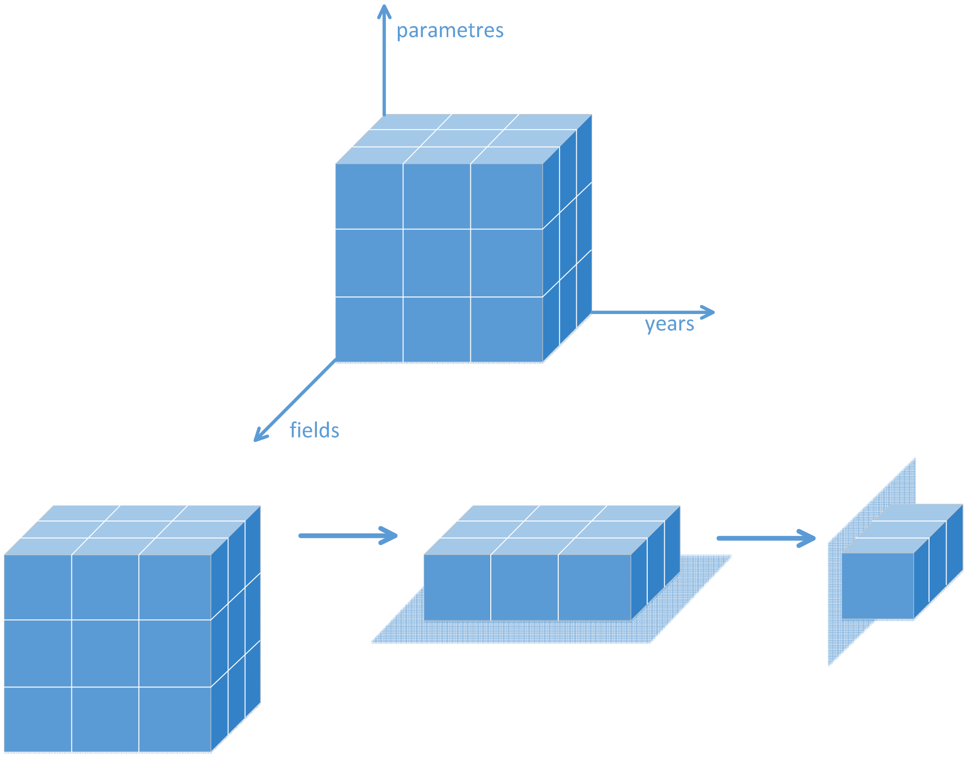

Figure 1. A multidimensional array of reservoir data

Using the hierarchy of OLAP cubes allows to store complex data structures, such as technical and economic parameters of the project or the history of field development. Application of this technology is scheduled on the basis of a developed data structure of oil and gas fields [1].

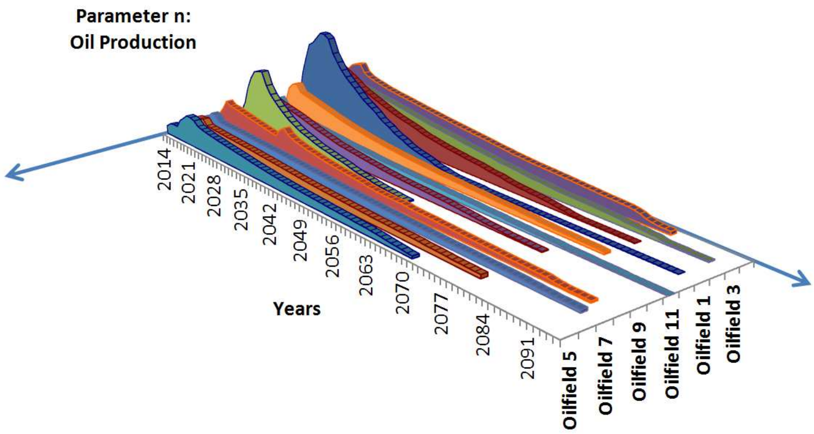

Figure 2. The data cube slice

An OLAP cube with data on fields of a particular region or of the subsoil user, which includes the entire history of their development, is an experience in the development field and is an instrument of accumulation and analysis of such experience.

In addition, the use of OLAP as a accumulation and analysis of data tool allows one to perform the following multicriteria tasks:

- the choice of the system of positioning of planned wells;
- selection of geological and technical measures (GTM);
- assessment of approved field properties and development parameters;
- the choice of analogies of parameters (the problem of choice of analogy when one's own researches or data are incomplete or absent):

$$k = \sum (ks, kd, kf, khyd) / 4 \times C, \quad (1)$$

where k – a factor characterizing the degree of similarity of fields (at a value of more than 0.8 viewed fields, it can be considered similar in bedding conditions and some parameters may be approved in the absence of one's own researches at the early stages of development), ks – the degree of closeness, kd – the similarity of the depth of bedding, kf – similarity of deposits layers, khyd – the similarity of the properties of hydrocarbons, C = $\{c_1, c_2, c_3, c_4\}$ – the weight vector of parameters;
- approval of the oil recovery factor (ORF);
- express-analysis and engineering for reducing the number of possible variants;
- assessment of the relevance of project solution based on a comparison of project and actual performance;
- assessment of the correctness of project decisions on the basis of experience of development of fields with similar conditions of bedding;
- the development of risk assessment;
- and etc.

The process of field development designing is connected with a high proportion of expert participation in decision-making, so it becomes important to consider an experience in developing similar fields. In addition, there are often situations when the necessary parametres of the field have not yet been studied and parametres of fields with similar conditions of bedding are approved.

An OLAP structure (figure 1), including as much available information about the fields as possible, is the the tool for accumulation and analysis of the development experience in the form of multi-dimensional historical data from a variety of fields. This tool is necessary for the specialist in the engineering, support of the development and decision-making, as well as for the analysis of the correctness of project decisions.

Using OLAP allows one to assess the correctness of the approved project solution, obtaining the correlation between actual and project parameters of field development (figure 3).

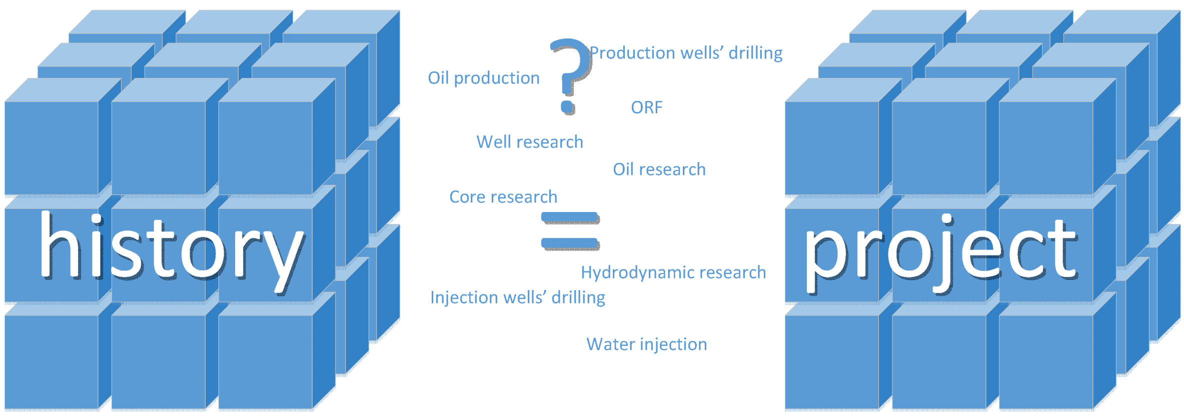

Figure 3. The comparison of data cubes

Another feature of the field development engineering process lies in its multivariance because there is a hierarchy of models and only one of branches of that hierarchy leads to an acceptable project

IOP Conf. Series: Journal of Physics: Conf. Series **803** (2017) 012183 doi:10.1088/1742-6596/803/1/012183

solution. Reducing the number of model variants by analyzing the experience of the development, one can achieve a significant reduction in time and resource consumption in the engineering process.

The efficiency of using OLAP structures is achieved by the higher speed of data arrays processing, computing and retrieving pre-aggregated data (table 1). The issue of speed of data arrays processing is crucial in case of multi-dimensional hierarchically nested data from fields. Another significant advantage of OLAP is the confidentiality of data in the event of the need for interaction with the external environment, such as the preparation of statistics on fields of another subsoil user group.

Table 1. Average time spent by the specialist on making decision by the example of some of the parameters, one iteration, in man-hours

Method	Hydrocarbon properties	The analysis of the project	ORF	Selection of GTM
Raw data	5	15	3	5
Arranged data	3	9	2	4
Data base (DB)	2	3	0.5	1
DB + OLAP	1	2	0.3	0.7
Automated system	0.3	1.8	0.3	0.5

It is obvious that in order to reduce the decision-making time, it is required to reduce the degree of the human expert intervention in the process and assign its functions to the automated system (figure 4) [1], which is based on algorithms of processing of field development experience and which is able to act like a human expert. Such a system reduces the percentage of errors due to the influence of the human factor.

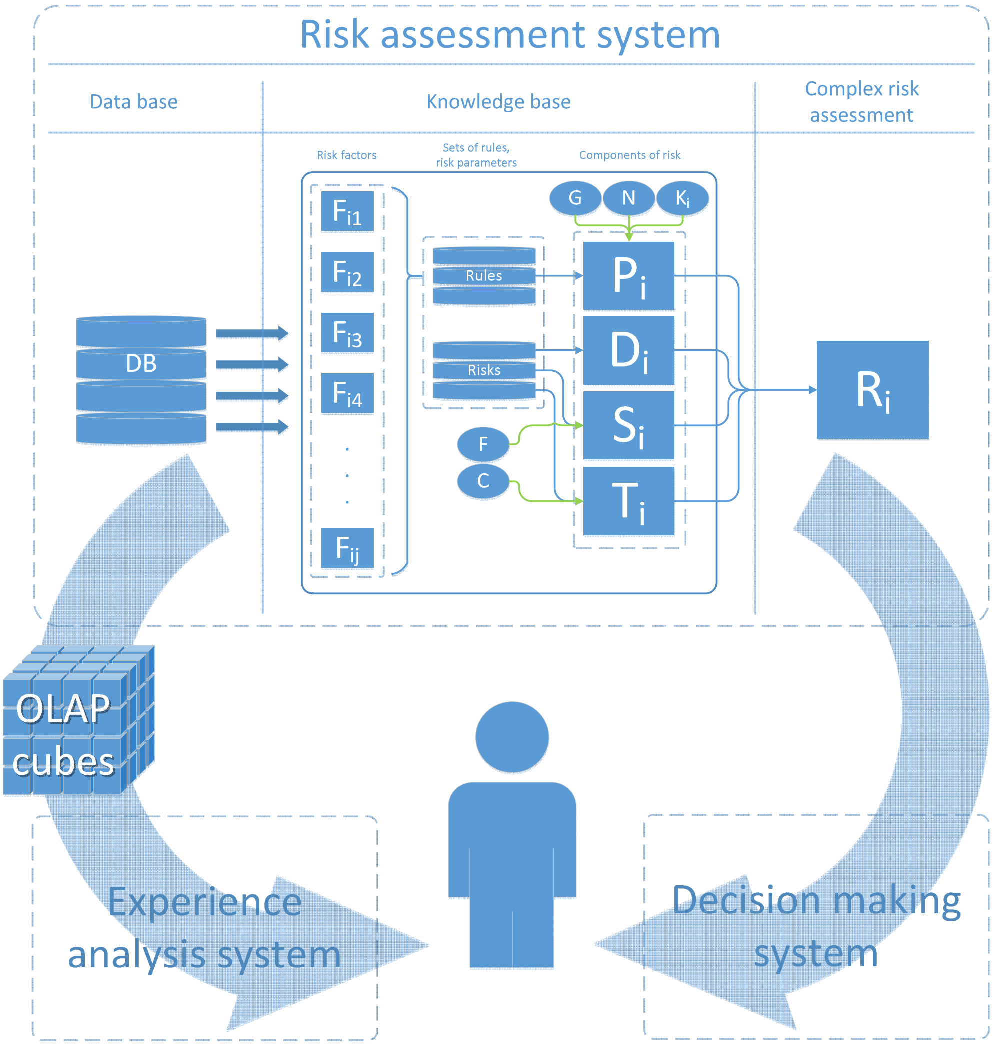

Figure 4. The automated risk assessment system

The subsystem of development experience analysis on the basis of OLAP technology is planned to be included in an automated risk assessment system to develop a more informed decision.

4. Conclusion

The use of OLAP technology as the tool for accumulation and analysis of the development experience and as a part of an automated information system [1] at the engineering stage allows one to implement convolution of hierarchy of models and thereby to reduce the number of variants under consideration. Using the experience of fields development on the basis of analytical calculations allows one to estimate possible risks to make more balanced decisions, and reduce labor costs and project time.

References

[1] Zavyalov D A, Zakharova A A 2016 Expert system for integrated assessment of the risks of hydrocarbon field development *Cybernetics and Programming* **5** 1-9

[2] Zeng K, Agarwal S, Stoica I 2016 IOLAP: Managing uncertainty for efficient incremental OLAP *Proceedings of the ACM SIGMOD International Conference on Management of Data* pp 1347-1361

[3] Xie X, Hao X, Pedersen T B, Jin P, Chen J 2016 OLAP over probabilistic data cubes I: Aggregating, materializing, and querying *2016 IEEE 32nd International Conference on Data Engineering, ICDE* pp 799-810

[4] Sadlier A, Says I, Hanson R 2013 Automated decision support to enhance while-drilling decision making: Where does it fit within drilling automation? *SPE/IADC Drilling Conference, Proceedings* **1** 288-295

[5] Sealy I, Scott H, Walker K 2016 Development and implementation of a risk-based environmental management system in an oilfield services company *Society of Petroleum Engineers - SPE International Conference and Exhibition on Health, Safety, Security, Environment, and Social Responsibility*

[6] Xiu Y, Liu W, Liu B, Li H 2015 An oilfield ecological risk assessment system integrating OERAM and GIS *Chemical Engineering Transactions* **46** 733-738

[7] Özpeynirci Ö., Özpeynirci S., Kaya A. 2017 An interactive approach for multiple criteria selection problem *Computers and Operations Research* **78** 154-162

[8] Ettehadtavakkol A., Jablonowski C., Lake L. 2016 Development Optimization and Uncertainty Analysis Methods for Oil and Gas Reservoirs *Natural Resources Research* pp 1-14

[9] Navabi S., Khaninezhad R., Jafarpour B. 2015 A generalized formulation for oilfield development optimization *IFAC Proceedings Volumes (IFAC-PapersOnline)* **48** 56-61

[10] Hunsaker C.T., Graham R.L., Suter II G.W., O'Neill R.V., Barnthouse L.W., Gardner R.H. 1990 Assessing ecological risk on a regional scale *Environmental Management* **14** 325-332

[11] Xiong H.P., Liu W.W., Zhao C.Y. 2014 A metadata management model for massive data engineering in oilfield *Applied Mechanics and Materials* **513-517** 4372-4377