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THE CONCEPT OF AN ARCHITECTURAL SOLUTION FOR THE SERVICE INTENDED TO BUILD AN ENTERPRISE STRATEGY MAP

Пропонуються архітектурні рішення програмного забезпечення для задачі побудови стратегічної карти підприємства, наведено процес побудови стратегічної карти та методи, що використовуються при розв'язанні задач на етапах цього процесу. Наведено стислий огляд існуючих на IT-ринку програмних продуктів, які використовуються у стратегічному управлінні. Зроблено висновки про доцільність використовувати сервіс-орієнтовану архітектуру для програмної реалізації окремих модулів системи стратегічного управління та мікросервісної архітектури для модуля стратегічної карти підприємства.

Ключові слова: статистичні дані, обробка, клас, класифікація, соціологічне опитування, алгоритм.

Предлагается архитектурное решение программного обеспечения для задачи построения стратегической карты предприятия, приведен процесс построения стратегической карты и методы, используемые при решении задач на этапах этого процесса. Приведен краткий обзор существующих на IT-рынке программных продуктов, используемых в стратегическом управлении. Сделаны выводы о целесообразности использовать сервис-ориентированную архитектуру для программной реализации отдельных модулей системы стратегического управления и микросервисную архитектуру для модуля стратегической карты предприятия.

Ключевые слова: стратегическое планирование, корпоративная информационная система, архитектурное решение, микросервис, стратегическая карта, ключевые показатели деятельности.

The article examines an architectural solution of a software application for building an enterprise strategy map. It gives a short review of existing software products at the IT-market, which is used in strategic enterprise performance management. Much attention is dedicated to the separate stage of the development program formation, i.e. strategy map building. For building such a map it is proposed to formulate general enterprise strategic goals on the basis of an analysis of the development direction priorities and then check them for their feasibility. Next, the selected goals are decomposed into goals by the perspectives in accordance with the balanced scorecard. The goals are analyzed for the impact of key success factors. Based on the success factors, bunch of strategic key performance indicators are formed. The paper examines problems that need to be solved at each stage of the map building, and proposes mathematical methods for their solving such as the analytic hierarchy process, the trajectory approach in conjunction with the system optimization and the cognitive analysis. The author suggests using service-oriented architecture for EPM-system implementation and microservice architecture for the implementation of the strategic map application. As result the study identifies four services that implement the following business functions: an identification of priority directions for the enterprise development and general strategic goals; a verification of the feasibility of common strategic goals and planned targets formation; a definition of the goals by the perspectives, KSF definition and building of the strategy map; a definition of KPI by the perspectives. The structure of the software application is presented as a component diagram.

Keywords: strategic planning, corporate information system, architectural solution, microservice, strategy map, key performance indicators.

Introduction. Strategic management practice shows that all the difficulties of decision-making at this level are usually related to the gathering and processing of a large amount of diverse information as well as the solving of complex poorly formalized tasks. It increases the risks of the enterprise activity in the long-term and complicates the process of strategic plans formation for the enterprise development [1]. Thus, enterprise management systems increasingly include corporate information systems with strategic management modules, which implement methods for solving strategic level problems. In rapidly changing competitive environment, it is necessary to use different methods of enterprise management for successful functioning of any modern enterprise. This is especially related to the level of a strategic management. Therefore, the problem of developing adequate methods for enterprise management and corresponding software products, which informationally, analytically and algorithmically support the processes of making strategic decisions within these modern management methods, remains relevant.

Problem analysis. In recent years, modern enterprises have increasingly started to use Balanced Scorecard (BSC) in strategic management [2, 3]. Such a system provides the opportunity to analyze the enterprise activity and to make planning for both short-term and long-term periods, taking into account the interests of all stakeholders. Usually in these cases, Key Performance Indicators, which are formed by built strategy map, are

considered as a system of indications [4]. The strategy map covers the main strategic goals of the stakeholders and reflects their interaction. It means that a strategy map is a system of interrelated strategic goals, on the basis of which KPI system is formed. These KPIs are the basis for building long-term plans of the enterprise activity. Building a strategy map relates to systems intended to support strategic management. In order to build such a map it is necessary to analyze a lot of information, carry out forecasting and evaluation of different sides of the enterprise activity. This map should be the basis for the system of enterprise plans for the strategic period.

For solving individual tasks or complexes of strategic management tasks, usually companies use special software systems for informational and analytical support to the strategic planning process. The first name of such systems BPM (Business Performance Management, BPM) was proposed by the international analytical company IDC. Later The Gartner Group offered an alternate acronym CPM (Corporate Performance Management). In addition, it should be mentioned another popular acronym EPM (Enterprise Performance Management) [5]. However, all these systems are used within decision support at the top management level.

The business efficiency management system (BPM, CPM, EPM) is an enterprise management concept based on a set of information technologies that automate the base management processes: forecasting, planning, budgeting, monitoring and analysis. It provides an

opportunity for a comprehensive analysis of the enterprise performance and trends in their changes, integrates various components for local strategic management tasks. Also, the task of such a system is to provide management with up-to-date and reliable information for decision-making at all levels of organization management with minimal cost.

The market of such systems is considered broad enough: it includes large corporate products such as Oracle EPM, Oracle Hyperion Planning, IBM Cognos Disclosure Management, SAP EPM, IBM Cognos FPM, IBM Cognos TM1, SAS Strategy Management, as well as small open-source projects: Host Analytics, Infor, Longview Solutions and etc.

The corporate performance management (CPM) application suite market is mature and composed of vendors offering solutions that are widely adopted by both large and midsize organizations (midsize can roughly be defined as having annual revenue of \$100 million to \$1 billion). Given the range of solutions available, CPM suites are also accessible to smaller organizations (those with \$10 million to \$100 million in annual revenue). CPM initiatives aim to either improve processes within the office of finance (OOF) or support performance management (PM) throughout the organization. CPM deployments can typically be categorized as one of two types: OOF CPM and strategic CPM. OOF CPM largely involves the improvement of financial processes, while strategic CPM supports organizationwide transformation and growth [6].

The general shortcomings of existing EPM-systems include the following:

- they do not take into account the evolution of the indicators and the connection between them;
- most of the known systems usually use only financial indicators, although there is a tendency to develop indicators that take into account various factors [4];
- do not allow to define and formalize the strategy, the strategy is always formed by a person, there is no methodology for determining its feasibility;
- the problem with reconciliation of strategic goals has not been solved.

The existence of separate strategic goals and their strategies, which are developed by various decision makers, can lead to a violation of the integrity and strategic management connectedness in general. As result, there can be an inconsistency and contradictions in enterprise activity at the tactical and operational levels of the management [4].

Therefore, it is proposed to consider the process of strategic plans formation as a set of stages intended to develop strategic annual plans and budgets of the enterprise. This process is the basis for building EPM-system.

Problem statement. The papers [7, 8] show the general structure of the EPM-system, which is introduced in the strategic enterprise management systems.

Based on the analysis of architectural decisions regarding EPM software packages, the following conclusions were made.

Firstly, software products that implement all the components for strategic management, such as Oracle EPM, SAP EPM and others, are thought quite cumbersome. Usually they have a high cost and require installation of big platforms, without which their work is impossible. The introduction of such products may result in lack of return, their loss-making or low operating efficiency. All this is an obstacle to their implementation for many businesses.

Secondly, small open-source products have a poor functionality and very often do not provide a mechanism for integrating with other corporate systems at all.

That is why the main task is to choose such architectural decisions regarding the software implementation of the strategic management system, which will allow the decision maker quickly and efficiently to solve individual tasks, to analyze various aspects of the enterprise activity and to combine solutions of strategic management tasks in different combinations.

Since one of the key missions in strategic management is the definition of long-term goals, it is proposed to consider the autonomous task of strategy map building. The goal is to develop architectural concept for software solution that implements building of this map. The software solution should allow the decision maker to model the goal creation process, to take into account different information for the goal formation, to check the feasibility of all the considered goals, and also to be able to use the results of the strategy map building for the further formation of the enterprise development program.

The process of building an enterprise strategy map. The main stages of the process of a strategic program formation for the development of the enterprise were proposed in the paper [9]. Let's take a look at the more detailed process of strategy map building.

1. Determine the priorities of the enterprise development directions. Guided by the fact that the main goal of any enterprise is to get profits, which is always achieved in a market economy by improving the enterprise competitiveness, it is proposed to consider the following areas of competitiveness as the development directions: production, finance, marketing and personnel. An analysis of these areas will allow us to formulate general strategic goals of the enterprise. The choice of these areas is also explained by the fact that in order to develop a system of performance indicators of the enterprise within the strategic development program it is proposed to choose BSC methodology. The BSC is based on a strategy map, which is a set of goals by the four perspectives: financial, customer, internal business processes, learning and growth. Since the strategy map goals must be consistent with the strategic goals, the following is proposed. Firstly, formulate general strategic goals based on the analysis of possible development directions and evaluate their feasibility. Based on the analysis of general strategic goals feasibility, choose that goals which are considered to be planned. Then decompose them into the goals by perspectives.

To determine the priorities of development directions (production, finance, marketing, and personnel), it is proposed to use the analytic hierarchy process. Hierarchy

direct process is built in the following way. Either a problem focus, which is an integrated enterprise development, or the purpose of the development, i.e. improvement of the enterprise competitiveness, is placed at the top level. At the next levels, actors as interested parties in the directions development are presented. Development strategies in these areas will form a generalized development scenario which is the lower level of the hierarchy. Based on the built hierarchy of direct and reverse processes, during all HP procedures factors, which influence the directions development, goals and policy of the stakeholders in the enterprise development, is reviewed. As a result of calculations, the importance ratio values, which characterize the degree of influence of a separate direction on the enterprise development success and indicate which directions need to be developed in the first place, are determined. Thus, on the basis of these ratios the priority directions of enterprise development are determined.

2. For the development of each direction, taking into account their importance ratios, formulate expertly possible general strategic goals. These goals can be represented as the following set $Z^\Sigma = Z_E^\Sigma \mathbf{Y} Z_F^\Sigma \mathbf{Y} Z_P^\Sigma \mathbf{Y} Z_M^\Sigma$, where $Z_E^\Sigma, Z_F^\Sigma, Z_P^\Sigma, Z_M^\Sigma$ – set of all general strategic goals related to the development directions: production, finance, marketing and personnel.

3. Identify general enterprise strategic goal from all possible goals Z^Σ . Let's consider that Z^G is a set of general strategic goals $Z^G \subset Z^\Sigma$. At the same time, it should be mentioned that a separate general strategic goal covers all development strategies.

4. Verify the feasibility of each general strategic goal from the set Z^G . For this, it is necessary:

4.1 Identify possible strategies for achieving each common strategic goal. Can be considered the following two strategies for achieving the goal: a maximum effort strategy and a minimum effort strategy (eg, strategy of taking market over and strategy of market presence for the strategic goal "diversification");

4.2 Build production trajectories for all strategies. Each trajectory is based on the criterion of maximizing total returns at all the period intervals. For trajectory building it is proposed to use the system optimization methodology;

4.3 Analyze a possibility of the enterprise to implement chosen strategies and ensure delivering the production with correct volumes. The output trajectory determines the necessary resources and investments volumes to adjust the resource base of the enterprise. As a result, for each strategy a development trajectory is formed as a set of values: output volumes; production resources volumes; investments, i.e. funds for the necessary resources. Then for each goal, a set of effective trajectories is formed based on the solution of the two-criteria problem: maximizing the total profit from production and minimizing investment costs for development in accordance with strategies;

4.4 Choose a strategy for achieving a general strategic goal based on the analysis of development trajectories. A particular trajectory, which is more in line with the enterprise capabilities, is being chosen. If it turns out that the enterprise is not able to implement at least one trajectory, it will mean that this general strategic goal cannot be achieved during the foreseeable course of business success and selected strategies. Consequently, it may be reasonable to reject the strategies for achieving this general strategic goal. Thus, building of development trajectories for each strategy gives owners, management and senior management an ability to analyze market opportunities of the enterprise, reconsider strategies for achieving a general strategic goal and make the right choice of the goal itself.

5. Choose the planned strategic goals that form the set Z^E , where $Z^E = \{Z_j^E\}, j \in N^T$, where Z_j^E – j -th planned strategic goal for the period T , N^T – set of indexes of planned strategic goals for the period T , $Z^E \subset Z^G$. For each planned strategic goal, the strategy for its achievement will be chosen. Also the planned output values for assortment groups, necessary production resources and investments will be defined.

It should be noted that all obtained values of output volumes, resources and investments have value-laden nature. Since the long-term period is considered, then all values for computational procedures are predicted or determined expertly.

6. Form enterprise strategic goals by the perspectives: finance, clients, business processes, personnel. The planned strategic goals are transformed by the perspectives. This means that the general goals $Z^E = \{Z_j^E\}$ are aligned with the set of goals by perspectives

$$Z^H = Z^{HF} \mathbf{Y} Z^{HK} \mathbf{Y} Z^{HBP} \mathbf{Y} Z^{HP}, \quad \text{where}$$

$$Z^{HF} = \{Z_g^{HF}\}, g \in G^{HF}, \quad Z^{HK} = \{Z_g^{HK}\}, g \in G^{HK},$$

$$Z^{HBP} = \{Z_g^{HBP}\}, g \in G^{HBP}, \quad Z^{HP} = \{Z_g^{HP}\}, g \in G^{HP} - \text{goals}$$

by perspectives: finance, clients, business processes, personnel, $Q^F = |G^{HF}|, Q^k = |G^{HK}|, Q^B = |G^{HBP}|,$

$$Q^P = |G^{HP}|, G^{HF}, G^{HK}, G^{HBP}, G^{HP} - \text{set of goal}$$

indexes by perspectives: finance, clients, business processes, personnel, and their capacity is equal respectively Q^F, Q^k, Q^B, Q^P .

Then an enterprise strategic map can be imagined as a set of terms: $\overline{SM}^H = \langle Z^E, Z^H, CZ^H \rangle$, where CZ^H – a set of adjacency matrixes.

7. Perform a cognitive analysis of a strategy map \overline{SM}^H to determine the 'power of influence' of goals by perspectives to planned strategic goals and their interdependence. As a result of a cognitive map building and its analysis, less meaningful or duplicate goals by perspectives and weak links between them will be removed. As a result, new strategy map SM^H is being built.

8. Build extended version of strategy map.

8.1 Identify key success factors (KSF) that affect the feasibility of the relevant strategic goals by the perspectives. The achieving of goals by perspectives is associated with a set of key success factors.

8.2 Build a cognitive map for analyzing the tightness of KSF relations to strategic goals. This process should remove connection duplications between the goals and the KSFs as well as non-essential KSFs. It must significantly reduce the number of KPIs in the next steps. As a result, a set of KSFs and their impact on strategic goals by the perspectives is formed.

8.3 Based on KSF, form a set of key performance indicators (KPI) by the perspectives: finance, customers, business processes, and personnel. As a result, an extended version of enterprise strategy will be formed:

$$SM_T^H = \langle Z^E, Z^H, CZ^H, KSF^H, SF^H, S^H \rangle,$$

which consists of the map $\overline{SM^H}$, key success factors KSF^H , strategic KPI $S^H = \{ S^{HF}; S^K; S^{HBP}; S^{HP} \}$ by the perspectives and connections between KSF and goals SF^H .

Using microservice architecture for a software application intended to build a strategy map. The entire process of formulating an enterprise development program, which is suggested in [9], can be implemented as only one application. Nevertheless, in this case the logical solution is to present separate stages of this process as a set of several small applications. This is because each step of the process involves solving many problems. It requires a lot of data from different sources of information. Moreover, these data usually have a different scope. Therefore, it is proposed to consider each stage as a separate application that will be implemented programmatically.

For example, the process of building a strategy map can be considered as a separate management task. It need to be resolved at the stage of the program development as well as at the stages of the analysis of the strategic plan execution. The solution of this task may also be required in reviewing and evaluating the enterprise future by its owners in order to assess the future of development directions and to form new prospective ones in the enterprise activity. Hence, it is suggested implementing EPM-system as a software product with a service-oriented architecture (SOA) [10].

SOA is a set of architectural principles that are independent of technology and products. Splitting the system into services will allow easily extending and replacing functionality without affecting the entire information system of strategic management – the EPM system. SOA facilitates using of data and logic in the next generation of this system, i.e with its reengineering.

Despite the fact that it was decided to choose service-oriented architecture for the EPM-system, it is proposed to implement application for building a strategy map as a micro-service application, that is, as some kind of subapplication that has its own business responsibility [11, 12].

The microservices represent an architectural style in which complex applications are created as a set of small, lightweight, self-contained, independent, not strongly connected services, each of which is responsible for a particular process. The main advantage of the choice is the ability to horizontally scale overloaded microservices, in particular those that use mathematical algorithms for data computation [15–17]. The micro-services provide alternative means for creating applications, providing flexibility, scalability and fault tolerance. However, the development and support of applications with the micro-service architecture also has several difficulties related to the distribution, data inconsistency and so forth. [11, 14].

Figure 1 shows a component diagram for a service intended to build an enterprise strategy map using a micro-service architecture. It is suggested to create a set of microservices by the following bounded contexts.

1. *Strategic Goal.* It is responsible for defining the priority directions of the enterprise development and forming general strategic goals.
2. *Goal Validation.* It is responsible for verifying the feasibility of the general strategic goals of the enterprise and the formulation of planned strategic goals.
3. *Strategic Map.* It is responsible for defining goals by perspectives and relevant KSFs as well as for building a strategy map.
4. *KPI.* It is responsible for defining key performance indicators by the perspectives.

In addition, API Gateway pattern should be also noted. Briefly, it's a single entry point for all clients. The API gateway handles requests in one of two ways. Some requests are simply proxied/routed to the appropriate service. It handles other requests by fanning out to multiple services. Rather than provide a one-size-fits-all style API, the API gateway can expose a different API for each client [16].

Using an API gateway has the following benefits:

- insulates the clients from how the application is partitioned into microservices;
- provides the optimal API for each client;
- reduces the number of requests/roundtrips.

However, there are also some drawbacks:

- increased complexity since the API gateway is yet another moving part that must be developed, deployed and managed;
- increased response time due to the additional network hop through the API gateway.

The API gateway might also implement security, e.g. verify that the client is authorized to perform the request [16].

Conclusions. The work have examined the process of building an enterprise strategy map, which software implementation was suggested to perform with using microservice architecture. Given arguments for chosen architecture type and the description to each microservice. In future works it is necessary to solve the problems of choosing (developing) the API Gateway, data integration, communication with third parties and other issues related to software implementation of the solution for building a strategy map.

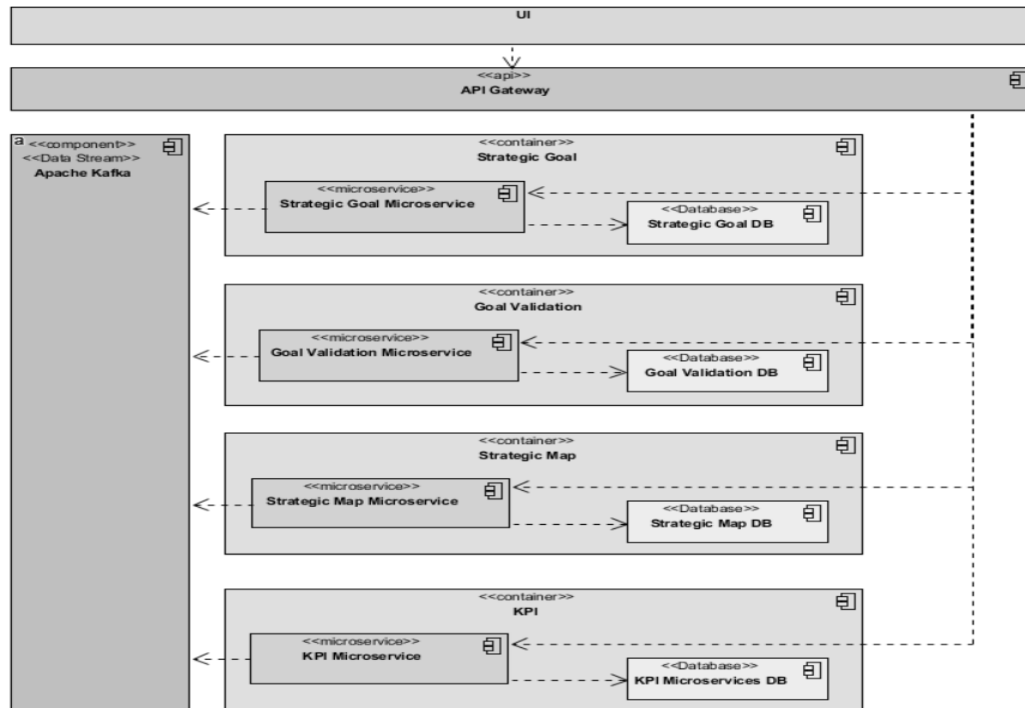


Fig. 1 – Component diagram of strategy map building application

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