Development of a model of the single information space of the enterprise supporting the replacement of layers

B M Shifrin\textsuperscript{1}, I V Eliseev\textsuperscript{1,*}, V A Sokolova\textsuperscript{1} and V A Kalyashov\textsuperscript{2}

\textsuperscript{1}Saint-Petersburg State Forest Technical University
\textsuperscript{2}Saint Petersburg State University of Architecture and Civil Engineering
*E-mail: yeliseyef@yandex.ru

Abstract. The main purpose of this article is to substantiate and develop the methodology of replacement of generations of layers in an attempt to minimize destruction of links between adjacent layers of the single information space of the enterprise, caused by extreme instability of states of the single information space.

1. Introduction

Nowadays, one of the most popular development trends of information technologies is an attempt to unify all information resources and systems, handling the data in a remote multiuser mode, this is especially necessary for the development and support of automated systems in construction and engineering, requiring constant updating. Such an integration of the data and the handling software within the company constitutes the single information space (SIS) of the enterprise.

In theory, the mission of the SIS of the enterprise is to avoid information’s doubling thanks to automatic synchronization of databases of various information systems (IS). This will enable to reduce organisational barriers between various departments, owing to quick exchange of electronic data, as well as to cut down time and labour costs falling on the paperwork. Thus, the controllability of a business can be increased through transparency of operations with data and online monitoring of SIS users’ activity.

It is noted in the modern literature [1-4] that, besides technological aspects of the creation of the SIS of the enterprise, there are points of the similar importance: the management, the organizational and the financial. According to management points, the leaders of the enterprise should not be simply interested in deployment of the SIS but rather actively favoring it. Within organizational aspect, the enterprise’s personnel supposed to be the immediate users of the single information space, is to comprehend purposes and objectives of its creation. Furthermore, as every solid campaign, the development, acquisition and launching of the firmware of the SIS requires an appropriate budget, for its financial costs.
2. The body of the text

An universal SIS of the enterprise can be represented by a hierarchy of a set of n layers \( \{ S \} = \{ S_1, \ldots, S_n \} \), which possess the accumulated information (the level of knowledge) \( \{ I \} = \{ I_1, \ldots, I_i, \ldots, I_n \} \) and influence each other (Figure 1).

\[
I_i = I_{i-1,i}(\{F_{i-1,i}\}, I_{i-1}), \quad i = (2 \div n), \quad (1)
\]

where \( \{ F \} \) is the set of various factors affecting the conversions (for instance, the topology and the capacity of data networks, the technical architecture of the hardware etc.), whilst the dependence the knowledge of the lower level on the knowledge of the higher level can be formalized in the following way:

\[
I_i = I_{i+1,i}(\{F_{i+1,i}\}, I_{i+1}), \quad i = (1 \div n-1). \quad (2)
\]

In a simplified form, the lifecycle of the IS related to the layer \( S_i \) can be presented as follows (Figure 2).
To the time \( t_1 \) the system will stop its modernization, but the knowledge accumulated during its running time is relevant, that is to the time \( t_2 \) there are two simultaneous systems belonging to various generations the first and the second (\( S^1_i, S^2_i \)). The phase between \( t_2 \) and \( t_3 \) represents the situation where the preceding generation is to be completely replaced by the new generation of the IS, etc.

Let us, by using the automatic approach [5-10], compose the transition graph for the layer \( S_i \). (Figure 3).

**Figure 3.** The transition graph for the layer \( S_i \) by generations.

The graph nodes (the positions) are generations of the lifecycle of the IS of the layer \( S_i \) (\( S^1_i, S^1_i, S^2_i, S^2_i, ..., S^{j-1}_i, S^j_i, ... \)).

The graph arcs show the conditions under which the position will change and those under which those will not (so called loops). Near arc, it is accepted to show under which input actions the transition is about to be, and which output signals are to be generated.

In this way, the Figure 3 shows that until time \( t_1 \) (\( t^1_1 \)) is reached, the IS of the first generation with the knowledge \( I^1_i \) level is being used; after reaching time \( t_1 \), there will be two systems with accumulated knowledge \( I^1_i, I^2_i \), belonging to various generations (\( S^1_i, S^2_i \)) will be in use, etc.

Now let us formulate the global criteria of minimization the difference between transitions to other layers, in changing the generation.

Using the expression (1), for the set of generations 1, 2, ..., \( j \), ... we obtain the following dependences of the knowledge of the higher level on the knowledge of the lower level:

\[
I^1_i = \phi^{1}_{i-1,i} (\{F^1_{i-1,i}\}, I^1_{i-1}), \quad I^2_i = \phi^{2}_{i-1,i} (\{F^2_{i-1,i}\}, I^2_{i-1}), \quad ..., \quad I^j_i = \phi^{j}_{i-1,i} (\{F^j_{i-1,i}\}, I^j_{i-1}), \quad ..., \quad i = (2 \pm n).
\]
Then, the set of goal functions minimizing the losses caused by destruction of dependencies of the knowledge of the higher level on the knowledge of the lower level for n layers can be formulated in the following way:

\[
\begin{align*}
    & d_{i-1,i}^{1,2} (\varphi_{i-1,i}^{1}, \varphi_{i-1,i}^{2}) \rightarrow \min, \\
    & d_{i-1,i}^{2,3} (\varphi_{i-1,i}^{2}, \varphi_{i-1,i}^{3}) \rightarrow \min, \\
    & \ldots, \\
    & d_{i-1,i}^{j-1,j} (\varphi_{i-1,i}^{j-1}, \varphi_{i-1,i}^{j}) \rightarrow \min, \\
    & \ldots
\end{align*}
\]

Likewise, by using the expression (2), for the set of generations 1, 2, ..., j, ... the following dependencies the knowledge of the higher level on the knowledge of the lower level are obtained:

\[
\begin{align*}
    & I_{i}^{1} = \varphi_{i+1,i}^{1} (\left\{ F_{i+1,i}^{1} \right\}, I_{i+1}^{1}), \\
    & I_{i}^{2} = \varphi_{i+1,i}^{2} (\left\{ F_{i+1,i}^{2} \right\}, I_{i+1}^{2}), \\
    & \ldots, \\
    & I_{i}^{j} = \varphi_{i+1,i}^{j} (\left\{ F_{i+1,i}^{j} \right\}, I_{i+1}^{j}), i = (1 \div n-1).
\end{align*}
\]

Then, the set of goal functions, which minimize the losses cause by destruction the dependencies of the knowledge of the higher level on the knowledge of the lower level for layers n, are formalised as follows:

\[
\begin{align*}
    & d_{i+1,i}^{1,2} (\varphi_{i+1,i}^{1}, \varphi_{i+1,i}^{2}) \rightarrow \min, \\
    & d_{i+1,i}^{2,3} (\varphi_{i+1,i}^{2}, \varphi_{i+1,i}^{3}) \rightarrow \min, \\
    & \ldots, \\
    & d_{i+1,i}^{j-1,j} (\varphi_{i+1,i}^{j-1}, \varphi_{i+1,i}^{j}) \rightarrow \min, \\
    & \ldots
\end{align*}
\]

In the Figure 1, the universal SIS of the enterprise is displayed as a hierarchy of layers. For many modern companies engaged in IT activity, the SIS can be represented in the following way (Figure 4).
Figure 4. The SIS of an IT-enterprise.

Information technologies should easily adopt changes of the outside environment and requirements of the business. This is in fact the goal of improvement of mechanisms of software re-usage and increasing their compatibility and transferability. Processes of migration and modernization, known as collective name “re-engineering”, are of great demand [11].

Everything in this world is subject to change, business requirements to information systems included. As a result, such systems are subject to be enlarged, widened and integrated. Their number and function grow. This leads to the qualitative transformation of the automation concept itself, required re-organization of information infrastructure covering items automated. Sooner or later, the re-engineering is noted. This is not only typical for “inherited” systems but for relatively new developments as well.

A ground to rebuild the information system can now be of a politic or psychology nature: the lead programmer has moved away; the relations to the platform developer have been decayed; the level of technical support or contractor’s financial level has been changed. With no doubt, the key factor is the total cost of ownership of the information system.

Consequently, due to various circumstances – and those are not mandatory the technical issues – one popular database management system is often today changed one for another. Moreover, projects of transition to another DBMG appear, and this presumes organization of the support of more than one platform.

Many replicated solutions are developed for the enterprises of various scales and for the wide society of clients, everyone of each has its own preferences. Even having developed the concept in accordance with requirements of a company, one can face the requirement to apply different servers. Say, a central office of a geographically distributed company can be operated on Oracle platform, and their affiliates
(handling lower data volumes and having little personnel) are run by MS SQL Server, whilst mobile users are supported through MS SQL Desktop or Sybase.

In accordance with our hierarchy, let us consider layer S₂, where the objects stored in the bases, the libraries etc. are used in capacity of accumulated information I₂.

The global problem, solved in present days to some extent, is to keep data available (layer S₁), where ERP data (the financial, accounting and operative information etc.) are used in capacity of I₁, in changing the DBFS.

Having used the ratio (1) and accepted the current level of the generation of DBMS as j, we come to the following information dependences j₁², j₁²⁺¹ between layers S₁ and S₂:

\[ I_j^2 = \varphi_{j2}^j \left( \{ F_j^1 \}, I_j^1 \right); \quad I_{j+1}^2 = \varphi_{j2}^{j+1} \left( \{ F_{j+1}^1 \}, I_{j+1}^1 \right), \]

where the set of main affecting factors \( \{ F_j^1 \}, \{ F_{j+1}^1 \} \) includes:

1. the extreme values of the information being stored and handled by the IS;
2. the condition of the IT fleet;
3. the natural obsolescence of development tools;
4. the increase of payload of the IS due to increase of computational processes and/or their users;
5. the development of integration mechanisms with adjacent IS based on other platforms;
6. the alteration of business-processes of the enterprise (the classification of company’s profile);
7. the alteration of license policy of software’s suppliers.

Then, the set of goal functions D, which minimize the loss in transiting of the DBFS layer from S₂ to S₂⁺¹, can be presented in the form of degrees of difference of information dependences j₁², j₁²⁺¹:

\[ D(\varphi_{j2}^j, \varphi_{j2}^{j+1}) \text{ min}. \]

Two main factors affecting in a negative way in changing the generation of the database:

1. the degree of risk to loose the functionality of the system for users, thanks to difference between information components (let us name it d₁);
2. the degree of loose of the availability level of historical data and the persistence of the registration (let us name it d₂).

Then, the following is obtained:

\[ d_1(\varphi_{j2}^j, \varphi_{j2}^{j+1}) \text{ min}; \quad d_2(\varphi_{j2}^j, \varphi_{j2}^{j+1}) \text{ min}. \]

Presently, two main classic approaches to the migration between DBMS are used: the approach I (building of the system «from ground zero») and the approach II (transition of data with the stand steel of the current system).

The approach I will in any event dissatisfy the developed model by the goal function d₂ and the approach II is efficient if the time of transferring data is limited – normally the transition time is not more than 60 hours. Otherwise, such a transition will not satisfy the developed model by goal function d₁.

A conclusion can be drawn, that in a climate of running of big enterprises’ corporative information systems which as a matter of fact consists of various databases (more 10) with sound volume of information (several terabytes per each DB) and the requirement to implement persistent analytical functions, the existing approaches are not efficient in usage, and a principally new methodology of step-by-step migration between DBMS of every DB without loss of overall functionality of the system, is to be developed.

3. Conclusions

The grave problem of the development of the single information space of the enterprise lies in the fact that the position of the SIS is very unstable and is subject to many factors: the digenesis of hardware,
the digenesis of developers, the alteration of business requirements, the alteration of country’s legislation etc.
Most likely, it may be affirmed that the instability of the SIS leads to intersection in functionality of various IS within the enterprise, causing significant losses. In this connection, the idea to develop the methodology of replacement of generations of layers in an attempt to minimize destruction of links between adjacent layers, is seen actual.

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