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SOME APPROACHES TO CREATING AN INEXPENSIVE INFORMATION SYSTEM TO SUPPORT ENTERPRISE MANAGEMENT IN THE DIGITAL ECONOMY

The article discusses the methodological aspects of building a two-tier enterprise information management system based on cloud information storage technology. The main disadvantages of the existing information management systems of Ukraine enterprises is that almost all of them are focused on the use of local computer systems of the enterprises without the use of Internet technologies. Some systems use limited informational WEB sites. Such control systems has the high costs of creating, rebuilding and operating, caused by the need to modernize computer networks and attract professional programmers for each significant modernization.

The so-called cloud information storage technology allows users not only to store large amounts of their data on remote servers, but also to quickly make changes and synchronize data with the current state of the enterprise. A significant advantage of cloud storage is the relatively low cost of renting online storage, the reliability provided by the storage and restoration of archives, the simplicity of creating and adjusting the structure of the repository, the advanced data protection system, the simple implementation of information relationships with other repositories.

Accumulated over several years of experience in the design and operation of a multi-user Internet system suggests that the disadvantages of cloud storage technology include slowing synchronization with large amounts of data. At the same time, there is a decrease in the efficiency of information processing that is significant compared to the time spent on replenishing and correcting data when using the local servers of the user himself.

Theoretical analysis and long experience in the development and operation of an information system with one large cloud storage allows us to offer a two-level information system universal for any type of enterprise management structure. The upper level is implemented as a network of interconnected personal cloud storages. The owner of a particular cloud is a specific enterprise manager (director, deputy director, head of department, specialist of the department). Each manager uses his personal computer, which has full access to the corresponding personal cloud through the company's Internet network connected to the global network. The lower level of the system is implemented in the form of local subsystems for preparing solutions. Each such subsystem is focused on the tasks of an individual manager and can be implemented both by cloud-based tools for distributed information processing and by software packages that run directly on the

manager's computer. To select information into the personal cloud of the manager, it is necessary to perform an expert analysis of the existing technology and information support for the decision-making of this manager. The next design task is to identify informational relationships between clouds. To do this, you may need to perform a new expert analysis, taking into account the administrative and informational subordination of managers. Formally defining such relationships and minimizing their number can be done using methods and models of graph theory, for example, methods of splitting a graph into subgraphs.

It is advisable to start designing and testing an information system with the creation of a prototype (pilot project) of the upper level, in which the cloud structure and data formats comply with the standards of the WINDOWS operating system and the MSOFFICE package. In this case, to develop a cloud-based information storage system, there is enough knowledge and experience of any computer-literate enterprise manager.

***Key words*:** information system, management, digital economy, cloud technologies.

Formulation of the problem. In the digital economy, there is an urgent need to adapt the existing enterprise management system to the requirements and capabilities of modern Internet technologies. Enterprises whose management for the sake of economy does not switch to a system of paperless information support for the preparation of marketing and production decisions inevitably loses in the speed and quality of making such decisions and loses its position in its target market.

There is a problem of choosing the technology of creating a new one or adapting the existing information system of enterprise management to the conditions of the digital economy. Such a technology should, at minimum cost, ensure the safety of the core of the established debugged management structure and, on the other hand, use all the capabilities of the developed Internet networks. At the same time, it is necessary to take into account a wide variety of enterprise management structures, starting from simple linear to distributed network structures [1].

The selected information support technology should ensure minimal costs for design and operation, a high level of cybersecurity, efficiency of data transmission channels comparable to telephone communications, the possibility of expanding and restructuring the information management structure. The latter requirement is especially relevant when a developing enterprise moves to a more efficient management structure, which is characterized by an increase in the number of elements (divisions) and a complication of the interrelationships between them.

Analysis of recent research and publications. Ukraine has developed a large number of information management systems of enterprises [2]. However, almost all of them are focused on the use of local computer systems of the enterprises without the use of Internet technologies. Some systems use limited informational WEB sites. The main disadvantage of such control systems is the high costs of creating, rebuilding and operating, caused by the need to modernize computer networks and attract professional programmers for each significant modernization.

At the same time, in modern Internet space, various commercial systems are offered that are focused on solving a wide class of information management and processing tasks, ranging from simple information stores to specialized distributed enterprise management optimization systems.

Consider the main advantages and disadvantages of typical information Internet technologies.

The so-called cloud information storage technology allows users not only to store large amounts of their data on remote servers, but also to quickly make changes and synchronize data with the current state of the enterprise. A significant advantage of cloud storage is the relatively low cost of renting online storage, the reliability provided by the storage and restoration of archives, the simplicity of creating and adjusting the structure of the repository, the advanced data protection system, the simple implementation of information relationships with other repositories. Software and technical implementation of these functions is fully provided by the company that provides storage for rent to any users. Examples of such cloud storage can be GoogleDrive, OneDrive, and others [3].

Accumulated over several years of experience in the design and operation of a multi-user Internet system suggests that the disadvantages of cloud storage technology include slowing synchronization with large amounts of data [4]. At the same time, there is a decrease in the efficiency of information processing that is significant compared to the time spent on replenishing and correcting data when using the local servers of the user himself. The value of this disadvantage will decrease when using new communication technologies such as 4G and 5G. As a disadvantage, one can also mention the inconsistency of data formats used in the repositories of different companies with data formats adopted in the most common operating systems and application packages.

Another type of cloud technology is specialized systems of distributed data processing that allow using remote computers not only for storing information, but also for solving computing tasks of users. A complex of user tasks can be distributed among several computers on the Internet. Such cloud computing not only reduces time to solve problems, but also reduces the cost of computing equipment acquired by the user [5]. However, the distribution of computations across several remote computers is economically justified only when using complex mathematical methods for processing information of a large dimension, which is rare in most enterprise management systems.

Formulating the goals of the article. The purpose of this article is to substantiate the choice of such an information system structure, which, with minimal costs for design and operation, will not require a radical restructuring of the existing

hierarchical enterprise management system and at the same time will provide significant advantages compared to more conservative rivals.

Presentation of the main material of the study. Theoretical analysis and long experience in the development and operation of an information system with one large cloud storage allows us to offer a two-level information system universal for any type of enterprise management structure (fig. 1).

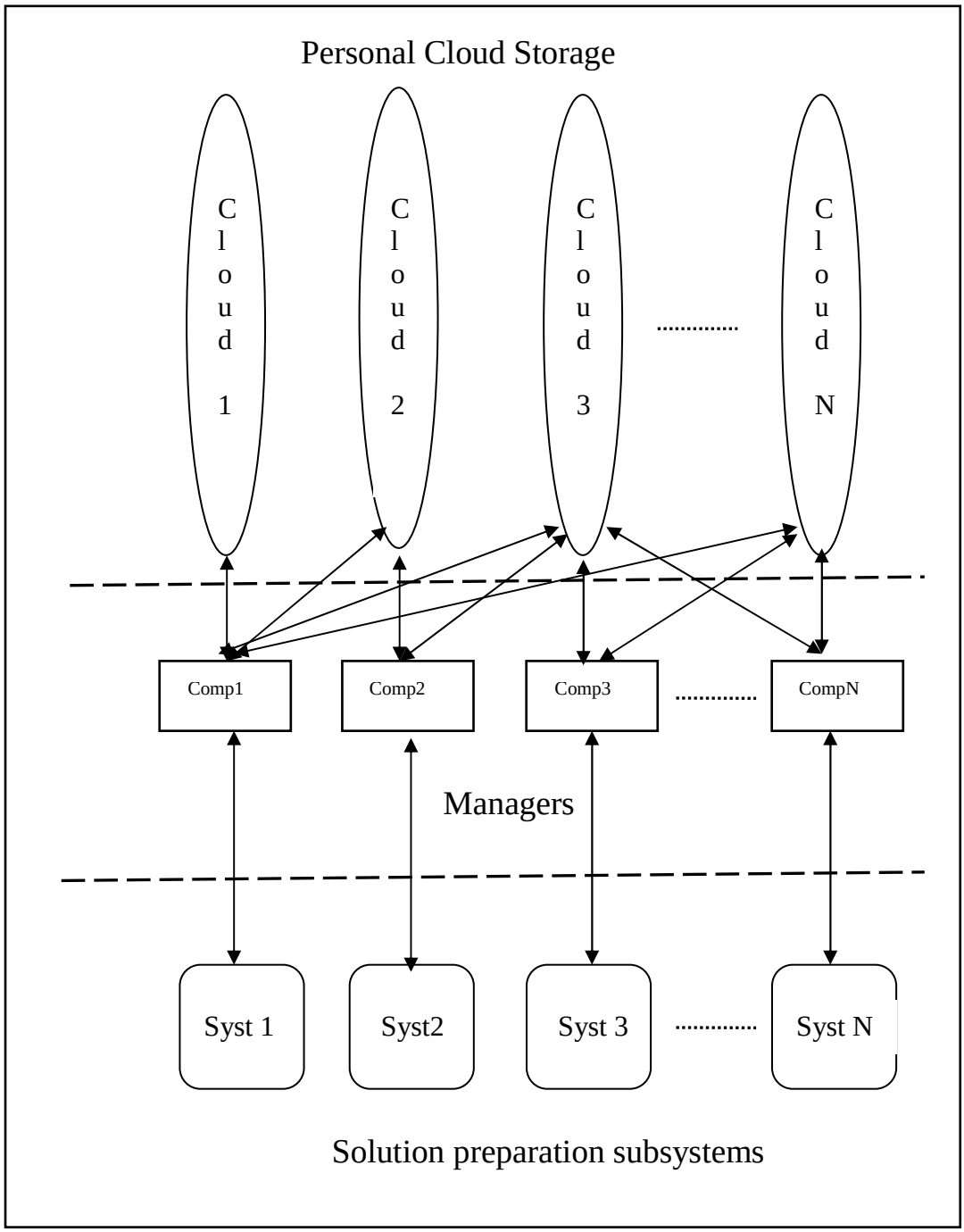

Fig. 1. The structure of a two-tier information system for supporting enterprise management with personalized cloud storages

The upper level is implemented as a network of interconnected personal cloud storages (clouds). The owner (administrator) of a particular cloud is a specific enterprise manager (director, deputy director, head of department, specialist of the department).

Each manager uses his personal computer, which has full access to the corresponding personal cloud through the company's Internet network connected to the global network.

Information communication between the clouds is carried out through the computers of managers. All informational relationships between managers are carried out through their personal clouds. In practice, the task of identifying information relationships between individual clouds is simplified, as in a long-running enterprise management system, management and information relationships between departments have already been established and only change significantly with a rare reorganization of the management structure.

In essence, each connection between the clouds is access to the cloud, which was authorized by the owner of the cloud to the computer of another manager. That is, in order for Manager A to be able to view or edit information in Manager B's cloud, he must receive permission (access) from the Manager B.

The structure of the cloud and its content is uniquely determined by the established range of tasks of a specific manager. Even a change of storage, represented by one company, to another company's storage should not cause significant costs, since the basic principles and functions of such information services are currently of the same type for all companies. Although, of course, overloading large accumulated amounts of data from one storage to another will require some additional one-time investment.

The main advantages of storing information in individual manager clouds should be noted compared to the use of a common cloud for an enterprise.

First of all, a relatively small amount of information with which a particular manager operates can significantly reduce the time required to synchronize data stored in the cloud and in the manager's computer and reduce the bandwidth requirements of Internet channels. In addition, the autonomy of each cloud enhances the cybersecurity of the business information of both a specific manager and the entire enterprise management system.

An additional advantage of personalizing cloud storage for managers is the ability to add or exclude individual units or change their functions in an economically painless way. The small volumes of personal clouds of many managers make it possible to reduce the cost of computing equipment and allows you to use of laptops and tablets instead of more expensive computers with large-capacity drives.

The lower level of the system is implemented in the form of local subsystems for preparing solutions. Each such subsystem is focused on the tasks of an individual manager and can be implemented both by cloud-based tools for distributed information processing and by software packages that run directly on the manager's computer.

It is assumed that the basic information needed to prepare effective solutions is concentrated in the personal cloud of this manager. If necessary, the manager can use information, for example, databases stored in the local computer network of the enterprise, since his computer is included in this network.

Conclusions and perspectives of further exploration. Thus, the main advantages of the considered approach to the creation of an information management system for an enterprise with personalized cloud storages compared to a centralized cloud storage or local computer network are:

- reduction of time spent on synchronization of information between small clouds and users' computers, which increases the efficiency of decision-making;
- increasing the cybersecurity of an individual cloud and the entire system by minimizing connections between the clouds;
- cost reduction and simplification of the restructuring and modernization of the enterprise management structure due to the fact that it is necessary to change individual fragments of the information system, and not the entire system. At the same time, the core, that is, the main, stable part of the system is preserved, and only new managers with their personal clouds are added or the structure, content and interrelationships of manager clouds with changed functions and tasks are adjusted;
- the ability to quickly organize Internet conferences and expert surveys performed by a specific manager;
- the uniqueness of the choice of information stored in the cloud, based on the requirements of the methods and models of forecasting and optimization used by a particular manager in the preparation and evaluation of solution options;
- application of standard technology for information coordination of personal clouds and the corresponding subsystems of solution preparation;
- reduction of requirements for technical devices of processing and transmitting data due to small information volumes of clouds;
- reducing the cost of designing prototypes of the upper level of the information system due to the low requirements for the qualifications of designers.

To realize these advantages, it is necessary to solve a number of basic research tasks during system design. You can use the following well-known methods for solving them:

- to select information into the personal cloud of the manager, it is necessary to perform an expert analysis of the existing technology and information support for the decision-making of this manager. It is possible to use the known methods of expert analysis [6]. Then, according to the results of the expert survey, in order to refine and optimize information support, it is necessary to identify the goals, functions of the manager and the tasks he is solving. At this stage, it is possible to use methods for building a tree of goals [7]. The results obtained should be used when re-expert analysis with the participation of the potential owner of the cloud;
- the next design task is to identify informational relationships between clouds. To do this, you may need to perform a new expert analysis, taking into account the administrative and informational subordination of managers. Formally defining such relationships and minimizing their number can be done using methods and models of graph theory, for example, methods of splitting a graph into subgraphs [8]. Reducing the number and volume of information interconnections between the clouds will reduce the load and, consequently, the cost of Internet data transmission channels. In addition, clouds are protected from cyber attacks;
- when designing the lower level of an information system, that is, the level of decision preparation, the usual problems of choosing methods and models of forecasting and optimization arise. Given the rather stringent requirements for minimizing the cost of renting cloud storage, preference should be given to methods that do not require the use of very large amounts of statistical and accounting information, for example. methods of regression analysis [9]. If such information is generated on the basis of large databases created in the local network of the enterprise, then it should be prepared directly on the manager's computer and then sent to the right cloud.

It is advisable to start designing and testing an information system with the creation of a prototype (pilot project) of the upper level, in which the cloud structure and data formats comply with the standards of the WINDOWS operating system and the MSOFFICE package. In this case, to develop a cloud-based information storage system, there is enough knowledge and experience of any computer-literate enterprise manager who has become familiar with the rules for using an online store of a particular company. According to the results of the pilot operation of the prototype system, you can, if necessary, develop a more automated system in languages like

C++, which, however, will require the involvement of professional programmers and, accordingly, an increase in development costs.

To assess the effectiveness of an information system, it is necessary to take into account the costs of the used Internet resources and determine the quality of decisions made by managers. Since computers and cloud services in the proposed system structure are personalized, then cost accounting should be carried out individually for each manager. Technically, this task is implemented in many existing control systems and even among individual users of Internet services.

To determine the effectiveness of existing information systems, an expert estimate is made of the share of the income of an enterprise that relates specifically to the information system.

Thus, the effectiveness of the *E* two-tier information system for a specific period can be estimated by the following expression

$$E = F\,(S, C, K, A, D), \tag{1}$$

where *S* – the cost of cloud storage of information for all managers, taking into account the amount of each rented personal cloud;

C – the cost of cloud computing performed by all managers, taking into account the performance and lease time of remote computing servers;

K – the cost of the Internet connection used by all managers, taking into account the speed of the channels provided by the provider, and the amount of data transmitted and received;

A – depreciation costs of the enterprise's computing equipment used by all managers;

D – the effectiveness of decisions made by all managers.

The function *F* with high probability is non-linear, since the effectiveness of the decisions of each manager depends on his qualifications and can only be approximately estimated by an expert method. Determining the type of function *F* requires additional research.

For a preliminary approximate estimate of the value of *E*, we can represent the function *F* as a linear convolution of the weighted normalized values of the listed indicators. Normalization is performed, as usual, to bring them to the same scale. And the weights of each indicator are expertly selected in accordance with the administrative level of the manager. The higher this level, the more the efficiency of the decisions taken by him.

It is possible to estimate *E* beforehand using the prototype (pilot project) of the system. By changing the distribution of resources between managers during trial operation, it is possible to improve the efficiency of the system.

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Деякі підходи до створення недорогої інформаційної системи підтримки управління підприємством в цифровий економіці

У статті розглядаються методичні аспекти побудови дворівневої системи управління інформацією підприємства, заснованої на хмарної технології зберігання інформації. Основними недоліками існуючих систем управління інформацією підприємств України є те, що майже всі вони орієнтовані на використання локальних комп'ютерних систем без застосування інтернет-технологій. Такі системи управління мають високі витрати на створення, розбудову і експлуатацію, викликані необхідністю модернізації комп'ютерних мереж і залученням професійних програмістів при кожному вдосконалення структури управління.

Так звана хмарні технологія зберігання інформації дозволяє користувачам зберігати велику кількість своїх даних на віддалених серверах, а також швидко змінювати і синхронізувати дані з поточним станом підприємства. Значною перевагою хмарного зберігання є відносно низька вартість оренди інтернет-сховища, надійність, забезпечена автоматичним створенням і відновленням архівів, простота розробки і налагодження структури сховища, вдосконалена система захисту даних, проста настройка інформаційних зв'язків з іншими сховищами.

Теоретичний аналіз і накопичений багаторічний досвід розробки та експлуатації багатокористувацької інтернет-системи показує, що істотним недоліком технології хмарного зберігання є уповільнення синхронізації при великому обсязі сховища. В результаті спостерігається значне зниження ефективності обробки інформації при поповненні та коригування даних. Для усунення цих недоліків доцільно створювати дворівневу

інформаційну систему, універсальну для будь-якого типу структури управління підприємством. Верхній рівень реалізується як мережа взаємопов'язаних особистих хмарних сховищ. Адміністратором хмари є конкретний менеджер підприємства (директор, заступник директора, начальник відділу, спеціаліст відділу). Кожен менеджер використовує свій персональний комп'ютер, який має повний доступ до хмарі через інтернет-мережу компанії, підключену до глобальної мережі. Нижній рівень системи реалізується у вигляді локальних підсистем для підготовки рішень. Кожна така підсистема зосереджена на завданнях відповідного менеджера і може бути реалізована як хмарними інструментами для обробки розподіленої інформації, так і програмними пакетами, які працюють безпосередньо на комп'ютері менеджера. Для відбору інформації в приватну хмару менеджера необхідно провести експертний аналіз існуючої на підприємстві технології інформаційної підтримки прийняття рішень. Наступним завданням є визначення інформаційних зв'язків між хмарами. Для цього може знадобитися провести новий експертний аналіз з урахуванням адміністративного та інформаційного підпорядкування менеджерів. Формально визначення таких зв'язків і мінімізацію їх кількості можна зробити за допомогою методів і моделей теорії графів, наприклад, методів розбиття графа на підграфи.

Доцільно починати проектування і тестування інформаційної системи з створення прототипу (пілотного проекту) верхнього рівня, в якому структура хмарності і формати даних відповідають стандартам операційної системи WINDOWS і пакета MSOFFICE. В цьому випадку для розробки хмарної системи зберігання інформації достатньо знань і досвіду будь-якого комп'ютерно-грамотного менеджера підприємства.

Ключові слова: інформаційна система, управління, цифрова економіка, хмарні технології.

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Некоторые подходы к созданию недорогой информационной системы поддержки управления предприятием в цифровой экономике

В статье рассматриваются методологические аспекты построения двухуровневой информационной системы управления предприятием, основанной на облачной технологии хранения информации. Проанализированы основные достоинства и недостатки существующих реализаций облачного хранения информации и облачных вычислений. Показаны преимущества организации верхнего уровня системы управления в виде набора персональных хранилищ (облаков), каждое из которых администрируется одним из менеджеров предприятия. Рассмотрены основные задачи необходимых научных исследований, возникающие при проектировании такой системы, и возможные пути их решения. Даны предложения по организации проектирования и техническому обеспечению системы, позволяющие существенно снизить затраты на разработку.

Ключевые слова: информационная система, управление, цифровая экономика, облачные технологии.