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СТРУКТУРНА МОДЕЛЬ ПОБУДОВИ ХМАРНОГО СЕРВІСУ

STRUCTURAL MODEL FOR BUILDING CLOUD SERVICES

АНОТАЦІЯ. Хмарні обчислення на теперішній час є основним трендом у галузі ІКТ. При побудові та використанні хмарних сервісів виникає необхідність прийняття значної кількості технічних і управлінських рішень. У статті досліджено теоретико-методологічні підходи до визначення суті та особливостей планування та проектування хмарних сервісів, описано їх формалізовану модель.

КЛЮЧОВІ СЛОВА: хмарні обчислення, модель, хмарні сервіси, компоненти хмарних обчислень, інформаційні технології, бізнес-процеси.

АННОТАЦИЯ. Облачные вычисления в настоящее время является основным трендом в области ИКТ. При построении и использовании облачных сервисов возникает необходимость принятия значительного количества технических и управленческих решений. В статье исследуются теоретико-методологические подходы к определению сущности и особенностей планирования и проектирования облачных сервисов, и описывается их формализованная модель.

КЛЮЧЕВЫЕ СЛОВА: облачные вычисления, модель, компоненты облачных вычислений, информационные технологии, бизнес-процессы.

ABSTRACT. Cloud computing is a major trend in the ICT industry. When building and using cloud services, it becomes necessary to make a significant amount of technical and management decisions. The article explores theoretical and methodological approaches to defining the essence and features of planning and designing cloud services, and describes their formalized model.

KEYWORDS: cloud computing, models, components of cloud computing, information technologies, business processes.

Problem statement. The rapid development and distribution of cloud computing is one of the key trends, that in the next 5-8 years will noticeably affect the global development of the IT industry and in the areas of business, finance, public administration, medicine, education, and many other areas of human life. In the construction and use of cloud services there is need for a large number of technical and managerial decisions. The task is complicated by the quantitative and qualitative development of a new paradigm and has led to the need to consider them as complex information systems, which may include thousands of users and contain hundreds of thousands of distributed elements to support dynamic scaling using communications and computing services, interact with other information systems. Many existing technologies allow the development of cloud services of different scale and functionality. From the totality of decisions depends the quality of cloud services and the value of the cost of its development and operation. Thus, there is a clear relevance of the study of the economic side of the processes of comparison, selection and use of cloud services in the activities of enterprises and organizations.

Analysis of recent research and publications.

International research and consulting firm IDC believes that cloud computing paradigm – is the foundation for the development of corporate information systems, and they will be the main driver of the market of information technologies, both in the world and in certain countries [1].

According to IBM employees, cloud services are applications for business automation, distributed by the SaaS model (software as a service), or by other models, through public clouds and accessible to a wide range of customers at an affordable price [2].

Researchers Keiko Hashizume, Eduardo B. Fernandez and Maria M. Larrondo-Petrie in their work say that the PaaS (Platform as Service) model offers virtual cloud environments for collaborative tools and libraries for cloud development and implementation. PaaS uses the IaaS model (Infrastructure as a service) as the basis (servers, memory and network). In this case, the PaaS model hides the complexity of IT infrastructure management [3].

Transfer of basic services and applications to the cloud created new requirements for the development of productive software. Cloud concepts and technologies provide development of software development environment "cloud to cloud", because they can easily provide enough computing resources to develop and test code, support for collaborative developer systems that is key to developing software applications [4].

At present, cloud computing is recognized as the dominant computing model in IT infrastructure, providing a flexible, universal and cost-effective access to a wide range of shared resources. Thus, having considerable practical interest, research problem of construction and operation of cloud services is relevant and requires special attention.

The purpose of the article. The article aims to justify the theoretical and methodological approaches to determining the nature and characteristics of building a cloud service, the creation of their formalized model.

Modern cloud services are complex dynamic information systems that include a large number of different components. Research of planning and design of cloud services requires the use of modeling techniques.

The main research material.

Cloud service (as defined by ISO/IEC 17788:2014) – is one or more of the features offered via cloud computing caused by using a particular interface. When constructing and operating cloud services, you have to deal with a number of factors: a large number of service components; a large number of users; the influence of various random factors on the functioning of the service; a large number of technologies and software used for its construction; inclusion of services in various business processes of organizations.

"Cloud services" can be represented as a multilayer model consisting of layers (levels of virtualization): IaaS, PaaS, SaaS.

- IaaS level – virtualization of the hardware level and various computing resources (processor, RAM, disk space). Resources are allocated on demand and paid on time consumption;
- PaaS level – developers are offered the environment for developing, testing and deploying their applications, which can include various base software, horizontally and vertically scalable tools, load balancing capabilities, and more. Level PaaS uses virtual resources and resource management tools of IaaS. At one level of virtualization of IaaS can be deployed several PaaS solutions;
- SaaS level consists of simple or composite services (services) that are offered to end-users. The model data applications deployed through PaaS platforms.

Each level in accordance with the basic properties of cloud computing includes management tools provided resources and applications. Consider the case where IaaS, PaaS, and SaaS levels belong to different business process participants. In this case, each level will only use the resources and applications of the lower layer in the closed architecture mode. Due to differences in business goals, each layer will have different optimization goals, criteria and mechanisms.

Let's consider the main goals of the SaaS business process participant, as well as the available optimization tools and optimization criteria, see table 1.

Table 1

THE MAIN OBJECTIVES OF THE SAAS SERVICE DELIVERY PROCESS

Level	Business Goals	Criteria for optimization
SaaS	Support for a given level of service quality Reduce the cost of PaaS resources	The level of customer service quality Spending on PaaS resources per client
PaaS	Increase profits from the platform	The level of effective loading of virtual machines SaaS Quality of Service The cost of basic software licenses
IaaS	Efficient hardware downloads	The level of efficient loading of resources (processors, RAM, hard drives) Level of service quality PaaS

Each layer reflects the main economic interests of the owner - increasing profits or increasing satisfaction of end users of services. For owners of the data center, the level of income depends largely on the amount of consumed computing resources and capital and operating costs for these resources. In this regard, the main task of optimization is to minimize the number of equipment when servicing PaaS-level requests in terms of providing contractual obligations to provide a set of network and computing resources [2].

The IaaS level has the means to monitor downloaded information, availability and location of resources, both for hardware and for virtual machines (VMs). The main means of optimization of IaaS is the redistribution of computing power and storage space for the VM.

PaaS-related revenues are associated with SaaS applications and services hosted by developers: consumable resources and software licenses. The PaaS provider pays the resources provided by the IaaS level (virtual machines, disk space, data networks), the cost of third-party licenses (for example, application servers or databases) and violation of service level agreements (SLA).

In this regard, the main business objectives of the PaaS level are: increasing the load on the platform from SaaS application developers; minimization of used computing, disk and network resources; minimizing penalties for performance of the SLA.

For SaaS owners, the revenue level typically depends on the number of end-users and / or the one-time use of the application, such as billing service. Expenses, in turn, include the payment of resources and capabilities of the PaaS level (in terms of use or in accordance with the agreement).

SaaS has the ability to control the quality of service provision (QoS) in order to optimize according to their own tasks. Depending on the type of service provided, various QoS parameters can be used, for example, the response time for the user's request.

As a result of studying the goals, criteria and means of optimization, one can single out a common point, the only one for all participants of the business process – is to support a given level of quality of the service provided.

Analysis shows that each cloud service SaaS can be conventionally split into n independent functions $F_i, i=\overline{1,n}$. Performing each function F_i on the SaaS end-user request requires a certain amount of PaaS-level resources $Rpaas_i, i=\overline{1,l}$ for specified time intervals Tf_{1i}, l.

As resources means the virtual computing power provided to the application container at the PaaS level, for example: processor resources of different platforms on request; the amount of memory of different platforms on request (these resources have physical limitations for one container); disk space and disk operations for databases and ordinary data warehouses; network resources on request (internal and external), etc. Separately, licenses for software platforms of the PaaS level can be allocated, which will be taken into account depending on the topology of the cloud service, see. Fig. 1

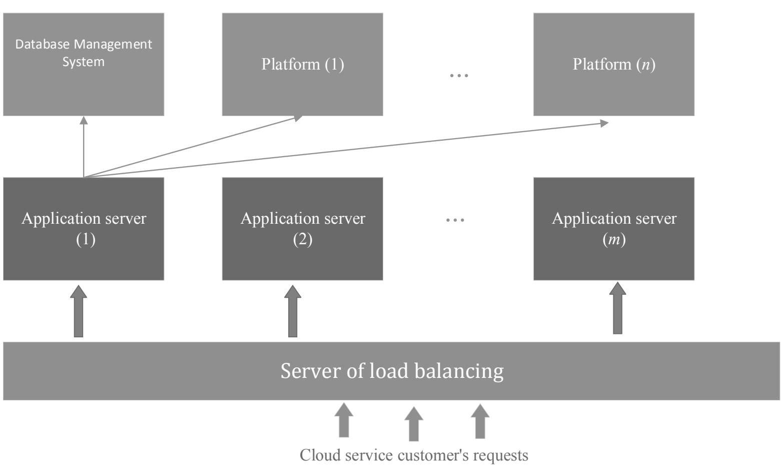

Fig. 1 Topology of cloud service

Cloud services can be created on the basis of cloud-based solutions from Amazon EC2, IBM x86, Microsoft Azure, EMC, VMware, openSource based OpenStack solutions, RackSpace based on OpenStack, etc., which enable the processing center to be transformed into a dynamic IT environment.

PaaS offers software developers the means of developing, testing, deploying and supporting various applications. In addition, the user is provided with tools for administration and management. Basically, PaaS is used to design and deploy related distributed cloud services (for example, SaaS mashup, "cloud" sites, etc.).

Consider the formal statement of the problem of building a cloud service. To do this, you need to represent different aspects of cloud services in terms of the theory of sets.

Cloud services can be viewed as a set of the form:

$$\mathbf{CA} = \langle \mathbf{M}, \mathbf{P}, \mathbf{CT}, \mathbf{R}, \mathbf{MC} \rangle \tag{1}$$

where:

M – a model of cloud service, which describes in general form its purpose and content;

P – a service project that describes its structure and components;

CT – a set of "cloud" technologies and models used to create a "cloud" service;

R – implementation of the service;

MC – a component that characterizes the use of cloud service and monitoring of its activities.

The components of the set generally correspond to the stages of the process of building a cloud service, similar to the stages of building a software application [2]. Each of these components characterizes the completion of one of the stages, presenting its result. Consider a more detailed model of cloud service.

The cloud service model is a collection of:

$$\mathbf{M} = \langle \mathbf{Tq}, \mathbf{Aud}, \mathbf{BP}, \mathbf{CM}, \boldsymbol{Stat} \rangle \tag{2}$$

which shows its purpose and place in the activities of the client company. The model may represent an existing service, a proposed variant of its development, or a new cloud service. Consider the components of the "cloud" service model.

The set:

$$\mathbf{Tq} = \{\mathbf{Tqi}\}, \mathbf{i} = \overline{\mathbf{1}, \mathbf{Ntq}}$$

describes the set of goals of "cloud service". Examples of such goals can be: "Increasing the level of product sales"; "Reducing labor costs for software development", "Informing about academic achievements of the university", "Simplifying the management of a bank account online", etc.

Each goal may contain some set of sub-targets (for example, "attracting young people to a brand" or "automated collection of tickets for a performance"), which, in their turn, may have the following objectives:

$$tq_i^{h-1} = \{tq_{ij}^h\},\ j = \overline{1, Ntq_i^h}$$

Thus, a tree of cloud service goals is formed, which determines a large extent of the other components of the model and applications. Note important feature of the "cloud" services. Within this model, it is the owner of service targets or "cloud", which may differ from the goals of its users. Harmonization and satisfaction of the goals of many participants is a prerequisite for the success of the project. The result is largely achieved through the activity of users of various categories, the possibility of feedback with them increases the value of the service for other users and its efficiency from the owner's point of view, and increases profits.

To do this, users also need to be addressed and satisfied. At the next stages of building a "cloud" service, after conducting relevant research, a lot of participants are added with their evaluation criteria.

The set that describes the audience of a cloud service and its use is as follows:

$$\mathbf{Aud} = \langle\{\mathbf{Auds_i}\}, \{\mathbf{Fn_j}\}, \{(\mathbf{Auds_l}, \mathbf{Fn_h})_\mathbf{k}\}\rangle$$

where,

$\{Auds_\mathrm{i}\}, \mathrm{i} = 1, \overline{\mathrm{NAuds}}$ – this is the set of roles of users of the service, for example: "Marketer", "Internet store moderator", "Buyer" (one user can act in several roles).

$\{\mathrm{Fn}_j\}, \mathrm{j} = 1, \overline{\mathrm{NFn_j}}$ – describes in the most general form the function of "cloud" service.

$\{(\mathrm{Auds_i}, \mathrm{Fn_h})_\mathrm{k}\}), \mathrm{k} = 1, \overline{\mathrm{NAudF}}, \mathrm{l} = 1, \overline{\mathrm{NAuds}}, \mathrm{h} = 1, \overline{\mathrm{NFn}}$ – defines the user's appeal of a particular category to a certain cloud service function.

The next component of the model determines the extent to which cloud service is involved in business processes in an organization:

$$BP = \langle\{BPr_i\}, \{O_{uv}^u\}, \{(BPr_l, O_h^l, lv_j)_k\}\rangle$$

where:

$\{BPr_i\}, i = \overline{1, NBP}$ – many business processes of the organization to which the cloud service will have a direct or indirect effect;

$\{O_{uv}^u\}, u = \overline{1, NBP}, v = \overline{1, NO^u}$ – a set that describes the operations of these business processes;

$\left(BPr_l, O_h^l, lv_j\right)$ - shows how the cloud service affects the operation $O_h^l, h = \overline{1, NO^l}$, of business process $BPr_l, l = \overline{1, NBP}$.

lv_j ∈ LV shows the level of cloud service usage when performing an operation. Many of these levels can be described, for example, as follows:

$$LV = \{Lv, Lv2, Lv3\},$$

where: Lv_1, – "The service supports the operations";

Lv_2 – "Operation is performed through cloud service";

Lv_3 – "The business process is fully perfomed within the cloud".

The model can be expanded by specifying the performers of each operation and identifying the components of the cloud service involved in the operation, cloud layers, etc. The considered aspect is now becoming of increasing importance.

Cloud services, especially in the SaaS model, are increasingly becoming a means of improving business organization processes. Cloud computing is to: reduce labor costs for the operations of the business process; reduce the number of errors; allow participation in business processes representatives of partners and remote employees; reduce the value of geographical factors in the organization of the business process, significantly reduce the capital costs of the organization. Therefore, consideration of business processes in the planning and design of cloud services is necessary.

In this case, visual models of processes performed by the cloud, can serve as the basis for the formation of simulation models of cloud services, which allow to estimate the cost of different variants of the construction of the service [5].

The conceptual model of cloud service can be represented as follows:

$$\mathbf{CM} = \langle \mathbf{S}, \mathbf{A}, \mathbf{Rl}, \{(\mathbf{rl_k}, \mathbf{s_i}, \mathbf{s_j})\mathbf{k}\}\rangle \quad (3)$$

where S $=\{s_i\}, i = \overline{1, Ns}$, – set of domain objects, represented by a cloud service, for example: "Contractor", "Account", "Client", "Product".

The set A $=a_j^i, i = \overline{1, Ns}, j = \overline{1, Nsa^i}$ – describes the attributes of entities.

The set Rl $=\{rl_k\}, k = \overline{1, Nrl}$, – describes the relationship between entities, and the set of elements of the type $(rl_k,s_i,s_j)_k$ connects attitude and essence.

The traditional means of presenting a conceptual model is ER-Diagrams. A conceptual model is defined by the goals and objectives of the cloud service, it shows what information will be collected or provided during the operation of the service. Conceptual model used to design schemes databases and data warehouses of cloud service and to build its navigation model interface and design components.

Along with other components, the conceptual model allows you to estimate the scale of the cloud service and the amount of work required for its construction and support.

A set of statistical indicators STAT $=\{stat_i\}, i = \overline{1, Nstat}$, characterizes the quantitative parameters of an existing or created cloud service. Such indicators are, for example: "Number of users per day" (existing or predicted), "Number of services in the directory", etc. Statistical characteristics influence the project of cloud service and to a large extent determine the requirements for the selection of service models and development technologies.

The feature of cloud service is the ability to separate to a certain extent the project from the means of its implementation. One and the same result (in terms of content and functionality) can be achieved using technologies of different levels, different operating principles and based on different cloud models.

The complex of cloud technologies and CT models defines the selected set of technologies (platform) for the implementation of the cloud service. The choice is determined on the one hand by the model and the project of cloud service, and on the other – for technical and economic reasons.

The Target Function uses the Total Cost of Ownership, the total cost of ownership of the cloud service. The TCO model includes the following components: cost of renting cloud resources; the cost of training developers; labor costs for the construction of the service;

labor costs for service operation; labor costs of users to work with the service. [3]

Each set of technologies requires different labor costs for the development and development of its components of the service. The use of certain technologies requires different expenses for the use of the cloud. Effectiveness of achieving the goals with different cloud technologies and deployment models is also different.

Conclusions

The formalized model reflects the different aspects of the cloud service, defines its components and links between them. The model components are grouped into blocks describing the "core" of a service, a project, a set of technologies, implementation and operation. When designing a project and choosing technologies alternatives are compared on the criterion of economic efficiency. The formalized model will allow us to formulate tasks that arise in planning, designing and implementing such a service.

The use of a complex of economic and mathematical models allows us to make informed decisions from the economic point of view on the creation, design and operation of cloud services. To solve the problem of choosing technologies for the creation of cloud services, it is possible to effectively use the method of selecting complex systems, although this requires its improvement and adaptation, which is the subject of further research.

Study cloud services and cloud computing paradigms like economic phenomena is important not only because they are a powerful resource efficiency of enterprises and individual companies, but also for reasons of their origin is an important indicator of the development of the information society.

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