§ 3 АВТОМАТИЗАЦИЯ ПРОЕКТИРОВАНИЯ И ТЕХНОЛОГИЧЕСКОЙ ПОДГОТОВКИ ПРОИЗВОДСТВА

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CREATING THE TOPOLOGICAL CAD-SYSTEM ON BASED OF THE CORPORATE CLOUD

Abstract: *The article deals with the issues related to the users' access to the system of topological PC board layout without buying the license for the system because the price of the license may reach dozens or even hundreds of dollars which is not of economic benefit to the majority of developers. This leads to the growing popularity of cloud technologies that allow to get access to the design systems based on inexpensive licenses. Thus, the authors of the present article analyze different services of cloud CAD and define the most popular services. Then the authors compare different kinds of CAD PC board layout and offer to use Topological Router as the topological router created on the cloud. According to the author, Topological Router has the most beneficial features. In addition, the authors define the platform for deploying the cloud. The main research method used by the author is the comparative analysis of parameters and features of CAD PC boards and cloud deployment platforms. The scientific novelty of the research is caused by the fact that so far there haven't been any practical implementation of WEB-oriented PC board design systems. The test case of the corporate cloud on the basis of the VMware platform has proved it possible to use cloud technologies in creating public access to the topological CAD. To deploy the full function corporate cloud and provide access to virtual CAD through web-interface it is necessary to install the additional server VMware vCenter Server 5.5.*

Keywords:*CAD, PC board layout, cloud technologies, topological router, 'TopoR' CAD, VMware ESX Servr, public cloud, corporate cloud, vendor cloud, selection factors*

Аннотация: *Рассматриваются вопросы организации доступа пользователей к системе топологического проектирования печатных плат без приобретения лицензий на соответствующую систему, так как в настоящее время стоимость такой рабочей лицензии может составлять десятки и даже сотни долларов, что ряду разработчиков экономически становится невыгодно. В этой связи начинают широко использоваться средства облачных технологий, при которых доступ к системам проектирования обеспечивается за счет облегченных недорогих лицензий. В этой связи в работе анализируются различные*

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сервисы развертывания облачных САПР и выявляются наиболее востребованные сервисы. Далее проводится сравнительная характеристика различных САПР проектирования печатных плат и в качестве топологического трассировщика, устанавливаемого на облаке предлагается использование Topological Router, характеризующегося лучшими на настоящий момент характеристиками. Кроме того выявляется платформа для развертывания облака. В качестве основной методики выполняемой работы используется сравнительный анализ параметров и характеристик как систем САПР печатных плат, так и различных платформ развертывания облака Научная новизна исследования заключается в том, что до сих пор не выполнялись работы по установке WEB-ориентированных систем проектирования печатных плат.Тестовый вариант корпоративного облака на основе платформы VMware показал возможность использования облачных технологий для организации режимов коллективного использования топологической САПР. Для развертывания полнофункционального варианта корпоративного облака и обеспечения режима доступа к виртуальной машине САПР через web-интерфейс необходима установка дополнительного сервера VMware vCenter Server 5.5.
Ключевые слова: *САПР, трассировка печатных плат, облачные технологии, топологический трассировщик, САПР "TopoR", Сервер VMware ESX, публичное облако, корпоративное облако, вендорное облако, факторы выбора*

Introduction

Modern methods of designing of analog and digital electronic circuits are fully focused on thorough usage of CAD in all stages of development, from the stage of receiving and analyzing device concepts to the stage of topological design. The greatest effect from the use of CAD is achieved at the final stage of designing the printed-circuit board layout or integrated circuit topography. Modern integrated CAD software in the field of electronics (EDA – Electronic Design Automation) with a subsystem topological design is widely represented on the world market [1]. Among the most widely used EDA it should be noted software from overseas companies Cadence, Mentor Graphics, Zuken, Atium and Synopsys, offering design tools of VLSI circuits, including SoCs. Altium Designer, which inherits the technologies of P-CAD system, is very popular on the Russian market . TopoR and SimOne systems are successfully developed by Russian developer company "Eremex" [2].

It should be noted the high cost of licenses for the use of CAD in design activity (from several tens to hundreds thousand dollars), which makes the purchasing and installation of EDA systems at each workplace unprofitable. One possible approach to solving this problem is the deployment of enterprise corporate cloud and shift to the cloud enterprise EDA systems available for the company with the possibility of shared access to cloud services. Using this approach we can limit the minimum necessary number of licenses, in addition some companies offer lighter mode of licensing when using CAD in the cloud.

Services to deploy cloud-based CAD

Source [3] gives the following definition of cloud computing: "Cloud computing" is a model of providing ubiquitous and convenient on-demand network access to shared pool of configurable computing resources (for example networks, servers, storage, applications and services both together and separately) that can be rapidly provided and released with minimal operating costs and/or appeals to the provider. Cloud computing clients can significantly reduce the infrastructure costs of information technology (in the short and medium term) and can respond flexibly to changing of computational needs using the computational elasticity (elastic computing) of cloud services.

The main features of cloud computing technologies:

– distributed virtualized infrastructures. Known virtualization technologies allow you to congregate servers, storage systems, data etc. into shared pools in order to use them more effectively. The pools are elastic, you can take as many resources as you need and when the need disappears, you can return taken resources back;
– access using the services. Authorized users can reserve and operate the required resources through the portals;
– focus on the user. The internal mechanics of the cloud is hidden from the client, who sees only what he needs, and knows nothing but the interface;
– the user pays for the resources he used, and the provider tracks the use of resources to improve their performance.

In the present time the concept of cloud computing includes the provision of different types of services to its users [4]. From a diverse set of desired services ***Enterprise Cloud Computing Ecosystem*** develops, which is currently the basis in the evolutionary development of corporate platforms. Currently there are three categories of "clouds" [4]: ***public***, corporate, and ***hybrid***.

Public cloud is an IT-infrastructure, which is used simultaneously by many companies and services. Users of these clouds do not have the ability to manage and maintain this cloud, the owner of the cloud has the entire responsibility for these matters. Any company or individual user can be a subscriber of the offered services. They offer an easy and affordable way to deploy web sites or business systems with large scalability, that would not be available with other solutions. Examples: online services Amazon EC2 and Simple Storage Service (S3), Google Apps/Docs, Salesforce.com, Microsoft Office Web [4].

The ***enterprise cloud*** is a secure IT infrastructure, that is controlled and operated in the interests of one (and only one) organization or a group of similar companies. The organization can manage the private cloud by itself or entrust this task to an outside contractor. Infrastructure can be hosted either in the client premises, or at an external operator, or partly at the client and partly at the operator. The perfect version of the cloud is when it is deployed on the territory of the organization and served by and controlled by its employees.

Hybrid cloud is an IT infrastructure that uses the best features of public and corporate clouds when solving problems. This type of cloud is often used when the organization has seasonal periods of activity, in other words, when the internal IT infrastructure cannot cope with current challenges, some computing power is taken from the public cloud. This arrangement

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also provides the user access to enterprise resources (enterprise cloud) through a public cloud.

The use of cloud technologies in CAD at the moment is limited, but according to experts the potential of cloud computing is very high. Given the specificity of the computer-aided design problems and a large size of graphical applications, we can assume that the most popular services in CAD will be:

- infrastructure as a service ***IaaS***;
- software as a service ***SfaaS***;
- data as a service ***DaaS***;
- security as a service ***ScaaS***.

Combinations of different services and service providers can create the following categories of clouds CAD [5]:

– ***public cloud CAD.*** The owners of clouds in this case will be an international companies promoting their own universal platforms for hosting cloud services and providing them on rent for deployment of the CAD system. The service consumer is the owner of the license and independently moves separate CAD subsystems in the cloud;
– ***corporate cloud CAD.*** The operator of CAD independently deploys the cloud on one of the instrumental platforms and creates the infrastructure for CAD on the Internet. All maintenance and operation of the cloud are fulfilled by IT specialists of the company or guest specialists;
– ***vendor cloud CAD.*** This type of cloud can be created by a large companies, that develop integrated computer-aided design (vendors). Instead of buying expensive licences users can rent CAD in the cloud for a certain time. The payment for rent of the CAD can be rated by elapsed time. Additionally, the user can store project data in the cloud.

The table below presents possible future applications of cloud technology in the field of computer-aided design.

The option of constructing cloud CAD	Owner of the cloud	User of the cloud	Cloud services				
			IaaS	***SfaaS***	***DaaS***	***WaaS***	***ScaaS***
Public cloud	Global IT companies	The company that is the holder of a licence for CAD	+	-	+	-	+
Corporate cloud	The company that is the holder of a licence for CAD	The company that is the holder of a licence for CAD	-	+	+	-	-
Vendor cloud	Firm that develops the CAD	The company that rents the CAD	-	+	+	+	+

It should be noted that in case of necessity to use high performance server hardware to solve large-scale problems, it is possible to use the cloud services – hardware as a service ***HaaS***.

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The choice of topological CAD

The domestic system of topological trace "Topological Router" ("TopoR") of the company "Eremex" [2] was chosen to test the deployment of enterprise cloud CAD. This system has a number of advantages in comparison with the tracers of printed circuit boards, which is based on the traditional orthogonal algorithms. In addition, this system has a free trial version, which was used as the base CAD system.

The choice of this system was determined also by the fact that systems that use traditional algorithms has a number of disadvantages, the main of which are:

– the rectangular grid, which nodes are determined by the geometric parameters of the smallest elements of a topology and in which each component, the transitional hole or conductor is represented by a set of rectangular discretes.

The complexity of modern electronic circuits operating at low currents (signals), the use of chips of high integration with a large number of external outputs (LSI), a variety of geometric sizes of the components of the circuits and increased density of their placement on printed circuit boards result in the need to significantly reduce the width of routes. In this regard, you need to reduce the size of the grid necessary for the routing. This, in turn, leads to quadratic growth in the number of nodes in this mesh, which means a corresponding increase of the required computer memory and the solution time. We can increase grid pitch in order to save computer memory and speed up finding solutions. However, in this case, the switching space is wasted, because the width of the signal routes is much smaller than a discrete space, which is allocated for them. Additional problems with the definition of the grid parameters and allocation of memory for it arise from the presence of different pitches on board, and in the case of extra vias to provide interconnection;

– orthogonality of the wiring, due to the squareness of the grid representation of switching space and routing algorithms. Where the conductors would have to go along an inclined straight line or a curve, skirting blocks on their way, they drawn with broken lines with angles of 45 and 90 degrees. In such a case the majority of the board conductors are parallel to each other. Orthogonality leads to a significant increase in the length of routes (sum of two sides is longer than the hypotenuse) and, therefore, unsustainable use of the switching space. The reflection effect in the zone of conductor rotation attenuates the useful signal, and the parallel routes lead to an increased crosstalk, which limits the frequency of operation of the device. In addition, the probability of exfoliation of the corner sections of the conductors from the substrate increases during the temperature influences on the circuit board;

– the rigidity of the routing defined by the fact that the strip conductors are carried out sequentially. At the same time the requirements of the conductors that have not yet been laid are not taken into account. After the strip, the shape of each conductor is fixed, and when seeking for the following routes you cannot automatically change the shape of routes that already laid, move a slice or move to another layer, etc. Therefore, each routed connection becomes an obstacle for subsequent routes, turning it into a

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maze. Regions of locked contacts (particularly planar) appear because of this, even if there is some free space. In order to reduce such negative effect, there is a recourse to a special measures, such as placement of stringers (short sections of conductors connecting contact area and the transitional hole). They, in turn, increase the stiffness, locking the direction of approach of the route to contacts and complicating the maze. All these measures lead to inefficient use of PCB area, increase the complexity of their production, cause delays of the transmitted signals and reduce the overall reliability of the circuit boards.

The topological tracer "TopoR" are free from all these shortcomings. It splits the board working area into triangles, the vertices of which are nodes in which the contacts of the components are located. Using such a grid we have a mach less nodes, and it consequently requires less memory, but performance increases tenfold. This provides significant freedom in choosing the geometrical parameters of routes within each triangular region (inside macrodiscrete). "TopoR" does not fix the physical position of each conductor within macrodiscrete at the initial stage, which eliminates the contradictions between such conductors, and it fixes the interlayer position of the transition on the conductor with accuracy only between two adjacent intersections. In addition, the layer is not fixed for conductors that do not intersect with others.

Comparison of traditional (orthogonal) and topological tracers by all objective measures shows a significant superiority of the latter. Such comparison criteria in absolute compliance with all technological restrictions that determine product performance and in normal temperature conditions and electromagnetic compatibility, first of all, should include:

- efficient use of board area;
- the number of layers used in the routing;
- the total length of conductors;
- the number of violations of technological norms;
- the percentage of undrawn lines;
- the number of additional vias;
- the drawing time.

The advantages of the system "TopoR" also allow to lower requirements to hardware platform when migrating CAD to the cloud.

Platform for deploying the cloud

VMware ESX Server was used as a virtualization tool when building enterprise cloud CAD, which is an embedded hypervisor and runs directly on the server platform, without requiring additional operating system [6].

VMware VSphere client was used to manage the virtual machines, which was installed on the client computer. With the VSphere client, you can open the console on the desktop of managed virtual machines. Using the console you can modify the operating system settings, run applications, browse the file system, monitor system performance, etc., as if the work was carried out with the physical system. You can also use the copy of the current state of the entire

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virtual machine. You must connect the VSphere client directly to the server to work only with virtual machines and physical resources of the ESX/ESXi server. You must use vCenter server to manage physical resources of multiple servers.

The main factors that influenced the choice of VMware virtualization:

- VMware ESX/ESXi 5.0 provides the most compact system and takes just 70 MB of disk space;
- scalable infrastructure supports 255 GB of RAM for virtual machines and up to 1TB RAM for large-scale server consolidation and data disaster recovery;
- each VMware ESX/ESXi supports up to 256 virtual machines;
- the data storage system adds and expands virtual disks without interrupting the running virtual machine to increase available resources. The functions of the storage management client vSphere provide customizable reports and topology maps;
- for high availability and disaster recovery VMware ESX provides the API for data protection vStorage - backup proxy-server, which relieves load from VMware ESX/ESXi and performs full and incremental backup at the file level;
- functions to ensure VMware high availability and fault tolerance eliminate downtime, data loss and ensure continuous availability during physical server failures with VMware Fault Tolerance;
- vCenter Server as part of VMware serves as the center of virtualization management and is a scalable and extensible management server for administering infrastructure and application services with deep review of all aspects of virtual infrastructure. vCenter Server supports alerts, performance graphs, and one vCenter Server can manage up to 300 hosts and 3000 virtual machines. In addition, you can manage up to 10,000 virtual machines from a single console in the Linked Mode. Multiple vCenter Server systems can be combined in a vCenter Server Connected group to manage them through a single channel of vSphere Client.

With vSphere Client VM manager you can:

- edit settings of start and stop of virtual machines;
- to access the virtual machine console;
- to add and remove virtual machines;
- use a copy of the current state for managing virtual machines;
- manage the existing copies of the current state;
- restore copies the current state;
- to convert a "thin" virtual disks into "thick";
- to view existing hardware configuration and execute the Add Hardware wizard to add or remove hardware;
- to view and configure the properties of the virtual machines, such as power management, the interaction between the guest operating system and virtual machine, and the VMware Tools settings;

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- to configure the processors, the resources of Hyper-Threading processors, memory and disks.

Thus, the cloud platform based on ESX Server hypervisor creates a virtualization layer between the hardware system and the virtual machines, turning the system hardware into a pool of logical computing resources that can be dynamically allocated to any guest operating system. Operating systems running in virtual machines interact with the virtual resources as if they were physical resources.

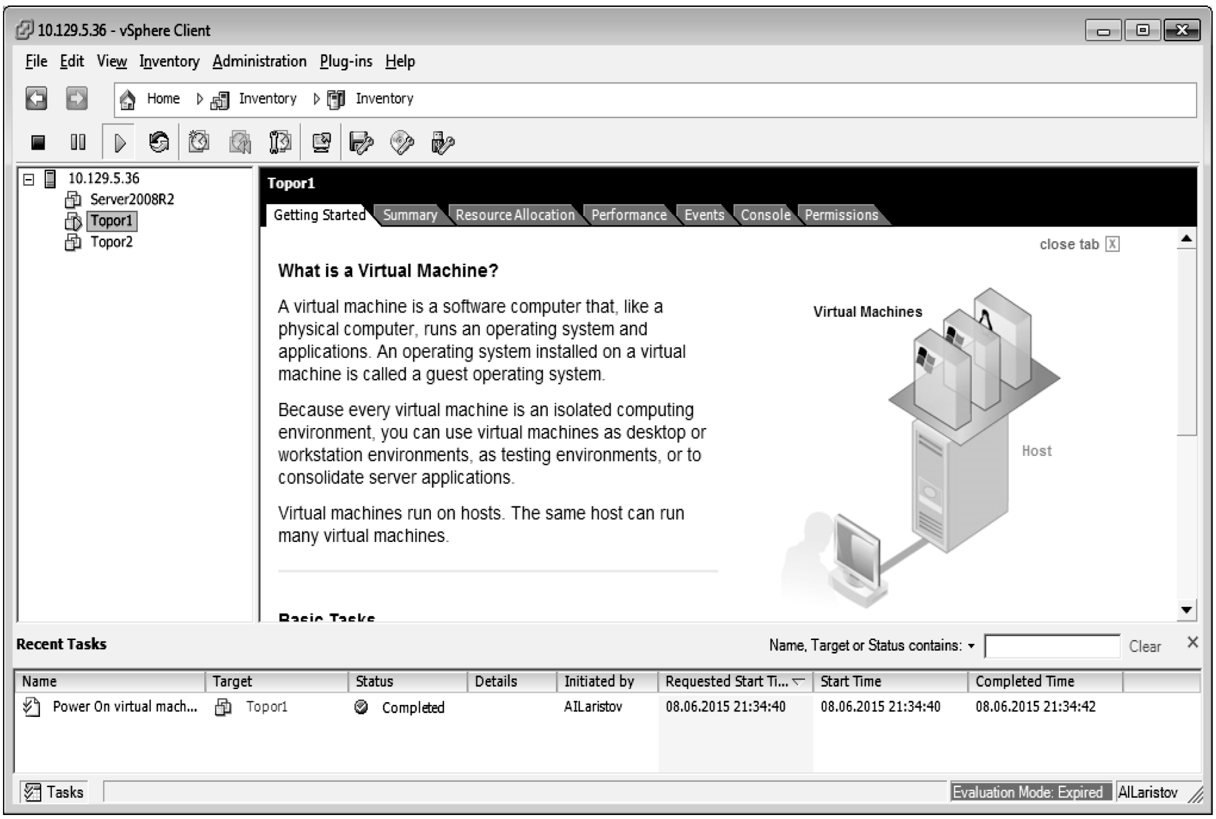

Fig. 1

Testing of corporate cloud CAD

As a hardware platform, we used the server Necs 3.Intel Xeon Q X5450A with 4 GB of RAM. VMware ESXi 5.5 software was installed directly on the server. Installation of VMware vSphere Client 5.5 on the client machine provides the connection to the server and ability to create and manage the virtual machines. In test mode on the server there were created two virtual machines with guest OS Windows XP and topological CAD “TopoR” installed. In addition, the virtual machine with Windows server 2012 R2 was deployed on the server for centralized storage of project data. Fig. 1 shows the main window of VMware ESXi 5.5 hypervisor with a tree of virtual machines.

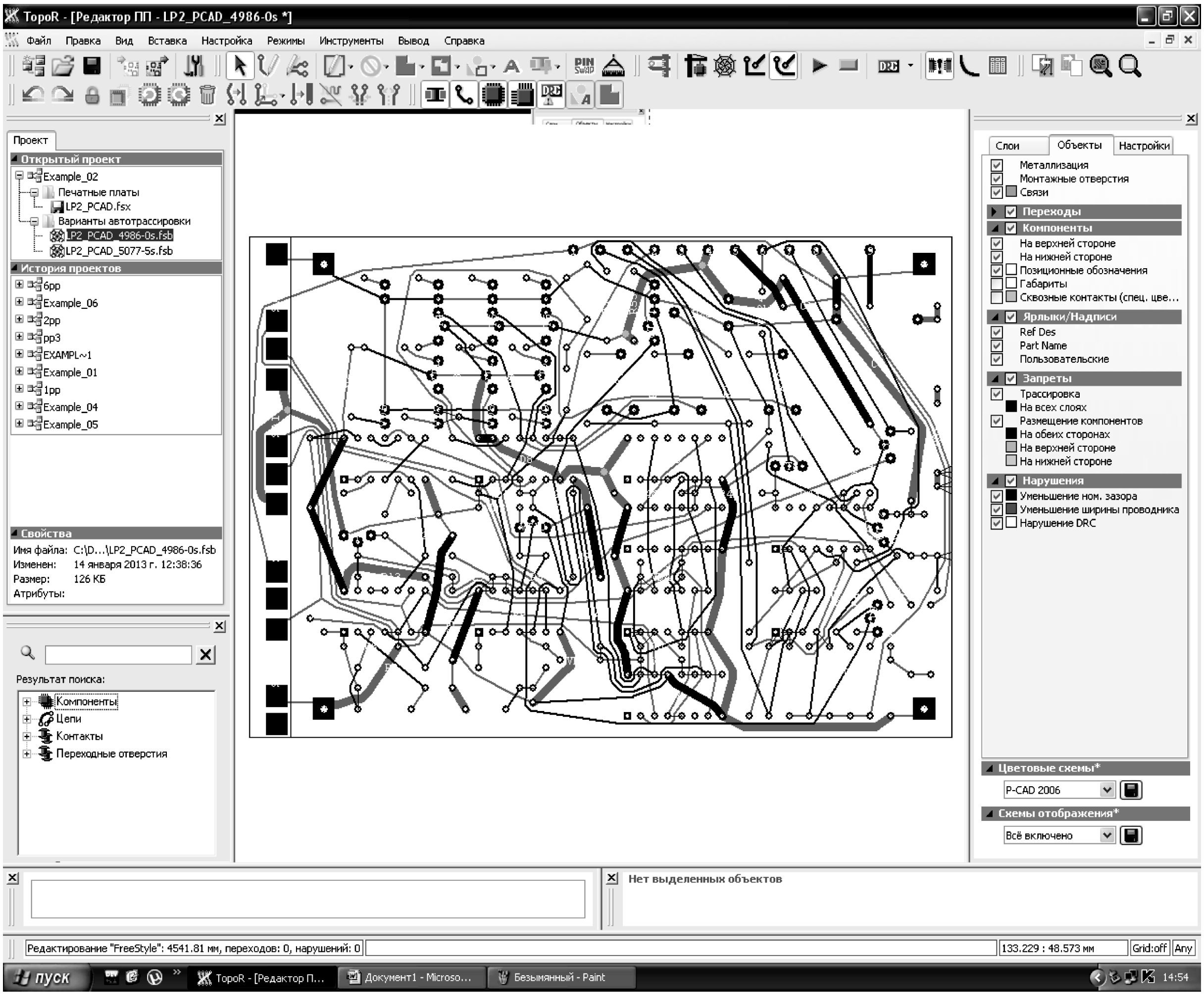

Fig. 2

Access to virtual machines from a client machine was organized through VMware vSphere Client 5.5. After a remote start of the virtual machine and loading of the guest OS it is possible to connect to the desktop and call the CAD “TopoR”.

Fig. 2 shows the working window of the test virtual machine’s topological CAD “TopoR” with opened project of PCB.

Conclusion

The test version of the corporate cloud based on VMware has shown the possibility of using cloud technologies for the organization of collective usage of topological CAD. To deploy the full-featured enterprise version of the cloud and provide access to the virtual machine CAD system via the web interface the installation of additional VMware vCenter Server 5.5 is required.

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