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Collaborative design in the era of cloud computing

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ABSTRACT

The paper describes the application of the latest Information Technologies in business processes such as design and manufacturing. More specifically it examines the use of cloud computing in the mechanical drawing and design process of an enterprise. It proposes a specific architecture with different servers, for the implementation of a collaborative cloud based Design system. Finally as an application example, it compares the operating cost of an industry's design department before and after the use of the proposed system. This example uses a private cloud deployment model so that the comparison of the operating cost would be feasible. While public cloud may offer more functionality and economy, private cloud is best suitable to make conclusions and comparison between on-premise and cloud operation, because all of the cost is handled by the organization that uses it.

1. Introduction

Despite the dramatically increasing penetration of cloud computing to industries [1–3] in recent years, many design departments stay out of it. The main reason seems to be the reluctance of users on the response times of applications. In CAD software, direct interaction with the user is vital and any delay between the command of the user and the graphical effect causes the rejection of the system.

Cloud computing however, has introduced a range of new services [4–6] and features that could improve the functionality of a design department, while new technologies have recently emerged promises to eliminate CAD users objections.

Paper [4] presents a new algorithm (Ranking Chaos Optimization) so that cloud services and computing infrastructures can then be quickly combined and shared with high efficient decision which is critical in virtualization.

Paper [5] utilizes virtual machines to remotely draw parametric design blocks to CAD software with no user interaction and compares the cost for cloud computing vs in-house regarding the hardware used.

Paper [6] also utilizes virtual machines to remotely draw parametric design blocks to CAD software with no user interaction and also introduces a ticketing system to coordinate execution.

Present paper moves forward transferring all CAD services to the cloud. It proposes a new infrastructure architecture that would be sufficient to support remote (cloud) execution. The design of the proposed architecture takes, in addition, into account new techniques that have been evolved recently (application virtualization, Graphics acceleration using GPU pass through) in order to design an infrastructure capable to satisfy the needs of CAD users.

The major challenges that a design department faces are the following:

- Application availability

The classic way of software disposal (license per user/workstation) raises an important issue regarding the operation cost of the department. In fact while software is installed in a number of workstations, it is used simultaneously by a smaller number of them. For example finite analysis software can be installed on all workstations of civil and mechanical engineers of the department, but only a few of them will use it simultaneously. Usually the solution given to the problem is to install the software in a small number of workstations that will be used alternately by the engineers. Obviously this is a compromise and not the desirable solution.

- Frequent software updates

In order to be competitive and efficient, the design department should frequently upgrade the software used so that it benefits from the new features offered by the new versions. New versions

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should be installed in a multitude of workstations with different characteristics and possibly operating systems. This leads to high maintenance costs because apart from the cost of the upgrade it requires the involvement of one or more specific IT specialists.

- Requirement for powerful workstations

CAD applications require significant computing power from both the workstation's CPU as well as the GPU. In fact they are considered as the most demanding applications regarding the computing power of a workstation. The ever increasing software requirements require hardware equipment updates more frequently than other departments.

- Custom solutions – Libraries

During the operation of the design department custom add-in applications and drawing libraries are created or purchased. A custom application could be, for example, software which will design three-dimensional parametric stairs or gears, while design libraries could be furniture, trees, etc. These applications, libraries, revisions and the latest versions of these are desirable to be available in all the workstations of the design department. This implies a very large workload in departments without access to the same servers (need to exchange files with emails – installation on workstations, etc.) and of course, greatly increases the probability of errors.

- Collaborative design

Collaborative design is a key challenge for a design department as more engineers or other specialists are involved in the design process of a product. Thus, for the design of a building, architects will design the architectural design (CAD), civil engineers will implement the static analysis (CAE), mechanical engineers the mechanical study (CAE/CAD), etc. These studies and designs interact with each other (e.g., static analysis may enforce reviewing the architectural design) while more than one people are likely to be engaged in individual studies. Additionally the physical location of those involved in the study may not be in the same place or office but instead in different cities or countries.

- Backup policy/data disaster recovery

Projects and studies are the "property" of a design department and preserving them is a (though usually underestimated) very critical process. Most often the maintenance of the process relies to the engineers without having established a standard policy. Even the most organized departments, where all files are stored on a central server; this is done at the local office and not for the whole department. Applying a backup policy which will ensure full restoration of files in case of failure requires special additional equipment and specialized IT services.

- Mobility

A particularly important issue is mobility. Employees of a design department are people who move frequently for in place supervision of a project or for collaboration with third parties (customers, partners) in their offices. So very often arises the need for full or partial access to drawings of the project. This remote access needs to be implemented through the engineer's laptop, the client's workstation or even a mobile device.

- Security

A design department faces all security issues [7] posed by exposure to the internet. To deal with intrusions from the Internet requires a high level of IT staff and expensive software. Even more especially complicated is the issue of access rights to files in order to ensure confidentiality simultaneously with functionality.

- CAM

When the final stage of a design project concerns CAM arise issues regarding transfer of new projects to the respective facilities, categorization of existing designs and access to them.

The paper tries to answer to these challenges, examining the use of cloud computing in the mechanical drawing and design process of an industry. It proposes a specific architecture with different servers, for the implementation of a collaborative cloud based Design system. Finally as an application example, it compares the operating cost of an industry's design department before and after the use of the proposed system.

The paper has the following structure: Section 2 defines the basic cloud principles, while a brief discussion about cloud based CAD is held in Section 3. The proposed System's approach is presented in Section 4, and its advantages and characteristics are described in Section 5. In Section 6 an application example is shown, comparing the operating cost of an industry's design department before and after the implementation of the proposed system and finally Section 7 provides conclusions and future work.

2. Cloud principles

According to the National Institute of Standards and Technology (Special Publication 800-145), "cloud computing is a model for enabling ubiquitous, convenient, on demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models". In the same publication the service and the deployment models, are described as:

"Service models:

Software as a Service (SaaS).

The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure.

Platform as a Service (PaaS).

The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services and tools supported by the provider.

Infrastructure as a Service (IaaS).

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

Deployment models:

Private cloud.

The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed and operated by the organization, a third party or some combination of them and it may exist on or off premises.

Community cloud.

The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g. mission, security requirements, policy and compliance considerations). It may be owned, managed