BIM in a cloud:

What structural engineers and architects need to know about cloud computing for business success

By Chris France, Associate AIA

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Cloud computing was once maligned as the most overhyped tech buzzword of the year in *CIO* magazine (McLaughlin, 2008). Yet the technology promises to be "no less influential than e-business," according to Gartner Inc. (2008). Defined as a computing style that provides scalable IT services using Internet technology, the trend is revolutionizing the IT industry. The reason, according to Forrester Research, is the No. 1 business benefit: Pay-as-you-go cloud computing is a cash-flow-friendly alternative to on-premise installation (Schadler, 2008).

Beyond the business benefit of significant cost savings, cloud computing has the potential to transform the way people connect and interact with employees, partners, and customers. On large-scale infrastructure projects with distributed project teams, cloud computing can provide engineers and architects with a centralized, secure computing platform for collaborative design using building information modeling (BIM). BIM in a cloud has real potential to elevate engineering and design quality and expedite workflows, while reducing engineering IT costs.

Forward-looking firms are ignoring the hype and investigating how cloud computing can contribute to their business success. This article clarifies what is meant by cloud computing in the architecture, engineering, and construction (AEC) industry; introduces the enabling technologies; explores both the business and project benefits of BIM in a cloud; and explains how to get started. A short case study illustrates how one firm successfully implemented a private cloud strategy to take BIM technology to the next level.

What is cloud computing?

Cloud computing can be broadly defined as delivering hosted IT services over the Internet (Whatis.com, 2010). According to the U.S. Institute for Standards and Technology, "[C]loud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable resources — networks, servers, storage, applications, and services — that can be rapidly provided and released with minimal management effort or service provider interaction" (Haber, 2010).

Cloud computing differs from traditional hosted services in three ways. First, it is a metered service that is sold on demand. Second, it is a scalable, elastic service that stretches or shrinks in response to demand. And third, it is managed by the provider, so the infrastructure is transparent to users. All the user needs to access a public cloud is an Internet-connected computer.

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Learning Objectives

After reading this article, you should be able to do the following:

- Know what cloud computing means and how this strategy is used to deliver IT services throughout the enterprise.
- Identify building information modeling (BIM) technology that can be deployed to geographically dispersed AEC project teams through cloud computing.
- Discuss at least six business and project benefits of using cloud computing for BIM.
- Understand the hardware and software requirements for a high-performance graphics workstation (HPGW) cloud.

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divides cloud computing services into three categories: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). A prominent example of IaaS is Amazon Web Services (AWS), which has leveraged Amazon.com's massive computing infrastructure to provide computing power, storage, and other services on demand since 2006 (Amazon Web Services, 2010).

While public cloud providers such as AWS sell services to anyone, a private cloud service is proprietary. The computing infrastructure and resources are controlled by the business that deploys the cloud. Private cloud computing is a cost-effective alternative when available public cloud services lack the desired level of service, security, and/or compliance (Gartnervideo, 2009).

To implement private cloud computing, a business enterprise configures the necessary resources to give multiple users shared access while hiding the physical characteristics of the computing environment. This so-called "virtualization" simplifies IT infrastructure operations and management, and secures enterprise data on the virtual servers (HP, 2008). In the past, most of the discussion around cloud computing has dealt with the servers (the back-end storage systems). Only recently have businesses begun to put their desktops and workstations into the cloud (France, 2010). Virtualization of these front-end computing components further reduces IT costs by prolonging their service life.

Private cloud computing has become viable, in part, because the cost of bandwidth has decreased enough to allow the economical transfer of large data files over a virtual private network. Companies can now get a 10 megabit per second (Mbps) Metro Ethernet for the same price as the 1.5 Mbps T1 line of yesteryear. Also, Windows 7 and Remote Desktop Protocol (RDP) have gotten much better at moving screen images of media-rich applications. RDP installed on a laptop or desktop computer enables the remote display and input to Windows-based applications running on a server (Microsoft Corp., 2010). Finally, hardware costs are coming down, and rack-mounted server-class workstations are now within reach of small- to medium-sized businesses.

Figure 1: By running BIM software on high-performance graphics workstations in a cloud computing environment, designers can work on any network-connected computer or device.

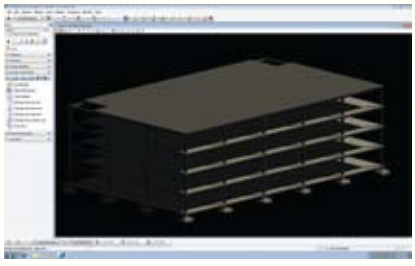
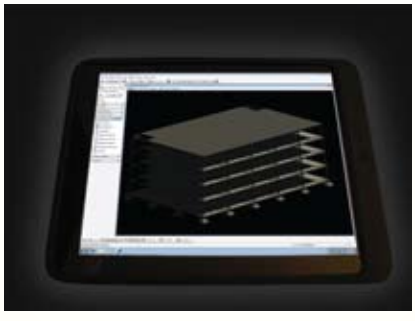


Figure 2: With a secure cloud gateway, project team members can access an HPGW from any Internet-connected mobile computing device — even an iPad — using an RDP client.



How BIM Works in the cloud

The convergence of virtualization technology maturity and affordability has made private cloud computing a viable option for structural engineering and design firms. The driving force behind this innovative approach is BIM, which McGraw-Hill Construction defines as "the process of creating and using digital models for design, construction, and/or operations of projects." (2009) According to McGraw-Hill's "Business Value of BIM" report, nearly 50 percent of the industry is now using BIM, and one in five BIM users who measure ROI see returns greater than 50 percent.

Designers are now able to construct a fully documented, 3D building on a computer before they build it on-site. BIM models manage not just graphics, but also information that allows the automatic generation of 2D drawings and reports, design analysis, construction simulation, operations management, and other lifecycle functions. This embedded information enables the design team to make better-informed decisions (Bentley Systems, 2010). Like cloud computing, BIM supports a distributed team so that people, tools, and tasks can effectively share this information throughout the building lifecycle, thus eliminating data redundancy, data re-entry, data loss, miscommunication, and translation errors.

These intelligent 3D models require a lot of computing power to perform simulations, analyses, and renderings. The typical AEC firm spends hundreds of thousands of dollars each year to maintain laptops, desktops, and workstations capable of running the most current engineering and design software applications. Refreshing computers every two years is not unusual.

Switching to a cloud computing strategy allows firms to prolong the hardware refresh cycle by providing access to high-performance workstations in the cloud. Laptop and desktop computers now operate as cloud access devices, which require far less individual computing power. Instead of spending several thousand dollars per computer, new laptops can be purchased for less than $1,000 when required and be used until the end of their service life.

While a cloud strategy does not change the licensing agreements with BIM software vendors or the related per-seat costs, it makes it much easier for IT staff to deploy and manage new applications. Many software applications have a network or concurrent licensing model. This means that anyone can work on any workstation as long as there is an available license in

the pool. If everyone in the firm needs access to an application, the traditional approach is to use sophisticated scripting or software automation to push the application to every laptop. This is time-consuming and problematic, especially if some laptops rarely connect to the network.

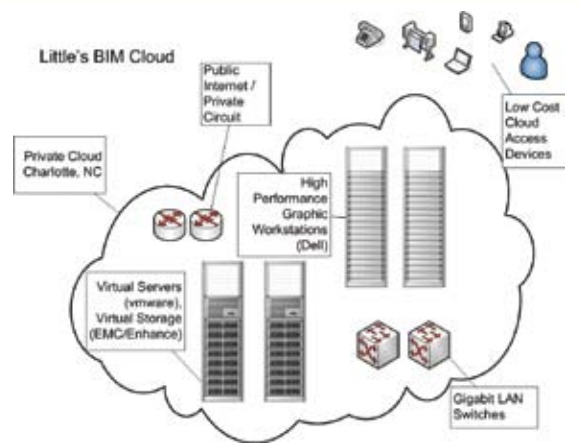
By running BIM software on high-performance graphics workstations (HPGWs) in a cloud computing environment, IT staff can easily maintain and update the machines with the latest software applications. In general, seven to 25 BIM designers can work on one of these workstations, depending on project size and hardware configuration. The physical infrastructure is located in a datacenter and is available 24x7. Designers access the cloud using any network-connected computer or device (see Figure 1). The virtual HPGWs do the heavy lifting.

Most design firms also have a 3D animation studio where they create photorealistic renderings of their building designs. Many take BIM renderings to the next level, making short movies and fly-throughs to give clients a better sense of what their new facilities will look like. These rendering programs crunch images frame by frame to create a video — a process that can take several days to complete. With an HPGW cloud, animation studios can use the cloud to perform renderings at the same time other people are using the cloud, but at a lower processor priority. When people go home at night, these programs crank up and fully utilize the cloud's computing capacity. Rendering time drops dramatically, making it possible to use renderings more often for high-quality client presentations with a "wow" factor.

Benefits of cloud computing

From an IT management perspective, cloud computing simplifies the logistics of equipping a BIM-enabled project team. However, it can yield many other benefits as well. Virtualization improves network performance by all but eliminating the transfer of large BIM data files between the network and networked computers. Data is accessed, updated, and stored in the cloud, so the bandwidth pipeline does not get clogged by network traffic. Hardware costs are also significantly reduced, because virtualized servers and storage require fewer physical data volumes.

Figure 3: Schematic diagram of Little Diversified Architectural Consulting's private cloud computing environment



Deploying BIM in a cloud consolidates the pared-down IT infrastructure in a central location. But it makes the BIM applications available to team members located just about anywhere. Firms with regional offices can give remote team members access to on-demand resources in the cloud, with no local hardware other than the cloud access devices.

Cloud computing gives firms the freedom to assign designers to projects based on their expertise and client needs, rather than physical location. Software vendors offer project collaboration solutions that have made distributed project teams a practical reality for some time. Their products typically operate over a wide-area network (WAN), using WAN accelerators to improve performance. Cloud computing takes this trend to the next level by allowing distributed project teams to work together just as if they were sitting in the same office. With BIM in a cloud, structural engineers in different offices can easily work on the same building model.

Does this solution work internationally? Technically, yes; but in practice, it does not — not yet. The network latency across oceans is too great to get a smooth desktop experience. Typing is laborious, and images transfer extremely slowly. It is not the "same-as-being-there" performance experienced on an in-country cloud. Within the United States, coast-to-coast latencies are negligible. Corporations with an international footprint should set up clouds on each continent.

BIM in a cloud not only unites project team members in geographically dispersed offices, but also accommodates the use of the most qualified consultants and contractors. Using BIM tools, they can all work on the same building models. But without the cloud technology, project teams are forced to trade models via FTP or project websites on set schedules. Real-time collaboration is difficult between external entities. Cloud computing facilitates real-time collaboration with outside consultants, who can enjoy the benefits of BIM without incurring the costs of maintaining the physical IT infrastructure. This opens the door to collaboration with firms of all sizes and in any location, including boutique shops, and minority- and women-owned businesses.

Whether they work for the lead firm or a subcontractor, project team members rarely work exclusively from one physical office work space. Telecommuting, travel, and co-location have made it necessary for employees to be able to run all their applications anytime, anyplace, just as if they were in their offices. Running applications on laptops and transferring data between local and remote sources causes problems with perfor-

mance and data security. WAN accelerators are not a satisfactory solution. With a secure cloud gateway, however, project team members can access an HPGW from any Internet-connected mobile computing device — even a smartphone — using an RDP client (see Figure 2). While working with a 3D model on a smartphone may not be practical, the model can at least be accessed and viewed if required.

Mobile computing raises serious concerns about data security. Project team members typically have all kinds of project, company, and client information on their laptops, smartphones, and personal digital assistants. A cloud computing strategy keeps corporate and client information "in the cloud," where it is secured, backed up, and replicated. Without the cloud, if a laptop is stolen or the hard drive crashes, a team member is out of commission until the IT department replaces, repairs, or rebuilds the old one. With an HPGW cloud, if a cloud access device (such as a laptop) fails, the team member can borrow or buy a replacement and keep working. There is no down time, and there is no data lost since the data is on the storage area network.

How to implement an HPGW cloud

Creating a private cloud computing environment is a two-step process that includes the virtualization of IT assets such as servers and storage and virtualization of the desktop — in this case, the HPGW. A schematic diagram of the cloud is shown in Figure 3.

Step 1: Virtualize the servers and storage — Virtualization of cloud servers begins with a hypervisor, also known as a virtual machine monitor. This software/hardware platform installs on top of the physical server and partitions it into multiple virtual machines that run simultaneously, sharing the physical resources of the underlying server. Each virtual machine represents a complete system, with processors, memory, networking, storage, and basic input/output system, and can run an unmodified operating system and

Case Study: AEC workstation cloud reduces hardware expense by 67 percent over 10 years

Based in Charlotte, N.C., Little Diversified Architectural Consulting has a national network of 200 professionals. Laptop computers running AEC applications along with general purpose business applications were replaced every two years. This refresh cycle cost $250,000 to $300,000 per year and was getting more expensive as the firm added more software capabilities.

In 2009, Little built an AEC workstation cloud to reduce laptop hardware expenses. The firm now provides design services on 10 high-performance graphic workstation (HPGW) cloud computers. These workstations are expected to last as long as five years, with some component upgrades in the interim. The private cloud strategy enables laptops to operate as cloud access devices. This will not only prolong laptop service life by at least two years, but also reduced the laptop price point to below $1,000.

Little's private cloud is on track to reduce workstation and laptop hardware expenses by 67 percent ($2 million) during the next 10 years. In addition, two virtualized servers have replaced 57 physical servers at a savings of about $135,000; and virtualized storage has helped to avoid an annual expense of $700,000 for added IT staff to manage the physical data volumes.

The private cloud is comprised of these core components:

Hardware

- 10 rack-mounted workstations, each with dual quad-core 3.0 Ghz Xeon processors, 32 GB RAM, and 1.5 GB video RAM
- Two Dell 2950 quad-core servers for virtualization
- Two redundant EMC CX500 networked storage systems
- Fast local hard drive
- User/design data mapped to virtualized storage on the storage area network
- Windows laptop as cloud access device

Software

- Microsoft Windows 7, 64-bit desktop operating system
- VMware ESX software platform for hypervisor architecture
- Utility software for multi-user access and load balancing of CPU, network, and memory
- Remote Desktop Protocol for client remote access

In addition to realizing the business benefits of private cloud computing, Little has learned the following lessons from production users on the cloud:

- Multiple designers can share the same AEC workstation without interruption.
- An entire regional office can operate exclusively in the cloud with no local storage.
- Excessive consumption of memory and processing power may indicate a training issue.
- Limiting the number of designers per workstation avoids "cloud bursts" (memory at capacity).
- Not all mission-critical applications perform well in the cloud, so testing is mandatory.
- People forget where they leave stuff. With a little coaching and practice, they catch on.

At Little, the HPGW cloud strategy promises to improve the efficiency and longevity of IT resources. At the same time, cloud computing has enhanced project team productivity by allowing remote team members to share resources as though they are located in the same office. The HPGW cloud is an invaluable asset for optimizing the performance of both design and IT resources.

applications (vmware, 2010).

There are multiple hypervisor products and, as with any IT infrastructure acquisition, administrators should carefully consider their unique requirements before selecting one or more vendors (Reeser, 2010). The right virtual machine monitor can significantly reduce hardware expenses as well as increase operational capabilities such as instant provisioning, disaster recovery, and business continuity. It enables the IT department to deliver on the corporate challenge to "do more with less."

Storage virtualization can be achieved with various software applications or by using hardware and software hybrid appliances. Virtualization pools the physical storage capacity from multiple network storage devices into what appears to be a single, centrally managed storage device (Whatis.com, 2009). Virtualized storage saves money and enables IT to manage a mountain of data with existing staff.

Step 2: Virtualize the HPGW — Desktop virtualization separates the desktop environment from the physical machine using a client-server model. The virtualized desktop is stored on the remote cloud server instead of on the local hard drive. When users work from the virtual desktop, software applications and data are in the cloud.

To realize the full benefits of cloud computing for BIM, virtualized workstations must perform as well as, if not better than, traditional workstations. Unfortunately, most desktop virtualization products do not virtualize the graphics processing unit, which leads to poor performance — a cloud that is slower than a user's laptop. The key to getting users to move to a workstation cloud is providing not just the same experience as their laptops, but an experience that is significantly better than their laptops.

One solution is a hybrid approach that uses RDP to access a workstation in the data center. This approach requires a one-to-one mapping of people to workstations and, consequently, doesn't reduce IT costs. A more cost-effective option is to turn a single-user workstation into a multi-user workstation by partitioning it in the same way the cloud server is partitioned into multiple virtual machines. To end users, the virtualized workstation is in the cloud. To the IT staff, it is a piece of shared hardware. This strategy allows several people to share one HPGW.

Conclusion

BIM in a cloud may sound like a tech trend with limited application to structural engineering and architectural design. But, the private cloud strategy has been proven to enhance BIM productivity while delivering real business benefits to AEC firms. As business owners strive to maximize the use of both IT and human assets, innovative approaches — no matter how buzzword heavy — become a practical reality.

Private cloud computing provides a platform for assets to be fully utilized, so the firm gets the most work done with the fewest assets (and least cost). Most hardware that is dedicated to a single function is not fully utilized all the time. Using virtualization technology, the IT department is able to use workstations, servers, and storage devices to maximum capacity without disrupting workflows.

Cloud computing is not rocket science, but it does take thought and planning. IT strategies are generally multi-year endeavors, and innovative approaches can take two to three years to deliver results. Today's tough economy is driving innovation at AEC firms worldwide. To stay competitive, forward-looking firms are designing virtual offices that pool expertise and designer talent from multiple locations — enabling project members to perform their best work in the cloud (Zeiger, 2010). ▼

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Go to **www.stagnitomedia.com/cedu** to take the following quiz online. Quiz answers will be graded automatically and, if you answer at least 80 percent of the questions correctly, you can immediately download a certificate of completion.

1. Cloud computing is defined as a centralized computing environment that provides IT services:

a) Over the Internet

b) On demand

c) From a third-party host

d) All of the above

2. What do users need to access a public cloud?

a) Pre-paid account

b) Internet-connected computer

c) Broadband cable service

d) Cloud computing software

3. A private cloud can deliver IT services throughout the enterprise by:

a) Pushing applications to user desktops

b) Connecting users on a wide area network

c) Giving local users access to remote IT resources

d) none of the above

4. Building information modeling (BIM) technology that can be deployed to geographically dispersed project teams includes:

a) Digital 3D models

b) Engineering and design software

c) High-performance graphics workstations

d) all of the above

5. BIM in a cloud offers significant business benefits. What is the number one incentive for an AEC firm to implement this approach?

a) Reduce computer hardware expenses

b) Reduce software licensing costs

c) Reduce the number of project designers

d) Reduce the number of physical offices

6. AEC project teams benefit from cloud computing because:

a) Everyone has access to the same shared resources

b) File sharing is fast and efficient

c) Designers in remote locations work as if they are in the same office

d) All of the above

7. Virtualization is characterized by the process of:

a) Distributing IT hardware to multiple locations

b) Separating the computing environment from the physical machine

c) Consolidating multiple devices in one location

d) Connecting multiple computers on a network

8. A private cloud computing environment includes what three key components?

a) Virtualized servers, storage devices, and workstations

b) Software as a Service, local-area network, and cloud access devices

c) Hypervisor, storage area network, and smartphones

d) Remote Desktop Protocol, data center, and graphics processing units

9. High-performance graphics workstations in the cloud can perform double duty as:

a) Microsoft Office application servers

b) Cloud access devices

c) Training tools

d) Rendering farms

10. What is the first step toward implementing BIM in a cloud computing environment?

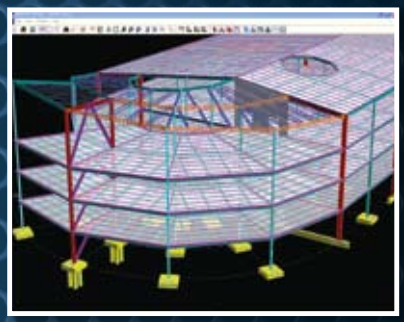
a) Evaluate the current IT infrastructure costs and requirements

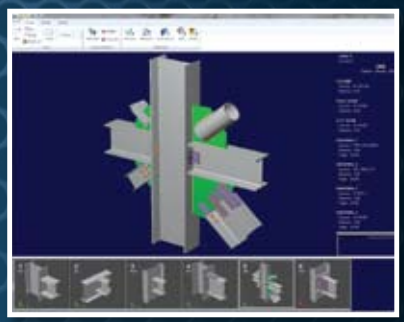
b) Test mission-critical applications in a cloud computing environment

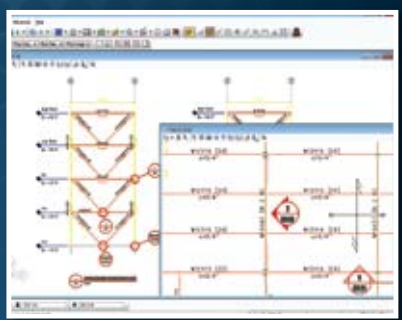
c) Purchase as much bandwidth as the company can afford

d) Equip project team members with BIM-enabled laptop computers

Intelligent Structural Design







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