

An Oracle White Paper
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Oracle's Cloud Solutions for Higher Education and Research

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Executive Overview

For more than three decades higher education and research institutions have devoted significant human and fiscal investments in information technology to support goals tied to teaching, learning, research and the expansion of knowledge and understanding. Due to the mission they support, however, these institutions typically required technology and computing approaches that were significantly different from the needs of traditional commercial enterprises in which most computing and technology offerings originally had been developed. As a result, most institutions today find themselves supporting, largely with their own internal staff, computing solutions that are significantly customized and increasingly complex. Regrettably, this has proven to be a very costly model, and has not, in many cases, delivered the level of service desired by students, faculty, researchers, and staff who increasingly demand access to systems from any device, anytime, anywhere.

During this same time period, the amount of data and content the average institution must maintain and store has gone from a trickle to what could now only be described as a flood. This data deluge adds complexity and cost. Unfortunately, all the data, complexity and volume have not resulted in greatly enhanced access to information. In fact, one of the main challenges facing education and research institutions is in the area of information management and access. This is true on multiple levels, ranging from business operations to administrative computing to education and academia. The issues are compounded in research environments that maintain large data sets from scientific computing. As if these challenges were not significant enough, increasing demands for transparency, governance, and data-retention regulations are adding to the “big data” problems faced by higher education.

In eras of expansion and economic growth, having internal teams that supported highly customized systems and managed increasing complexity may have been the most economical and appropriate solution. However, significant changes have occurred that call these approaches into question. Today, many developed nations face what are unquestionably the most significant reduction in funding and resources in their collective histories. Such significant economic realities are creating a sea change across the landscape of academia. As massive, and in many cases destructive, reductions in funding become reality; institutions are increasingly challenging traditional approaches. Faced with demands requiring slashes to curricula, cuts in staff (including tenured faculty), and reductions in financial aid, it may not be surprising that leaders in information technology and computing in higher education and research find themselves reexamining what was once an almost unassailable creed.

Considering that technology growth and expansion has continued throughout this period at breakneck speed, it becomes increasingly and painfully clear that those organizations that are unable to change their approaches to computing will likely face increasing challenges, complexity, and costs. Unfortunately, if they continue down the same path, they may well see decreasing returns from their human and capital investments. Agility is no longer just a hype-cycle term; it is a baseline reality.

Interestingly, it may be experience that slows an institution's ability to innovate and take advantage of new opportunities. Having invested in evolving technologies and structures over time, it can be hard to make the leap to more effective, less costly approaches. Although great examples exist in computing, mobile phone service is a perfect metaphor. Supporting large, complex, and well entrenched systems, many developed countries have moved more slowly toward the adoption of mobile telephony. On the other hand, by 2002, mobile penetration in emerging markets had grown 321% compared to 46% in developed countries. Able to skip over the infrastructure history of more developed nations, developing countries have been able to seize the opportunity because they did not need to make the costly, interim investments.

At the same time, however, some developing countries have not had a similar experience with computing technology as they have had with the mobile phone. Some countries have been restrained from adopting computing technologies and innovating because they are required to adopt the technology solutions dictated by and shared with their governments.

Cloud computing has the potential to play a contributing role as a solution in all of these scenarios. Cloud computing is a significant advancement in the delivery of information technology and services. By providing on-demand access to a shared pool of computing resources in a self-service, dynamically scaled and metered manner, cloud computing offers compelling advantages in cost, speed and efficiency. However, caution must be taken. As with most computing solutions, cost and complexity are sometimes preserved—meaning that if one is not careful, one could end up with simply a different set of computing and funding challenges by shifting certain services to cloud.

It has already become commonplace for many consumer-type services to move “below campus” onto commodity or public cloud provider networks (i.e. electronic mail, instant messaging, calendaring, network-based productivity suites) and off the list of services considered integral to the central IT organization of a higher education institution. But as cloud computing moves from the arena of over-hype and divergent definitions to one of solid, proven delivery models, the next major frontier may well be in the area of architectures that move

applications and services that are critical to an institution's mission and provide competitive advantage "above campus" into cloud services. Higher education leaders will need to carefully consider which services they elect to deliver locally or centrally and which they wish to source "above campus" in the cloud. These decisions will need to be thoroughly deliberated because, although the applications and support staff surrounding these mission critical solutions and services represent significant costs, they also include some of the "crown jewels" of an institution's computing infrastructure and differentiates and distinguishes it from other institutions.

There are also opportunities to leverage cloud technologies and standards to consolidate and centralize into a shared services model across disparate institutions, both traditional higher education and research entities as well as common services that can be shared with primary and secondary (K-12) school systems. NACUBO President and CEO John Walda commented, "We need to come together in groups to optimize our strength, not simply determine how to bridge the gap. This is the right time for this conversation because of our necessity to take advantage of emerging technologies to change how we do business on campus. And that includes looking at a higher education solution for maximizing the benefits of cloud computing."

Introduction to Cloud Computing

Cloud computing is a model for enabling 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.

Today, cloud computing is at an early stage in its lifecycle. However, the evolution and convergence of technology trends over the last several years has been driving enterprise data centers and service providers to grid computing, clustering, server virtualization, SOA shared services, and large-scale management automation. For more than a decade, Oracle has been the leader in these areas with thousands of customer successes and a high level of investment. One of Oracle's most significant acquisitions, Sun Microsystems, authored "*The Network Is the Computer*". Cloud computing is merely the latest term used to describe that reality. Today, Oracle powers the cloud and is the foundation for many of the world's public and private clouds.

This paper is intended to provide an overview of the standard definitions of cloud computing, opinions from leading organizations in education IT on prospects for cloud computing adoption, and provide recommendations and opinions from Oracle on cloud models and architectures that hold the greatest potential to deliver on the promises of cloud computing for higher education and research—efficiency, cost savings, and improved service delivery.

What is Relevant in Cloud Computing for Education?

Key Points

Several key factors are driving cloud computing in higher education and research—none of which are new to IT leaders: shrinking budgets, increased complexity, and continuously accelerating user expectations. Added into this mix for many institutions is the use of legacy or customized software and technologies that are resource-intensive to maintain much less update.

Here are some of the key points Oracle has seen in our work with higher education and research institutions around the world:

- Cloud computing builds on well-established distributed computing and shared services concepts.
- Data center consolidation, optimization and virtualization are logical steps in the evolution of an organization towards a cloud computing model.
- For higher education, the challenge is 'how and what' to move to the cloud—not 'if'.

- The US Federal Government's National Institute of Standards and Technology (NIST) has provided a comprehensive framework to describe cloud computing, including service and deployment models and a framework for the development of cloud computing interoperability and security standards.
- There are important differences between the public and private cloud deployment models.
- Operating system (OS) virtualization is not equivalent to cloud computing; and in fact may exacerbate problems of cost and complexity through "VM sprawl."
- Virtualization can be delivered at different levels; service-driven virtualization rather than infrastructure-driven virtualization is the most beneficial form of virtualization.
- OS virtualization (hypervisor-based) is limited and deficient as it essentially promotes creating "virtual silos" instead of physical silos; it therefore does not necessarily deliver the benefits of a true cloud model.

Perhaps the most important perceived benefit of cloud computing by higher education and research institutions is that shared service models through cloud computing offer affordable choices and a multitude of options never before available to an industry which has so long lagged behind the private sector in its ability to keep pace with technology resources purchasing power.

"From the individual user's point of view, the only thing that matters is the power of choice: the opportunity to choose among cheap (or free) competing services that are user-friendly, accessible from any location, and—within higher education—potentially more reliable than campus services. Cloud services offer higher education and research institutions the power to choose: the opportunity to rethink which services are needed to support education and research and what will be the best way to deliver those services."

Cloud Computing and the Power to Choose by Ted Dodds, Richard Northam, Leo Plugge, EDUCAUSE Review, May/June 2009

History

The concept of shared services infrastructure has existed in the IT industry for a long time. One might even consider mainframe computing to be a forerunner of cloud computing as some of the characteristics of cloud computing such as virtualization, multi-tenancy, and metering (charge back) were well established during the heyday of mainframe timesharing computing and still exist today. Organizations tinkered with server and server consolidation or "utility computing" but centralized management and metering practices were still too immature from a functional business model perspective.

With the explosion of client-server computing, IT organizations within the enterprise began to grow vertically to meet the demands of various business functions. This led to a widespread proliferation of hardware and software resources across the enterprise. This proliferation was then later exacerbated by the widespread adoption of Internet-based technologies as businesses rushed to provide services using the Internet. After the initial wave of euphoria around the Internet had passed, many organizations began to examine their use of IT more carefully, asking questions such as:

- How do we run IT as a service not just cross-departmentally throughout the campus but across multiple institutions and even institutions outside our system?
- How can we manage IT resources in a "just-in-time" model?

- How do we control costs through predictable resource allocation?
- How can we identify applications that can be outsourced to reduce expenses and meet our institutional goals for sustainability?

In response to these questions, the IT industry began to market the concepts of “elastic computing,” and Software-as-a-Service (SaaS). These were extensions to the existing shared services infrastructure concept that were now more readily deployable over the Internet. However, these new models often did not sufficiently address issues such as data security, access reliability, service level agreements and data co-mingling across network, OS, and application layers. In the enterprise software market, initial adoption of the SaaS model was limited to a very small set of applications (most notably customer / constituent relationship management—recruiting, retention and fundraising) and catered to smaller organizations as opposed to the larger enterprise.

Over the last five years, the Internet, internet-based computing, and related IT services have matured in terms of stability, security and availability. Technologies that were in their infancy during the early years of internet computing (such as collaboration and web services frameworks) have matured as well. These changes have led enterprises to explore the feasibility of standardizing processes, reducing costs and increasing efficiency by adopting some form of cloud computing.

Defining Cloud Computing

Although it is true that a certain amount of marketing hype has tended to obscure the idea that cloud computing is only the latest phase in the evolution of network-based computing, it is also true that cloud computing is getting substantial attention in the marketplace. This is taking place even though there is still some confusion about what cloud computing is or why it might be important. Much of the confusion in the marketplace around cloud computing is due to a lack of common understanding among customers, vendors, and analysts as to what defines cloud computing.

One vendor-neutral definition of cloud computing for higher education comes from EDUCAUSE:

“In its broadest usage, the term *cloud computing* refers to the delivery of scalable IT resources over the Internet, as opposed to hosting and operating those resources locally, such as on a college or university network. Those resources can include applications and services, as well as the infrastructure on which they operate.”

7 Things You Should Know About Cloud Computing, EDUCAUSE, August 2009

NIST further defines cloud as “a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources...” The NIST cloud computing model is composed of five essential characteristics, three service models, and four deployment models. Many industry analysts and consulting organizations have embraced the NIST model in working with their higher education clients globally. For the purposes of this paper, we will use the NIST framework to discuss cloud computing and its component services and models.

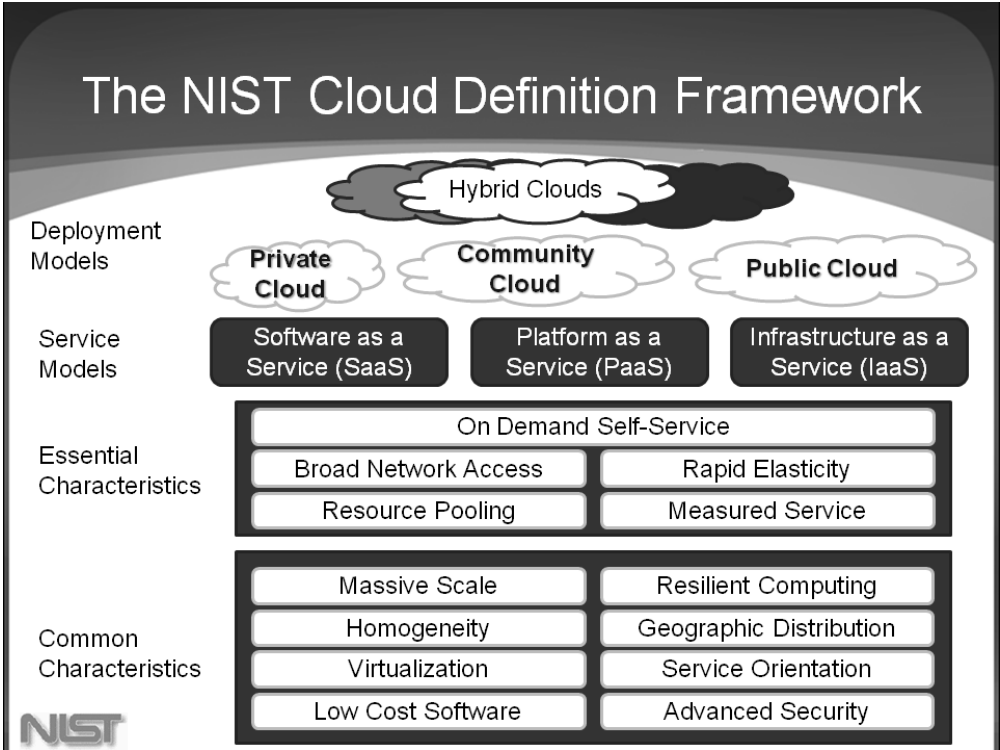


Figure 1. National Institute of Standards and Technology (NIST) Cloud Framework

Essential Cloud Characteristics

The essential characteristics of clouds include the following:

- **On-demand self-service.** Unilateral self-provisioning of any resource (CPU, OS, Memory, Storage, Network), hardware or software, as and when needed
- **Broad network access.** Unfettered access to services via standard methods over the Internet, via PDAs/Smart Phones, thin clients, laptops, and standard desktop workstations
- **Resource pooling.** Supports the use of hardware and software in a multi-tenant (multiple client organizations sharing computing resources) model while appearing to have infinite available capacity
- **Rapid elasticity.** Capability to scale up or scale down access to resources based on demand
- **Measured service.** Capability to provide usage metrics for the purpose of billing and chargeback; allows users to pay only for what they consume and avoiding paying for downtime of services /equipment not being utilized

Cloud Service Models

Service models for cloud computing include the following:

- **Software as a Service (SaaS).** Applications delivered as a service to end users over the Internet

- **Platform as a Service (PaaS).** Application development and deployment platform delivered as a service in the cloud
- **Infrastructure as a Service (IaaS).** Server, storage and network hardware and associated software delivered as a service in the cloud

Deployment Models

The following deployment methods are available for cloud computing:

- **Public cloud.** Available via the Internet for public use – can be free or subscription pricing by individuals or organizations
- **Private cloud.** A dedicated cloud for exclusive use by a specific organization or enterprise. Sometimes called an enterprise cloud; can be on-premise or off-premise hosted by a third-party provider
- **Community cloud.** Shared by various organizations in support of a specific community- can be either off-premise or on-premise
- **Hybrid cloud.** A mix of the specified cloud models cited above, or the use of technologies selected for their cloud capabilities integrated into traditional data centers

Cloud Computing: More than Operating System Virtualization

Many higher education and research organizations are considering or are already going through the process of data center optimization as a means to reduce their capital and operational expenses. These data center optimization efforts often involve the use of OS virtualization solutions to enable resource consolidation. Because server consolidation using virtualization and cloud computing share some common technologies, customers may think that having an OS virtualization strategy is equivalent to a blueprint for cloud computing. It is not.

Cloud computing implies a level of dynamic, flexible resource sharing and allocation of assets, but these services are generally not necessarily provided through virtualization alone.

One of the primary drivers for the use of virtualization solutions is the need to consolidate data, hardware, licensing, and disaster recovery capabilities. Virtualization enables consolidation by separating the OS and application layers from the hardware platform in a system. However, hypervisor-driven virtualization (O/S based virtualization) allows an enterprise to only share at the infrastructure level. As an enterprise, the true value of cloud computing is in moving away from physical silos to a shared model where *both* the infrastructure *and* services are shared, scalable and available. Without a service-oriented approach extending to the platform level, O/S Virtualization essentially runs counter to this—by promoting “virtual silos” and thereby severely limiting the true advantages of a cloud model. Also, one needs to understand that there are a variety of virtualization techniques available at various levels in a system that can provide, in many cases, improved scalability, performance, and manageability—including grid-based virtualization.

Similarly, consumers should not equate virtualization vendors (e.g. VMware) with cloud computing service providers. A cloud computing service provider may utilize virtualization technologies in its service infrastructure, but that does not mean that a vendor of virtualization products is a cloud

provider simply because it furnishes the virtualization software. Today, vendors of virtualization software often do not provide complete cloud computing services and may not be capable of doing so. Furthermore, OS virtualization vendors require the deploying IT organization to understand and control all applications that reside in the virtualized environment. In general, their tools treat the applications that live in these environments as a “black boxes”—not necessarily understanding and poorly capturing and applying requirements around data integrity and operational continuity as it relates to disaster recovery and data dependencies. Consequently, virtualization solution vendors do not provide the full array of technologies required to deploy and manage a cloud computing service.

Cloud Security

One of the common reasons given for the slow uptake of cloud computing thus far is concern about security. While security in a cloud model is often viewed in terms of network security, this is a highly restrictive view as it relates to higher education and research. Concerns regarding data integrity, physical security, back-up /recovery and addressing regulatory compliance are prevalent for every education and research IT organization today. The largest perceived risk is that of putting trust in a provider or being able to prove that trust to the end user. As with dedicated environments, the common practices and standards for risk mitigation regarding access, privileged user permissions, and monitoring remain relevant. The cloud-specific challenges focus more around intrusion detection, data location and impact on compliance requirements.

Data and application security in higher education and research may also be subject to controls by central governments and ministries. Many of today's cloud service providers do not explicitly address these controls. Guaranteeing compliance is a challenge in a cloud service model, as multi-tenancy can raise concerns about data co-mingling (multiple departments' data in a shared database or in use by a shared application).

Regulatory compliance is the most significant security challenge. The majority of regulatory standards were written when systems /applications were under physical and technical controls of the organization operating the application. Cloud turns this model upside down and therefore presents a challenge for both consumers and providers. Appropriate configuration and management controls can address the requirements, but validating these from a provider often proves tricky.

Oracle: The Leader in Cloud Computing

Key Points

Oracle's many qualifications make it the clear leader in cloud computing.

- Oracle is a key part of the existing cloud; Oracle is the computing backbone of the Internet and the enterprise.
- Only Oracle, with intellectual property that spans all layers of the computing stack (from application through OS, middleware, and database, to servers and storage) can engineer products, such as the Oracle Exalogic Elastic Cloud and the Exadata Database Machine, to facilitate truly elastic, scalable, shared service infrastructures with extreme performance and efficiency.

- Only Oracle now offers a secure, truly elastic public cloud.
- Oracle leadership includes founding members of the Cloud Security Alliance—helping to set standards and promote best practices.
- Oracle is aligned with the NIST cloud computing framework and fits into all three of the NIST service models.
- Oracle On Demand is a SaaS leader for many education institutions today
- Oracle products provide key security features for the cloud.
- Oracle complies with key standards, including DIACAP and FISMA and their equivalents.
- Oracle provides end-to-end management capabilities for cloud computing, including industry leading capabilities with Oracle Enterprise Manager (OEM).

Oracle has a solid history of providing the enabling technology for the evolution of computing solutions for the past 30 years. Cloud computing, which arrives on the heels of the rapid rise of internet-based computing, already takes significant advantage of Oracle technology and thousands of government, education and healthcare deployments of that technology. The vast majority of the largest businesses that operate on the Internet are using Oracle and Sun technologies to meet their requirements for scalability, availability and security. Just as the pioneers and leaders of Internet computing depend on Oracle, so do the pioneers and leaders of cloud computing, and in many cases these are the same businesses and organizations. Oracle is well established as a provider of core platform components of the Internet and internet-based businesses, and as such we are not only well positioned to enable cloud computing, we are already doing so. This is particularly important to our customers who are considering private cloud deployments to gain the benefits of cloud computing while retaining control over security, compliance and integration.

Oracle's Alignment with the NIST Cloud Framework

Oracle's cloud offerings align well with the NIST cloud computing framework. Figure 2 outlines how the various Oracle product sets are aligned with the NIST defined service models. These products satisfy the definition of cloud computing as it relates to self-service, elasticity, resource pooling, and broad network access and metering. These products can also be deployed in various delivery models as defined by NIST. Oracle supports all of the delivery models defined by NIST, including deployment on a public cloud or in a private or enterprise cloud.

SAAS	Applications CRM, Beehive, OnDemand	Security Self-Service & Manageability Enterprise Manager, Ops Center, Security Products
PAAS	Middleware Weblogic Server, Coherence, SOA Suite	
	Database RAC	
IAAS	Operating System, Virtualization Oracle Solaris, Oracle VM, Oracle Enterprise Linux Database GRID	
	Hardware/Storage/Network Oracle Sun Hardware Automatic Storage Management	

Figure 2. Oracle's alignment with the NIST framework

Oracle and Public Cloud Deployment

To date, the adoption of public clouds appears to have been limited to individuals and relatively small and medium sized businesses and organizations. As stated earlier, many higher education and research institutions have moved to the public cloud for email and collaboration services for students. However, the primary reluctance of many institutions to expand their use of public cloud services has been based on concerns over privacy, security and the potential or perceived risks associated with multi-tenancy databases.

However, Oracle understands the resource and economic challenges its customers are facing and the limitations and potential risks of today's existing public cloud services. As a result, Oracle has developed and announced a secure public cloud offering that includes Oracle's Fusion applications, middleware and database managed, hosted and supported by Oracle—offered on a pay-as-you-go model . More details about [Oracle's Public Cloud](#) can be found on Oracle.com through the link provided.

Besides cost savings, efficiency and security, another advantage of the Oracle public cloud to higher education and research institutions is that the applications, middleware and database services are standards-based—not proprietary—enabling institutions to deploy their applications in the Oracle public cloud, a third party cloud or on-premise. This means that higher education customers can move applications between the Oracle cloud to on-premise and back again without disruption of service or support. Oracle's public cloud is truly secure, flexible, and elastic.

Other services offered by Oracle in the public cloud are via the Amazon EC2 Public Cloud. Currently, Oracle provides pre-built templates based on Amazon Web Services (AWS) that enable Oracle customers to easily deploy Oracle's software on Amazon Machine Images (AMI) on EC2. Oracle also

provides a “cloud backup” tool to backup a database from local file systems to the Amazon cloud as part of an overall backup strategy as well as to initially set up your data in the cloud environment.

Private Cloud Deployment

While the ability to scale capacity on-demand and provide broadly available elasticity is a benefit of cloud computing and the future direction of the public cloud, Oracle believes the greatest near and medium term opportunities for education (K-12 as well as higher education) rests with shared services models and private clouds, where like-minded education or research organizations can use a shared cloud infrastructure, or single institutions can take advantage of specific cloud technologies such as virtualization-enabled self-provisioning of application environments. Oracle’s engineered systems along with powerful enterprise management software are the building blocks for these private cloud infrastructures.

Oracle is positioned to enable higher education and research organizations to be successful with private cloud initiatives. Oracle is the leading PaaS provider with prebuilt security and integration features based on open standards. Private clouds built on the Oracle platform will be inherently secure and provide standards-based application and data integration capabilities. Oracle has a proven track record in supporting higher education, research, public sector and healthcare shared service centers with integrated solutions that meet higher education and research institution requirements for secure access, data segregation, and manageability.

Oracle and Cloud Service Models

In addition to supporting multiple cloud deployment models, Oracle also provides both the technology and the applications to enable all of the cloud service models. In particular, Oracle On Demand has been a leading provider of SaaS services for several years, providing the full spectrum of private and public cloud deployment options. More recently, Oracle’s platform for SaaS has become a leading PaaS service platform.

The SaaS Service Model

The following are key points of the SaaS service model:

- Oracle On Demand provides a secure private SaaS cloud built on the scalable / elastic grid infrastructure of the Oracle PaaS platform.
- Oracle On Demand is available for ERP, CRM, PeopleSoft Campus Solutions, Hyperion, Business Intelligence and Beehive with more offerings underway.
- Oracle’s SaaS offering today supports 3.6 million end users. Customers drive and manage their utilization based on peak periods with self-service flexibility. This allows the consumer to maintain continuity based on demand and need, while only paying for those services utilized.
- Oracle On Demand currently provisions new systems and refreshes existing systems every week while providing high quality of service levels and high efficiency resource utilization.
- Oracle On Demand is hosted in the Austin Data Center, a highly secure world class data center.

Oracle applications have been built with shared environment considerations in mind, making them well suited to cloud deployment. The applications have also been built and certified on Oracle technologies such as application grids, RAC clusters, Oracle VM and Oracle Automated Storage Management, key technologies for implementing effective cloud infrastructure. Our SaaS Service implementations leverage our complete, open and integrated architecture through employment of Fusion Middleware 11g R3. Our next-generation Fusion Applications, also based on Fusion Middleware, will provide a roadmap of improved functionality and deployment flexibility in future SaaS service models.

More details about [Oracle On Demand](#) can be found on Oracle.com through the link provided.

The PaaS Service Model

The following are key points of the PaaS service model:

- Oracle is a technology enabler of the PaaS model.
- Many SaaS providers are using the Oracle PaaS platform today (also known as the Oracle Platform for SaaS). Over 250 ISV SaaS providers are using Oracle PaaS today. It is the market leader.
- The Oracle PaaS platform fully supports scalable, elastic, secure and manageable cloud computing services.
- Oracle Application Express lets customers rapidly build database applications entirely in the cloud.
- Oracle's new Exalogic Elastic Cloud product provides an ideal foundation for developing, consolidating, and deploying many Web based applications onto a single, highly scalable and performance platform.

Due to its global leadership position in enterprise technology platforms, Oracle is a de facto leader in PaaS. Oracle's database and middleware platforms are technology enablers for the platform cloud, allowing cloud vendors to provide highly available, secure, and flexible high performance solutions built on the Oracle technology stack.

Over 250 SaaS providers have already adopted the Oracle Platform for SaaS, including Salesforce.com, Ariba, and Perot Systems and, of course, Oracle's own SaaS offerings (Oracle CRM On Demand, Oracle E-Business Suite On Demand, Oracle Beehive On Demand, etc.) run on Oracle's PaaS platform.

More details about [Oracle Platform as a Service](#) solutions can be found on Oracle.com through the link provided.

The IaaS Service Model

The following are key points of the IaaS service model:

- Oracle is a technology enabler of IaaS model.
- Several of Oracle's IaaS technology building blocks are Open Source based, only requiring paid support (OVM, OVM Manager, OEL).
- Oracle VM and Oracle VM Manager provides complete manageability of virtualized environments.

- Oracle VM Templates are unique and provide a capability not available from VMware.
- Oracle Enterprise Manager provides end-to-end management and monitoring of cloud environments for all delivery methods (SaaS, PaaS, IaaS).

Only Oracle offers the industry's most complete and integrated virtualization, from desktop to the datacenter. Going far beyond simple consolidation, Oracle enables you to virtualize and manage your full hardware and software stack.

Oracle's virtualization technologies are a key component of IaaS solutions and cover the *entire spectrum* of hardware and software, including:

- Hardware domaining on the Oracle/Sun M Series enterprise servers
- Chip-level hypervisor-based virtualization for SPARC CMT processors
- Hypervisor-based virtualization for x86 servers
- Efficient and highly scalable OS environment virtualization that does *not* require a hypervisor, using Solaris containers

More details about [Oracle Infrastructure as a Service](#) solutions can be found on Oracle.com through the link provided.

Managing the Cloud

Oracle Enterprise Manager and Ops Center have been combined to provide a broad set of capabilities to reduce the complexity and ultimately the cost of managing cloud environments. One of the critical success factors for cloud computing is to provide managed services that can deliver high quality of service levels. End-to-end application, platform and infrastructure management is required to provide cloud customers with dynamic, flexible, reliable, cost-effective services. Oracle Enterprise Manager provides this management platform for the entire Oracle technology stack.

Oracle Solaris and Oracle Enterprise Linux are the operating systems that complete the IaaS software stack. Because they are the same operating systems that Oracle uses to develop and test all Oracle software, including all the components of our PaaS, the resulting IaaS platform is highly reliable and not subject to issues that might arise using another vendor's OS. Both operating systems are continuously tuned to work optimally with the rest of the PaaS platform.

More details about [Oracle Cloud Management](#) can be found on Oracle.com through the link provided.

Securing the Cloud

Oracle is one of the very few vendors that offer capabilities to secure a cloud environment from applications to disk.

Oracle follows a defense-in-depth strategy and believes that security needs to be built-in and not bolted on at a later point of time. Hence, all Oracle products have security capabilities built within. Also, Oracle's products regularly go through certifications like Evaluation Assurance Level (EAL) Certification as required by various higher education and research organizations. With the Sun

acquisition, Oracle is the only vendor in the market that can provide security services from an infrastructure perspective (at the chip level) all the way up to application security in a variety of Oracle's application product lines like Siebel CRM, Oracle E-Business Suite and PeopleSoft.

More details about [Oracle Cloud Security](#) can be found on Oracle.com through the link provided.

Conclusion

Oracle has three strategic objectives in cloud computing for education:

- Ensure that cloud computing is available as an enterprise-grade service to enable effective adoption by our education customers.
- Provide the infrastructure necessary to power both public and private clouds to give education institutions meaningful choices when they are making decisions about cloud deployment.
- Jointly develop with education institutions (ministries of education, higher education systems, state agencies, etc.) shared services models that drive extreme performance and efficiency.

Oracle and Sun were early pioneers in SaaS with Network.com and Oracle On Demand, providing customers with an off-premise hosting model for ERP and CRM applications as well as PaaS for many different kinds of applications. Oracle continues to provide on-demand services for various higher education institutions.

For higher education and research enterprises building private clouds, Oracle's grid computing platform provides the industry's most complete, open and integrated stack of virtualized and clustered databases, middleware and storage, including infrastructure and grid management solutions.

Oracle is the only enterprise software and hardware company that provides end-to-end (application-to-disk) architectures to provide education systems with cloud solutions that will dramatically reduce IT cost and complexity and maintain or enhance service levels for researchers, students, faculty, and staff.

Oracle welcomes the opportunity to join forces with education and research institutions globally to advance the adoption of cloud infrastructures in an effort to enhance core missions of superior teaching, learning, and research.

Additional Resources

- NIST definition – <http://csrc.nist.gov/groups/SNS/cloud-computing/>
- Oracle's cloud computing - <http://www.oracle.com/goto/cloud>
- Cloud Security Alliance - <http://www.cloudsecurityalliance.org/>
- The Higher Ed CIO blog: Cloud Computing -- <http://blog.thehigheredcio.com/category/cloud-computing/>

- EDUCAUSE: Cloud Computing Explained -- <http://www.educause.edu/EDUCAUSE+Quarterly/EDUCAUSEQuarterlyMagazineVolum/CloudComputingExplained/206526>
- NACUBO: Cloud Computing Initiatives -- http://www.nacubo.org/Initiatives/Cloud_Computing.html
- The Big Switch – Nicholas Carr - <http://www.nicholasgcarr.com/bigswitch/>



Oracle Cloud Solutions for Public Sector
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