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....chief information officer and vice president for information technology in today's higher education

 Contact me at samuel.conn@gmail.com or 770.851.1513

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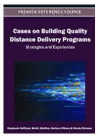

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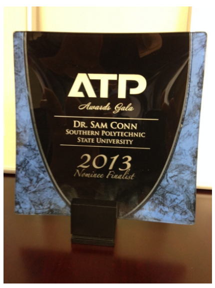

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Cloud Computing Development Models

SUNDAY, DECEMBER 9, 2012 AT 11:00AM

Four cloud computing development models are currently acknowledged: (i) public cloud, (ii) private cloud, (iii) community cloud, and (iv) hybrid cloud. Accordingly, public cloud computing can result in security risks not associated with private cloud computing. Public clouds involve a public service provider who offers free or pay-per-service fee structures. Using the Internet for connectivity, public cloud providers operate and maintain the infrastructure. Private clouds normally involve hosting by a single provider to deliver one or more service models to the organization. Community cloud models involve shared infrastructure between communities with similar interests (e.g., information security) such that cost sharing is possible. Hybrid clouds can be hosted by a combination of public, private, and community cloud models where end-users can enjoy the benefits of all three.

If an academic institution operates only one production network with access to existing cloud computing resources, testing and experimentation, instruction, and prototype development of online program information technologies and systems are difficult. The academic institution requires clear separation of development, test, and production environments from which to operate stable online program administrative and academic application environments, yet accommodate the instructional, research, and development needs of faculty and students involved in online computing and information sciences.

What network topology best facilitates use of a cloud computing paradigm in support of online research and education? Cloud resources can exist and reside in an academic institution’s central data center, managed host facility, or co-located computing center. Students and faculty in each aforementioned area require distinct technological environments to accommodate online course computing, experiential learning, action research, and applied instruction.

The term cloud computing represents a continuation of past computing paradigms and has evolved progressively over the past 19 years since the term was introduced by Ramnath Chellappa, Associate Professor of Management Information Systems at Emory University. In 1997, building on seminal concepts of computation as a “public service” or “public utility” put forth by John McCarthy, Chellappa joined an existing telecommunications industry term (cloud) used to describe large Asynchronous Transfer Mode (ATM) networks with the notion of ubiquitous computing. Thus, the term is used to describe older concepts in new ways.

Moreover, technology thought-leaders note the emergence of a meta-university concept that works in concert with a cloud computing paradigm. The term *meta-university* describes the future concept of higher education as a transcendent, accessible, empowering, dynamic, communally constructed framework of open materials and platforms on which much of higher education worldwide can be constructed or enhanced. Cloud computing works in concert with the sharing of knowledge and resources, a millennium- refined value of academia.

As a computing model, cloud computing follows traditional topological norms such as mainframe, client-server, distributed, multi-processing, n-tier, and grid computing, yet yields potential to support next generation computing paradigms. Accordingly, cloud computing represents the most significant advancement in information technology since the elevation of the global Internet network. Following mainframe computing, personal computing, client-server computing, and the World Wide Web, cloud computing is considered by many to be the fifth major paradigm shift in computing. Academic institutions continue to embrace the paradigm as a means of: (a) improving return-on-investment for technology infrastructure, (b) improving resource sharing, (c) enabling interactivity, collaboration and innovation among stakeholders of Web content and resources in online programs, (d) supporting mobile computing and e-learning, and (e) delivering virtual online environments.

Cloud computing architecture involves three service model abstractions: (a) infrastructure as a service (IaaS), (b) platform as a Service (PaaS), and (c) Software as a Service (SaaS). IaaS layers servers, storage, and network infrastructure into a pool of computing, storage, and connectivity capabilities that are delivered via the network as services that provide a flexible, standard, and virtualized operating environment. IaaS can be used to establish a foundation for PaaS and SaaS.

Normally, IaaS provides a standardized virtual machine hosted on a server cluster. IaaS consumers have responsibility for configuration and operations of the Operating System (OS), software, and Database (DB). Network delivered services (such as performance, bandwidth, and storage access) also can be maintained via service management strategies that cover the performance and availability of the virtualized infrastructure.

PaaS provides executable environments such application runtimes, storage, and application integration. Moreover, PaaS provides an efficient and agile method to instantiate scale-out applications in a predictable and cost-efficient manner. Information Technology service levels and operational risks are mutual as a result of the consumer taking responsibility for the stability, architectural compliance, and overall operations of the application while the provider delivers the platform capability.

SaaS provides business processes and applications (e.g., e-mail, groupware, and/or collaboration tools) as services where the provider assumes all operational risks. Significant delivery and cost efficiencies are possible as all infrastructure and information technologies are abstracted away from the consumer.

Cloud infrastructure is typically supported by block storage in the form of direct attached storage (DAS), network attached storage (NAS), or a storage area network (SAN). Additionally, server clusters to support virtual machines (VMs), and in some cases high-end computing devices, are all considered part of cloud infrastructure. Centers hosting cloud infrastructure (e.g., computing centers or data centers) can have managed host capability as a provider option. Secure and available network and internetworking components provide access to the cloud. Internetworking architecture can support cloud *partners* such as affiliated computing and data centers.

Use of cloud computing within online higher education initiatives is proliferating. Prototype initiatives, such as seen at Okanagan College and the University of British Columbia Okanagan, King's University College, University of California, Washington State University's School of Electrical Engineering and Computer Science, and North Carolina State University, reflect academic use and success with cloud computing paradigms. Accordingly, over the last few years higher education institutions have begun to transition to more research and ongoing update of information technology infrastructure as a foundation for online education activities and science research.

Moreover, academic institutions are finding compatibility between cloud computing and other major academic initiatives. For example, note the use of cloud computing in support of the Scholarship of Teaching and Learning (SoTL); cloud computing in support of convergent models of instruction; cloud computing used in experiential and project-based learning; and cloud computing coupled with strategies to reduce the cost of education.

Cloud architecture also is associated with higher education institution challenges. Accordingly, challenges include technology limitations, interoperability issues, network capacity, end-user perceptions, and adoption of cloud computing concepts. Additionally, policy and control issues, demand for services, and legacy constraints represent challenges when moving to a cloud computing paradigm. Of similar concern, note that migration to cloud computing requires a well-defined strategy. Successful cloud computing initiatives are dependent on alignment of cloud computing capabilities with higher education research and education needs, as well as clearly stating the architectural vision for infrastructure, platform, and software service delivery.

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