



Cloud Computing for DoD

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Outline



- **Introduction**
- **Cloud Computing Background**
- **Federal Government Cloud Computing**
- **Organizational Benefits Gained from Cloud Computing**
- **Summary**



Introduction



- **Rapid computer usage growth and Internet expansion along with growth in big data and analytics**
- **Desire for computing application solution that is:**
 - **Cost-effective**
 - **Able to meet consumer needs, especially adaptability and availability**
 - **Reliable**
 - **Secure**





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Problem or Opportunity



- **Large IT investment for computing**
 - Financial
 - Manpower
- **Centralization of function via cloud computing**
 - Economy of scale
 - Efficient resource usage
 - Availability to large user base
 - Agility to meet changing needs





What is Cloud Computing?



- **Computing resources held by provider**
- **Internet access to resources via PCs, laptops, smart phones, and PDAs**
- **Access to programs, storage, processing, and applications development**
- **Precursors include:**
 - **Thin clients**
 - **Grid computing**
 - **Utility computing**

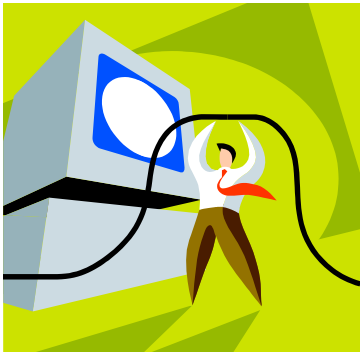




NIST Definition of Cloud Computing



- **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.*** (Mell & Grance, 2011, p. 3)





DISA - IT Trends Enabling Cloud Computing



- Increased Parallelism
 - ***New Moore's Law - 2X processors per chip generation***
 - ***Parallel software industries emerging to address challenges***
 - ***Redundant networks and storage increasing performance***
- Increased Virtualization
 - ***Processing, Storage, Bandwidth, Delivery***
- Commodity Components
 - ***X86 servers, consumer hard drives, ethernet***
 - ***Open Source SW – Freedom to customize and adapt***
- Increased Outsourcing of Core Elements
 - Carbon Disclosure Project estimated cost savings to 2000 large US companies from cloud computing adoption to be \$12.3 B/year by 2020





Four Cloud Deployment Models



- **Internal (private) cloud**
 - Enterprise owned or leased
- **Community cloud**
 - Shared infrastructure for specific community
- **Public cloud**
 - Sold to the public, mega-scale infrastructure
- **Hybrid cloud**
 - Composed of two or more cloud types





Cloud Delivery Models



- **Software as a Service (SaaS)**
 - Using provider's applications over a network
- **Platform as a Service (PaaS)**
 - Deploying customer applications to a cloud
- **Infrastructure as a Service (IaaS)**
 - Lease processing, storage, network, and other computing resources
- **Services above are all deployed on a cloud infrastructure**



Cloud Computing Growth



- **Four hour non-parallel session dedicated to cloud computing at ISC**
- **Extensive emphasis on cloud computing by IEEE Computer Society**
- **NSF cloud computing**
- **NIST support of cloud computing**
- **Rapid growth in cloud computing in both public and private sector**



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Federal Government Cloud Strategy



- **Federal Cloud Computing Strategy**
 - Adopting cloud 1st policy, $\frac{1}{4}$ of \$80 B IT budget to clouds
 - 30% reduction in data centers
- **DoD CIO's 10-Point Plan for IT Modernization**
 - IT Modernization Strategy
 - Requires Partnerships Across DoD to achieve
- **GSA launched Apps.gov to provide cloud computing information and services to federal agencies**





Federal Cloud Computing Initiative



- **Federal Cloud Computing Initiative (FCCI)**
 - **The FCCI focuses on implementing cloud computing solutions for the Federal Government that increase operational efficiencies, optimize common services and solutions across organizational boundaries and enable transparent, collaborative and participatory government.**
 - **Cloud computing definition (NIST)**
 - **Hosting cloud computing summit**
 - **Released IaaS RFI and RFQ**
 - **Launched cloud computing storefront: apps.gov**
 - **Steering Committee, Advisory Council, Working Groups**



- **Http://apps.gov by GSA for federal agencies**
 - **Federal CIO - Promoting President's agenda to modernize Federal IT**
- **Business applications**
- **Productivity applications**
- **Cloud IT services**
 - **Storage, virtual machines, web hosting**
- **Social media applications**





Air Force Cloud Computing



- **IBM effort to Design and Demonstrate Mission-Oriented Cloud Architecture for Cyber Security (2010)**
- **Air Force Research Laboratory/Information Directorate**
 - **University Center of Excellence (UCoE) in Assured Cloud Computing**
 - **Cloud Computing Collaboration with Cornell University**
 - **Ad-hoc Cloud Computing Collaboration with Harvard**
 - **Innovative Approaches to On-Demand Cloud Computing over Ad-Hoc Wireless Networks – Harmonia/VA Tech STTR**
 - **Cloud/Grid/Virtualization Architecture for AF Weather SBIR**
 - **HPC facility operates like cloud computing**



NASA Nebula Platform



- **Cloud computing pilot program at NASA Ames**
- **Integrates open-source components into seamless, self-service platform**
- **Provides high-capacity computing, storage, and network connectivity**
- **Virtualized, scalable approach**
- **Cost and energy efficient**
- **Mission support**
- **Education and public outreach**



(NASA Nebula, 2010)



NSF Supported Cloud Research



- **Support for Cloud Computing in response to America Competes Reauthorization Act of 2010**
 - **Cloud Computing Research Enhancement**
- **Cluster Exploratory (CLuE) program**
- **\$5 M to 14 Universities**
- **IBM/Google Cloud Computing University Initiative**
- **Employ SW and services on IBM/Google cloud to explore innovative research ideas in data-intensive computing, including:**
 - **Image processing**
 - **Large scale data analysis**
 - **Internet improvement studies**
 - **Human genome sequencing**



Cloud Comparison to DoD HPCMP

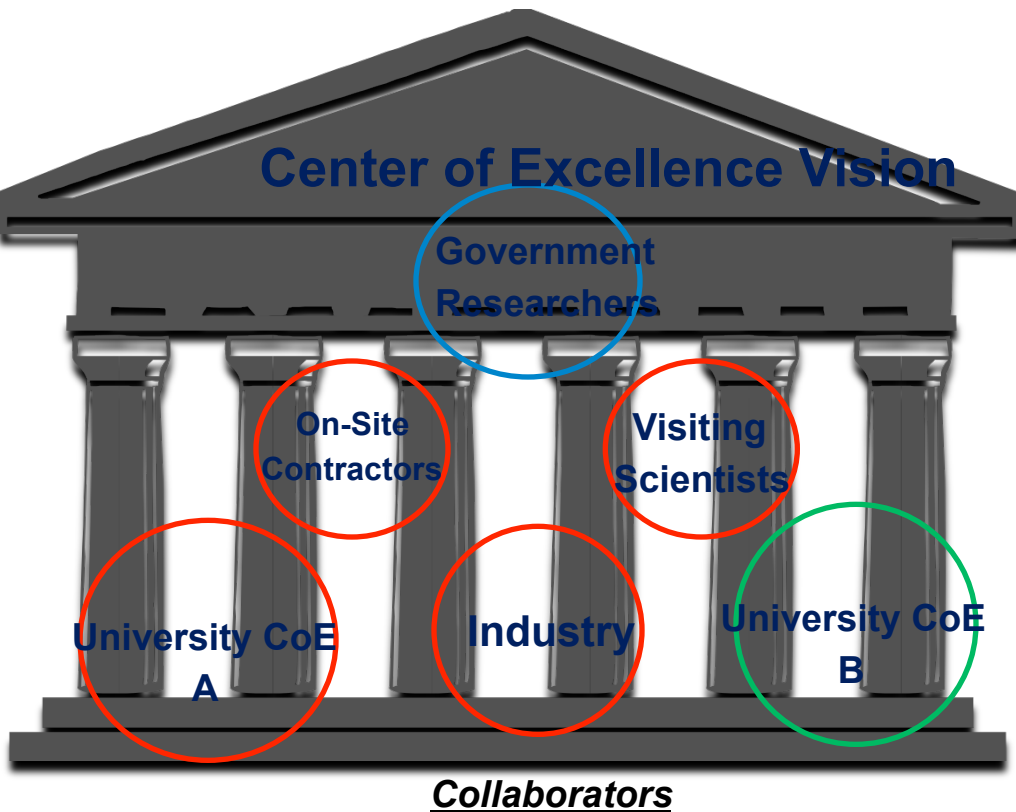


- **DoD High Performance Computing Modernization Program (HPCMP) has supported:**
 - **Grid Computing**
 - **Centralized computing resources**
 - **Centralized authentication and security**
- **DoD HPCMP currently emphasizes support for parallel computing jobs with users knowledgeable about parallel processing**
- **DREN/SDREN network support**





University Center of Excellence in Assured Cloud Computing



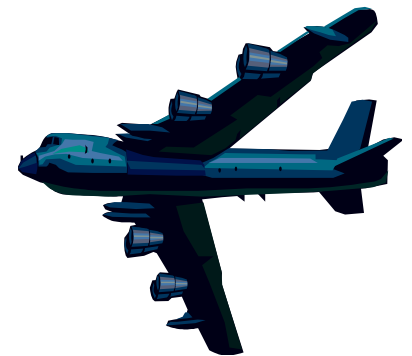
- EQUAL co-sponsorship between AFOSR and the Information Directorate (RI)
- Awarded to the University of Illinois at Urbana-Champaign for \$1M per year, 6 years
- Information Assurance research for cloud computing in a secure, timely and effective manner
- Assess and influence the predictability and performance of heterogeneous Air Force Networks
- Assured computing in dynamic, hostile, contested and high interference environments
- Responsive to Operational Needs; AFSPC Capability Need "Cyber Cloud Computing Infrastructure"



Government Cloud Strategy



- **Meet growing computational needs**
- **Enhance reliability**
- **Centralize security**
- **24/7 availability**
- **Adaptable to changing needs**





Distributed Test Events



- **Joint Mission Environment Test Capability (JMETC)** provides infrastructure to link distributed facilities
- **Incorporate Test and Training Enabling Architecture (TENA)**
- **Opportunity for cloud computing to capitalize on:**
 - **Network**
 - **Software infrastructure**
 - **Distributed test tools**
 - **Data management solutions**
 - **Reuse repository** (Norman, 2010)



Cloud Computing Advantages



- **Support for data intensive computing**
 - **Index and Parallelize large data sets**
 - **Support low BW transmission by data preformatting**
- **Ease of use – transfer complexity to cloud host**
- **Multi-user data access from large distributed cloud databases**
- **Default backup and cost effective archival for large data sets.**
- **Accessible any time, anywhere at low cost**



Programming Models

What's the right fit for DoD?



App-components-as-a-service



Google
App Engine



Software-platform-as-a-service



Data Intensive

Amazon Hadoop, Public
Data Sets, Simple DB



Virtual-Infrastructure-as-a-Service



Amazon Elastic Compute Cloud (Amazon EC2) - Beta



MOSSO
the hosting cloud



Physical infrastructure

Hardware Resources

Compute

Storage

Networking

GCDS Akamai

Content Delivery



Storage data charges of cloud computing providers (SaaS)



Vendor	Usage	Data transfer out	Data transfer in	No of requests
Amazon S3	\$0.15/GB	\$0.17/GB	No restrictions	\$0.01/1000 requests
AT&T Synaptic	\$0.25/GB	\$0.1/GB	\$0.1/GB	Nil
GoGrid	\$0.15/GB	No restrictions	No restrictions	No restrictions
Rackspace	\$0.15/GB	No restrictions	No restrictions	No restrictions

- **Prices shown for lowest usage tier and reduce with higher usage.**

Source: <http://www.thecloudtutorial.com/cloudcomparison.html>



Cost Savings



- **Centralized resources and management yield economy of scale**
- **Cost reduction of 5-7x for power, network, operations, software, and hardware**
- **Reduced energy usage and higher utilization for green computing**
- **Capitalize on low cost locations**



Need for Cloud Computing



- **Provide resources not available to individual users**
- **Minimize up-front user expenses**
- **On demand availability, ability to handle surges**
- **Provider manages security**
- **Handle data intensive applications**
- **Mobile interactive applications**
- **Large parallel computing jobs**
- **Serve countries/organizations with limited resources**
- **Medical research**
- **Online gaming**



Cloud Computing Reliability



- **Software reliability is critical**
 - **Malware**
 - **Bugs**
- **Quality of service approach beneficial**
- **Reliable Internet connectivity**



Security Effectiveness



- **Data integrity**
- **Commingling of data**
- **Virtualization**
- **Cost versus risk issues**
- **Multicore for data separation**
- **Social engineering and human error**
- **Remote access/authentication**
- **Strong, enforced security posture**





Availability and Usability



- **Proprietary software**
- **Portability between vendors**
- **Standards**



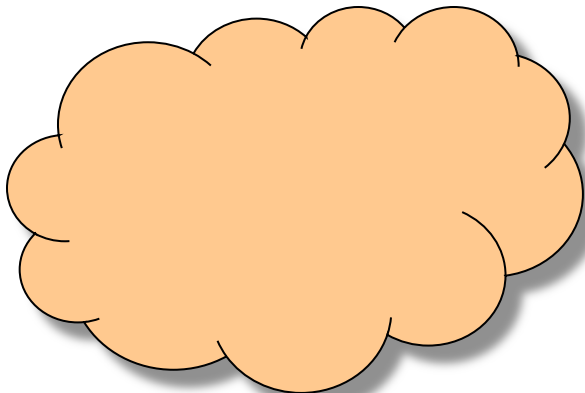


Cloud Adoption Study Implications



- **Non-technical issues influence cloud computing adoption decisions.**
- **Consideration of the overall organizational impact of cloud computing is important.**
- **A complex interaction between vendors and potential customers, considering factors such as security, need, reliability, and cost, could maximize customer benefit.**

(Ross, 2010)





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Summary



- **Cloud computing offers numerous potential benefits to the DoD**
- **AFRL can be a leader in successful DoD cloud computing ventures**





References



- Greenfield, T. (2009). Cloud Computing in a Military Context. DISA Office of the CTO. Retrieved from: http://www.au.af.mil/au/awc/awcgate/disa/cloud_computing_military_context.ppt
- Hoover, J. N. (2009, May 12). Federal Budget Lays out Government Cloud Computing Plans. Information Week. Retrieved from <http://www.informationweek.com/news/government/enterprise-architecture/showArticle.jhtml?articleID=217400505>
- Mell, P. & Grance, T. (2011). The NIST Definition of Cloud Computing. NIST Special Publication 800-145
- NASA Nebula (2010). Retrieved from nebula.nasa.gov
- Norman, R. (2010). Joint Mission Environment Test Capability (JMETC): Effective T&E by Improving Distributive Test Capabilities. Retrieved from http://www.dtic.mil/ndia/2010systemengr/WednesdayTrack8_10911Norman.pdf
- Ross, V. W. (2010). Factors Influencing the Adoption of Cloud Computing by Decision Making Managers. Capella University Doctoral Dissertation.
- Verdantix (2011). Carbon Disclosure Project Study 2011. *Cloud Computing – The IT solution for the 21st century*. Retrieved from <http://content.yudu.com/A1t6nj/Cloud-Computing/resources/index.htm?referrerUrl=>