# Introduction to Cloud Computing

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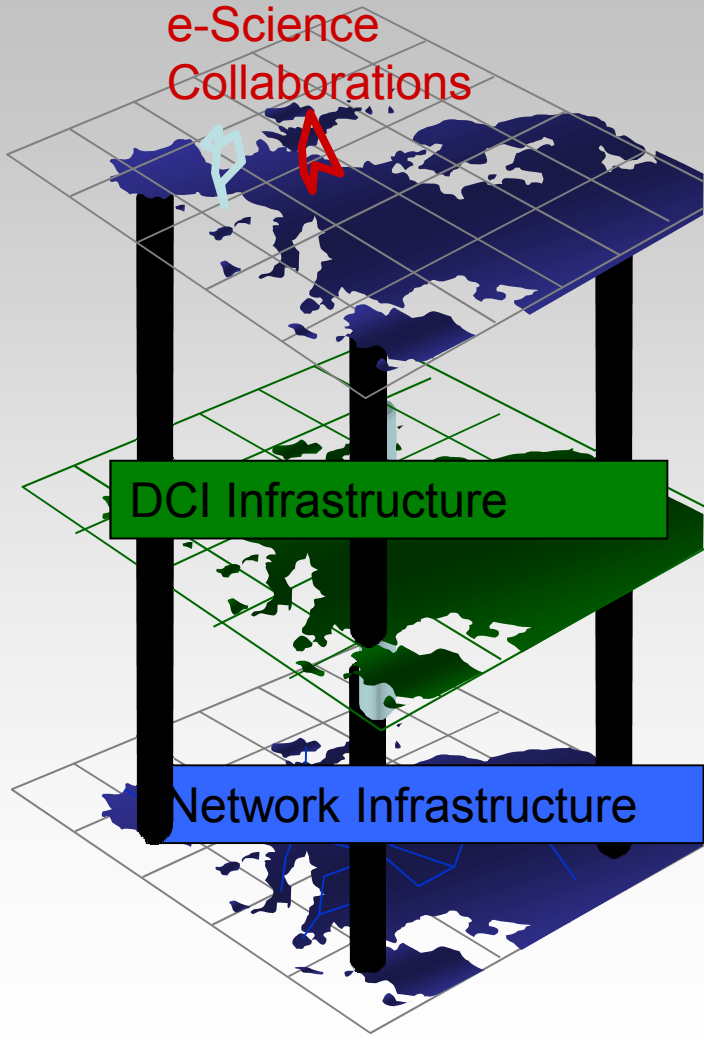
**Aneta Karaivanova, IICT-BAS, Bulgaria**

# The pan-EU e-Infrastructures vision

- The Research **Network infrastructure** provides fast interconnection and advanced services among Research and Education institutes of different countries'
  - Main Initiative: GEANT
- The Research **Distributed Computing Infrastructure (Grid, HPC)** provides a distributed environment for sharing computing power, storage, instruments and databases through the appropriate software (middleware) in order to solve complex application problems
  - Main Initiatives: EGI, DEISA, PRACE
- This integrated environment is called **electronic infrastructure (eInfrastructure)** allowing new methods of global collaborative research - often referred to as **electronic science (eScience)**
- Domain-specific infrastructures being constructed through ESFRI



# Historical View

- Local computations
  - All resources are concentrated in one place
  - The people travel in order to use that resources
- Remote access computations
  - The resources are available remotely
  - The important resources are centralized
- Distributed computations
  - The resources are distributed along different places
  - Specialized or even exotic communication protocols, especially for data transfer
- Grid computations
  - The resources and services are distributed along different places
  - *Standard Protocols*
  - Transfer of data and computations
- Cloud computing
  - Virtualization
  - The Industry accepts and standardizes the grid technologies

# What is Cloud Computing

- **Cloud computing**: provision of computational resources on demand via a network.
- **Cloud computing** offers application developers and users an abstract view of services that simplifies and ignores much of the details and inner workings. A provider's offering of abstracted Internet services is often called "The Cloud".
- **Cloud computing** is computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services. Parallels to this concept can be drawn with the electricity grid where end-users consume power resources without any necessary understanding of the component devices in the grid required to provide the service

# What is Cloud Computing? (2)

Multiple Choice: Cloud Computing is…

a) A way to access applications hosted on the web through your web browser (**Software as a Service -- SaaS**)

b) A pay-as-you-go model for IT resources accessed over the Internet (**Platform as a Service – PaaS**)

c) Use of computer infrastructure to perform parallel processing, distributed storage, indexing and mining of data (**Infrastructure as a Service – IaaS**). Rather than purchasing servers, software, data-center space or network equipment, clients instead buy those resources as a fully outsourced service.

d) Gartner: "Cloud computing is a style of computing where massively scalable IT-related capabilities are provided 'as a service' across the Internet to multiple external customers"

e) An IT buzzword that assures potential clients that your product is on the cutting edge of technology

f) All of the above

# Cloud Architecture

- *Cloud architecture* typically involves multiple cloud components communicating with each other over application programming interfaces (APIs), usually web services.
- The two most significant components of cloud computing architecture are:
  - Front end - the part seen by the client. This includes the client's network (or computer) and the applications used to access the cloud via a user interface such as a web browser
  - Back end - the 'cloud' itself, comprising various computers, servers and data storage devices.

# History

- The concept of cloud computing dates back to the 1960s, when John McCarthy said that "computation may someday be organized as a public utility."
- *The Challenge of the Computer Utility*, Douglas Parkhill, 1966:
  - Almost all the modern-day characteristics of cloud computing (elastic provision, provided as a utility, online, illusion of infinite supply) are described
- The actual term "cloud" comes from telecommunications companies, who until the 1990s primarily offered dedicated point-to-point data circuits, began offering Virtual Private Network (VPN) services with comparable quality of service but at a much lower cost. The cloud symbol was used to denote the demarcation point between that which was the responsibility of the provider, and that which was the responsibility of the user.

# History (2)

- AMAZON played a key role in the development of cloud computing by modernizing their data centers, which were using as little as 10% of their capacity at any one time, just to leave room for occasional spikes.
- Amazon initiated a new product development effort to provide cloud computing to external customers, and launched Amazon Web Service (AWS) on a utility computing basis in 2006
- In 2007, Google, IBM and a number of universities embarked on a large-scale cloud computing research project. In early 2008, Eucalyptus became the first open-source, AWS API-compatible platform for deploying private clouds.
- In early 2008, OpenNebula, enhanced in the RESERVOIR European Commission-funded project, became the first open-source software for deploying private and hybrid clouds, and for the federation of clouds
- 2008: efforts were focused on providing QoS guarantees (as required by real-time interactive applications) to cloud-based infrastructures, in the framework of the IRMOS European Commission-funded project

# Characteristics

- **Agility**
  - improves with users' ability to rapidly and inexpensively re-provision technological infrastructure resources.
- **Application Programming Interface** (API)
  - accessibility to software that enables machines to interact with cloud software in the same way the user interface facilitates interaction between humans and computers. Cloud computing systems typically use REST-based APIs.
- **Reduced Cost**
  - Cost is claimed to be greatly reduced and in a public cloud delivery model capital expenditure is converted to operational expenditure. The infrastructure is typically provided by a third-party and does not need to be purchased for one-time or infrequent intensive computing tasks. Pricing on a utility computing basis is fine-grained with usage-based options and fewer IT skills are required for implementation (in-house).
- **Device and location independence**
  - enable users to access systems using a web browser regardless of their location or what device they are using (e.g., PC, mobile phone). As infrastructure is off-site (typically provided by a third-party) and accessed via the Internet, users can connect from anywhere

# Characteristics (2)

- **Reliability**
  - is improved if multiple redundant sites are used, which makes well designed cloud computing suitable for business continuity and disaster recovery.
- **Scalability**
  - via dynamic ("on-demand") provisioning of resources on a fine-grained, self-service basis near real-time, without users having to engineer for peak loads. Performance is monitored, and consistent and loosely coupled architectures are constructed using web services as the system interface.
- **Security**
  - could improve due to centralization of data, increased security-focused resources, etc., but concerns can persist about loss of control over certain sensitive data, and the lack of security for stored kernel.

# Cloud Deployment Models

Deployment Models:

- *Internal (private) cloud.* The cloud infrastructure is operated within the consumer's organization.
- *Community cloud.* The cloud infrastructure is jointly owned by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations).
- *Public cloud.* The cloud infrastructure is owned by an organization selling cloud services to the general public or to a large industry group.
- *Hybrid cloud*. The cloud infrastructure is a composition of two or more clouds (internal, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability

# Cloud Computing Categories

## SaaS

**Software as a Service** – Instead of owning and running Applications on your computers, you rent them and get them over a network.

**Key Benefits:**
- Improved internal productivity
- Rapid delivery of new functionality
- Improved Government service

**On Demand Software:**
- Network Accessible
- One-to-many delivery model
- Leverage web technologies

**Featuring:**
- Central Management
- Remote Web Control
- Faster releases of new features

## IaaS

**Infrastructure as a Service** -Instead of owning and running your facility, servers, and network, you rent flexible computing capacity when you need it.

**Key Benefits:**
- Reduced acquisition cost
- Pay for usage, not capacity
- Reduce environmental impact

**IT Resources as a Service:**
- Servers
- CPU
- Storage
- Data Center Facilities

**Featuring:**
- Enterprise Grade Infrastructure
- Service Level Agreements
- Utility Billing Model
- Multi-Tenant Cost Spreading

## PaaS

**Platform as a Service** - Instead of owning and maintaining systems (e.g. development, testing, production, etc.) you rent them when you need them.

**Key Benefits:**
- Lower total cost of ownership
- Minimize management and maintenance
- Scalable & flexible system capacity

**On Demand IT Environment:**
- Full Development Support
- Full Testing Support
- Deploy/Host/Maintain

**Featuring:**
- Web User Interface Tools
- Concurrency Management
- Scalability, Failover, Security
- Web Services Integration
- Database Integration
- Application and User Reporting

Microsoft

# Enabling Clouds for e-Science (ECEE)

Open collaboration spot for cloud projects in Europe

- VENUS-C (Italy, Germany, UK, Spain, Sweden, Greece, Israel)
  - VENUS-C is co-funded by European Commission, as one of six European Distributed Computing Infrastructures (DCIs). VENUS-C is combining experiences in Grid infrastructures and Cloud computing to capitalise on EU investments. VENUS-C brings together 14 European partners.
  - Supporting basic research disciplines:
    - Biomedicine: Integrating widely used tools for Bioinformatics, System Biology and Drug Discovery into the VENUS-C infrastructure
    - Data for Science: Integrating computing through VENUS-C on data repositories. In particular focus will be on Marine Biodiversity through Aquamaps.
    - …

# Enabling Clouds for e-science

- StratusLab (France, Greece, Switzerland, Spain, Ireland), FP7 funded project
  - Enhancing Grid Infrastructure with Virtualization and Cloud Technologies;
  - Developing a complete, open-source cloud distribution that allows grid and non-grid resource centers to offer and to exploit an "Infrastructure as a Service" cloud.
- NGS (United Kingdom)
  - Cloud@NGS – The NGS Cloud Prototype is expected to be available until September 2011
- GRNET cloud (Greece)
  - Offering Cloud Services to Greek Research Community
- SARA cloud (The Netherlands)
  - HPC cloud computing
  - With the newly developed High Performance Computing Cloud environment researchers get access to their own Virtual Private HPC Cluster.

# Enabling Clouds for e-Science

- UCM (Spain –as part of the OpenNebula Project)
  - OpenNebula.org is an open-source project aimed at building the **industry standard open source cloud computing tool** to manage the complexity and heterogeneity of distributed data center infrastructures.
- SEECCI (Slovenia, Croatia, Serbia, Bosnia and Herzegovina, Montenegro, Kosova, FYRo Macedonia, Albania, Romania, Bulgaria)
- CESGA Spain –as part of the Open Cirrus project
  - Open Cirrus is an open cloud-computing research testbed designed to support research into the design, provisioning, and management of services at a global, multi-datacenter scale
- NEON (Sweden, Norway, Denmark, Finland, Iceland)
  - Northern Europe Cloud Computing
  - The aim with the NEON project is to review the promises and summarize the overall offering cloud computing could give to the Nordic eScience community
- BalticCloud (Estonia, Latvia, Lithuania, Belarus, Poland)
  - BalticCloud is a subproject of the BalticGrid project aimed at developing cloud infrastructure in Baltic states and Belarus

# Conclusions

The main drivers for future grid and cloud innovation are:

- **Standards** to facilitate interoperability and support freedom in choosing a service provider;
- **Integration** of existing grid layers with the on-demand delivery model typical of commercial clouds
- **Virtualisation and service-orientation** supporting better resource utilization, increased flexibility, and enchanced provision of user-focused environment,
- **Governance** models appropriate to driving open standards-based interoperability and integrated user services, and
- **Finance models** to support delivery of user-focused services leveraging a cost-effective shared infrastructure provision.

» e-IRG "Blue Paper" 2010

- Thank you for your attention.