Cloud computing

- La definizione classica di riferimento è quella del National Institute of Standards and Technology (NIST) USA (http://goo.gl/eBGBk)
- In sintesi il Cloud computing si occupa di:

Fornitura di tecnologia di informazione e comunicazione (ICT) come servizio

Caratteristiche del Cloud

- **Self-service, on-demand**
  - Il cliente chiede autonomamente ciò che gli serve, quando gli serve (e sperabilmente lo ottiene).
- **Accesso attraverso la rete**
  - Assume che una rete (Internet o intranet) sia disponibile, normalmente a banda larga.
- **Pool di risorse**
  - L'utente non si preoccupa di conoscere i dettagli delle risorse, che sono gestiti dai Cloud resource provider.
- **Elasticità**
  - Il servizio Cloud può scalare rapidamente come dimensioni a seconda delle necessità del cliente.
- **Pagamento a consumo**
  - Il cliente paga solo per ciò che usa.

Una analogia: l'autonoleggio

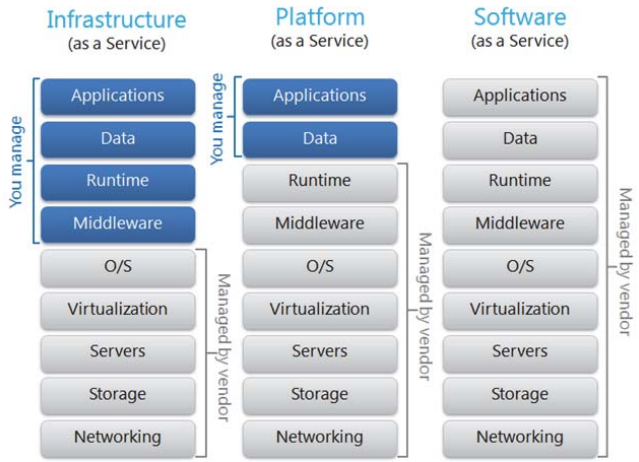
- Self-service, on-demand
  - Prenotazione telefonica oppure online
- Rete
  - Estesa rete di autonoleggi in tutto il mondo
- Pool di risorse
  - Pensa l'autonoleggio a gestire sapere quante macchine gli servono
- Elasticità
  - Il numero di auto disponibili normalmente varia a seconda della richiesta
- Pagamento a consumo
  - Il cliente paga per il tempo in cui usa l'auto (e non pensa ad assicurazione, gomme, etc.)

Fonte: http://goo.gl/cEa8M

Il focus sul "service"

- Abbiamo visto che nella definizione di Cloud computing ("Fornitura di tecnologia di informazione e comunicazione come servizio") il ***servizio*** nei confronti del cliente è parte essenziale.
- Il Cloud computing si può modellare infatti intorno a *servizi* legati principalmente a
  - Infrastruttura (**IaaS** → Infrastructure as a Service)
  - Piattaforma (**PaaS** → Platform as a Service)
  - Software (**SaaS** → Software as a Service)

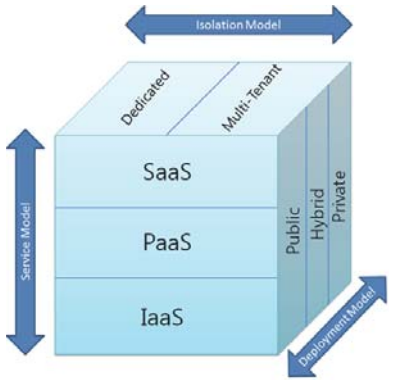
Chi fa cosa?



Fonte: http://goo.gl/1jmkR

Aggiungiamo dimensioni

- Oltre i modelli di *servizio*, parti importanti per definire e capire il Cloud computing sono i modelli di:
  - ***deployment*** (dove distribuisco i servizi)
  - ***isolamento*** (come isolo i servizi)



Fonte: http://goo.gl/1jmkR

Deployment: i “tipi di Cloud”

- **Cloud privata:**
  - L’infrastruttura viene fornita per un *uso* esclusivo da parte di una singola organizzazione. La gestione, l’operazione, la proprietà, la dislocazione della Cloud privata tuttavia può essere anche indipendente dall’organizzazione che la usa.
- **Cloud di comunità (Community Cloud):**
  - L’infrastruttura è disponibile ad una comunità di organizzazioni che hanno uno scopo comune (ad esempio missione, requisiti di sicurezza, conformità a regole comuni, etc.)
- **Cloud pubblica:**
  - L’infrastruttura è disponibile in generale al pubblico. La gestione può essere pubblica o privata. La dislocazione è presso il fornitore di servizi.
- **Cloud ibrida:**
  - L’infrastruttura è una combinazione di due o più infrastrutture Cloud (private, di comunità o pubbliche) che sono collegate in modo da garantire forme di portabilità ad esempio di dati o applicazioni.

Isolamento

- I modelli di **isolamento** nel Cloud (spesso ignorati) sono importanti e si dividono in:
  - Infrastrutture dedicate
  - Infrastrutture “multi-tenant” (con diversi [tipi di] clienti)
- Il tipo di isolamento è importante per molti aspetti, come:
  - Segmentazione delle risorse
  - Protezione dei dati
  - Sicurezza delle applicazioni
  - Auditing
  - Disaster recovery

Che differenza c'è…

- … tra virtualizzazione e Cloud computing?

- Risposta:

Virtualizzazione?

- Il Cloud computing può anche essere fornito *senza* l'utilizzo di tecnologie di virtualizzazione.
  - Spesso tuttavia l'utilizzo di tecnologie di virtualizzazione consente di ridurre i costi operativi e in conto capitale.
  - Essere in grado di fornire molto rapidamente delle macchine virtuali non è comunque efficiente, se servono diversi mesi per effettuare il provisioning e l'installazione degli host fisici.
    - Inoltre, il tempo impiegato per la fornitura dello strato di virtualizzazione è recuperato dai risparmi associati al non dover utilizzare server fisici?
    - Importanza di avere tool di installazione, monitoring e accounting il più possibile automatizzati.
- Ma che cosa si intende con *virtualizzazione*?

Riassumendo: virtualizzazione vs. Cloud computing

- **Installazione/reinstallazione** di server o di applicazioni su VM di per sé ***non è Cloud computing***.
- Verificare con le **5 caratteristiche del Cloud** mostrate precedentemente:
  - Self-service, on-demand → **NO** (tipicamente è un dipartimento IT che fornisce le VM)
  - Accesso attraverso la rete → **NO** (deployment limitato a "internal customers")
  - Pool di risorse → **SÌ**
  - Elasticità → **NO** (tipicamente è un dipartimento IT che deve installare sistema operativo + software, e non necessariamente in modo scalabile)
  - Pagamento a consumo → **NO** (spesso il billing non viene fatto a consumo ma in modo tradizionale)
- **Un esempio di virtualizzazione che non è Cloud?** (ma che è complementare al Cloud)

Cloud Computing

Part 1: What is Cloud Computing?

Alberto Zuccato
Department of Mathematics, University of Padova

July 14, 2014

Summary

1. Cloud computing at a glance
2. The NIST definition of cloud computing
3. Economics of the cloud
4. Open challenges

Computing utilites - Vision

- 1969, Leonard Kleinrock one of the chief scientists of the original ARPANET:

"As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of 'computing utilities' which, like present electric and telephone utilities, will service individual homes and offices across the country."

Referred to as utility computing or, recently (since 2007), as cloud computing:

- users access services based on their requirements without regard to where the services are hosted
- denotes the infrastructure as a "cloud" from which businesses and users can access applications as services from anywhere in the world and on demand
- cloud computing can be classified as a new paradigm for the dynamic provisioning of computing services supported by state-of-the-art data centers employing virtualization technologies for consolidation and effective utilization of resources.

Computing utilites - Enablers

- One of the most commonly-held views of cloud computing:

"I don't care where my servers are, who manages them, where my documents are stored, or where my applications are hosted. I just want them always available and access them from any device connected through Internet. And I am willing to pay for this service for as a long as I need it."

- strong similarities to the way we use other services, such as water and electricity
- turns IT services into utilities
- made possible by the effective composition of several technologies, which have reached the appropriate maturity level:
  - Web 2.0 technologies ⇒ Internet turned into a rich application and service delivery platform
  - Service orientation ⇒ to deliver capabilities with familiar abstractions
  - Virtualization ⇒ to confer on cloud computing the necessary degree of customization, control, and flexibility for building production and enterprise systems.

Cloud - The term

The term *cloud* has historically been used in the telecommunications industry:

- abstraction of the network in system diagrams
- the symbol of the most popular computer network: the Internet

This meaning also applies to cloud computing, which refers to an Internet-centric way of computing. Internet plays a fundamental role.

"Cloud computing refers to both the applications delivered as services over the Internet and the hardware and system software in the data centers that provide those services."

Traversing the entire stack:

- XaaS ⇒ everything as a service
- different component of a system:
  - delivered
  - measured
  - priced, as a service

Cloud Computing at a glance

The utility-oriented nature of cloud computing:

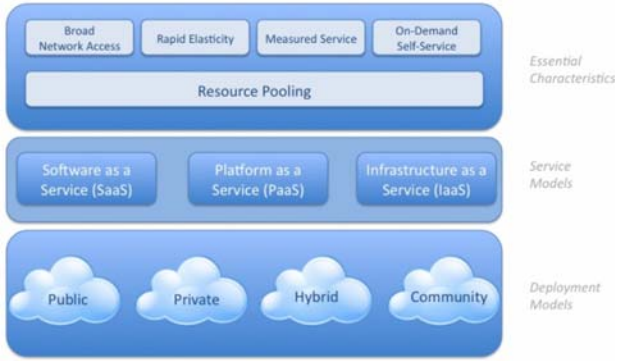
"A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers."

Buyya et.al

Cloud Computing - NIST Reference Model

"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."

Composed of: 5 essential characteristics, 3 service models, 4 deployment models.



Cloud Computing - 5 essential characteristics

- On-demand self-service
  - a consumer can unilaterally provision computing capabilities
  - doesn't require human interaction with each service provider
- Broad network access
  - capabilities available over the network
  - accessed through standard mechanisms
  - heterogeneous, thin or thick client platforms
- Resource pooling
  - provider's computing resources are pooled to serve multiple consumers
  - multi-tenant model
  - different physical and virtual resources dynamically assigned and reassigned according to consumer demand
  - customer generally has no control or knowledge over the exact location
  - may be able to specify location at a higher level of abstraction

Cloud Computing - 5 essential characteristics

...continued

- Rapid elasticity
  - elastic provision of capabilities, commensurate with demand
  - to the consumer, appear to be unlimited and can be appropriated in any quantity at any time
- Measured service
  - automatic control and optimization of resource
  - metering capability appropriate to the type of service
  - resource usage can be monitored, controlled, and reported
  - transparency for both the provider and consumer of the utilized service

Cloud Computing - 3 service models

- Software as a Service (SaaS)
  - consumers use the provider's applications running on a cloud infrastructure
  - applications accessible from various client devices
  - possible exception of limited user-specific application configuration settings
- Platform as a Service (PaaS)
  - consumers deploy onto the cloud infrastructure
  - consumers create or acquire applications using tools supported by the provider
  - consumers has control over the deployed applications and possibly configuration settings for the application-hosting environment
- Infrastructure as a Service (IaaS)
  - consumers provision computing resources (e.g., processing, storage, network)
  - consumers are able to deploy and run arbitrary software, including OS and apps
  - consumers have control over OS, storage, and deployed applications
  - possibly limited control of select networking components (e.g., host firewalls)

Consumers does not manage or control the underlying cloud infrastructure !!!

Cloud Computing - 4 deployment models

- Private cloud
  - cloud infrastructure provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units)
  - may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises
- Community cloud
  - cloud infrastructure provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy , and compliance considerations)
  - may be owned, managed , and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises

Cloud Computing - 4 deployment models

...continued

- Public cloud
  - cloud infrastructure provisioned for open use by the general public
  - may be owned, managed, and operated by a business, academic, or government organization, or some combination of them
  - it exists on the premises of the cloud provider
- Hybrid cloud
  - cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public)
  - remain unique entities , but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds)

Cloud computing economics - Facts

The main drivers of cloud computing are:

- economy of scale
- simplicity of software delivery and its operation
- biggest financial benefit $\Rightarrow$ pay-as-you-go model offered by cloud providers

In particular, cloud computing allows:

- reducing the capital costs associated to the IT infrastructure
- eliminating the depreciation or lifetime costs associated with IT capital assets
- replacing software licensing with subscriptions
- cutting the maintenance and administrative costs of IT resources

Cloud computing economics - Strategies

Pricing models ⇒ three different strategies that are adopted by the providers

- Tiered pricing
  cloud services offered in several tiers, each of which offers a fixed computing specification and SLA at a specific price per unit of time (e.g., Amazon for pricing the EC2 service)
- Per-unit pricing
  revenue for the cloud provider is determined in terms of units of specific services, such as data transfer and memory allocation. Customers can configure their systems more efficiently according to the application needs. (e.g., GoGrid pay according to RAM/hour units)
- Subscription-based pricing
  users pay a periodic subscription fee for use of the software or the specific component services that are integrated in their applications. All of these costs are based on a pay-as-you-go model

Cloud computing economics - Characteristics and benefits

Some interesting characteristics that bring benefit to both cloud service consumers and cloud service providers:

- no up-front commitments
- on-demand access
- nice pricing
- simplified application acceleration and scalability
- efficient resource allocation
- energy efficiency
- seamless creation and use of third-party services

The cost of buying hardware turns into a cost for leasing it
The cost generated by the purchase of software turns into a subscription fee paid for using it

Cloud Computing - Open challenges

Significant amount of work in academia focused on defining the challenges brought by this phenomenon. We highlight the most important ones:

- the definition and the formalization of cloud computing
- the interoperation between different clouds
- the creation of standards, security, scalability, fault tolerance
- organizational aspects

The definition and the formalization of cloud computing

- general agreement on the NIST definition, but there are alternative taxonomies
- being in its infancy the phenomenon is constantly evolving
- is a working definition, which by nature identifies something that continuously changes over time by becoming refined

Open challenges - Interoperability

The interoperation between different clouds

- vendor lock-in constitutes one of the major strategic barriers
- the standardization efforts are mostly concerned with the lower level of the cloud computing architecture
- use of a proprietary virtual machine format ⇒ Open Virtualization Format (OVF) attempt to provide a common format
- providing standards for supporting the migration of running instances
- devising a general reference architecture for cloud computing systems and providing a standard interface through which one can interact with them
- at the moment the compatibility between different solutions is quite restricted
- In the IaaS market, AWS plays a leading role, other IaaS solutions, mostly open source, provide AWS-compatible APIs

There is no consistent trend in devising some common APIs for interfacing with IaaS (and, in general, XaaS), and this constitutes one of the areas in which a considerable improvement can be made in the future.

Open challenges - Security, Scalability, Fault Tolerance

The creation of standards, security, scalability, fault tolerance

- scale on demand is one of the most attractive features of cloud computing
- cloud middleware has to be designed with the principle of scalability in mind
- the challenge in this case is designing highly scalable and fault-tolerant systems that are easy to manage and at the same time provide competitive performance
- the traditional cryptographic technologies are used to prevent data tampering and access to sensitive information
- a new way of using existing technologies creates new opportunities for additional threats to the security of applications
- the lack of control over their own data and processes also poses severe problems for the trust we give to the cloud service provider and the level of privacy we want to have for our data
- when a violation of privacy or illegal access to sensitive information is detected, it could become difficult to identify who is liable for such violations

Security, trust, and privacy issues are major obstacles for massive adoption of cc. The challenges in this area are mostly concerned with devising secure and trustable systems from different perspectives: technical, social, and legal.

Open challenges - Organizational Aspects

Organizational aspects

- billing model that is new within typical enterprise IT departments requires a certain level of cultural and organizational process maturity
- what is the new role of the IT department in an enterprise that completely or significantly relies on the cloud?
- the lack of control over the management of data and processes poses not only security threats but also new problems that previously did not exist
- traditionally, when there was a problem with computer systems, organizations developed strategies and solutions to cope with them, often by relying on local expertise and knowledge
- one of the major advantages is to reduce or completely remove the costs related to maintenance and support, as a result, users of such infrastructure and services lose a reference to deal with for IT troubleshooting
- the existing IT staff is required to have a different kind of competency and, in general, fewer skills, thus reducing their value

These are the challenges from an organizational point of view that must be faced and that will significantly change the relationships within the enterprise itself among the various groups of people working together.

References

- Mastering Cloud Computing. Foundations and Applications Programming. Buyya, Vecchiola, Selvi - Chapters: 1, 4
- The NIST Definition of Cloud Computing
  `http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf`
- An Introduction to Cloud Computing
  `http://www.slideshare.net/gxsinc/an-introduction-to-cloud-computing-part1-what-is-cloud-computing`
- Reference Model of Cloud Computing. Public Carrier's View
  `https://www.itu.int/dms_pub/itu-t/oth/15/08/T15080000050001PDFE.pdf`