Overview of Cloud Computing

(ENCS 691K – Chapter 1)

Roch Glitho, PhD
Associate Professor and Canada Research Chair
My URL - http://users.encs.concordia.ca/~glitho/
Overview of Cloud Computing

- Towards a definition
- Enabling technologies
- Cloud Layers
- Cloud Types
- Beyond the functional challenges
- Cloud based applications provisioning
References

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6. N. Bitar et al., Technologies and Protocols for Data Center and Cloud Networking, IEEE Communications Magazine, September 2013
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Towards a Definition
Towards a Definition

“Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services. These resources can be dynamically reconfigured to adjust to a variable load, allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs””

Reference [1]
Towards a Definition

“Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services. These resources can be dynamically reconfigured to adjust to a variable load, allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the infrastructure provider by means of customized SLAs””

Reference [1]
Towards a Definition

“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 interactions”

NIST definition as cited in Reference [2]
Towards a Definition

A better approach than a definition: Isolate the distinctive characteristics. Examples as per reference (3):

- Appearance of infinite computing resource available on demand
- Elimination of an upfront commitment by users
- Ability to pay per use
Towards a Definition

The combination of characteristics that make cloud computing a distinct paradigm

- Multiple tenancy
- Scalability
- Elasticity
- Rapid provisioning of services and applications
- Pay per use
Enabling Technologies
Key Enabling Technologies

Virtualization:
- Provides virtual resource from real resource (e.g. hardware, storage, network) to ensure an efficient usage of the real resource

Note: Users are isolated from each other and can interact in a harmful way like in P2P.
Virtualization:
- Provides virtual resource from real resource (e.g. hardware, storage, network) to ensure an efficient usage of the real resource

Note: Users are isolated from each other and can interact in a harmless way (unlike in P2P).
On Virtualization

Examples of virtualization types
- Node level
- Network
- Desktop
On Virtualization

Examples of virtualization platforms

- XEN
- Openstack
Key Enabling Technologies

Web services
- Integration of hardware/software systems over communication networks including Internet

Key enabler for:
- Rapid applications and services provisioning
On Web Services

Web 1.0

• Publication of documents
• Human interaction
• Proprietary ad-hoc interfaces

Web 2.0

• Publication of “reusable business logic”
• Automated Program to program interaction
• Industry standard interfaces

XML Technology

Note: There are other technologies such as JSON that may be used
On Web Services

“The term Web Services refers to an architecture that allows applications (on the Web) to talk to each other. Period. End of statement”

Adam Bobsworth in ACM Queue, Vol1, No1
SOAP Based Web Services

- UDDI
- UDDI
- WSDL
- SOAP
- HTTP, FTP, SMTP, MQ, IIOP, etc

Service Publication and Discovery
Service Description
XML-Based Messaging
Network

Security
Management
QoS
RESTful Web Services

- REST is a way to reunite the programmable web with the human web.

- Relies on HTTP and inherits its advantages, mainly
  - Addressability
  - Unified interface
Utility computing:
- Provisioning of resources on-demand and charging based on usage instead of a flat rate

Key enabler for:
- Pay per use
Cloud Layers
Cloud Layers

- Software-as-a-Service (SaaS)
- Platform-as-a-Service (PaaS)
- Infrastructure-as-a-Service (IaaS)
Layers

Software as Services (SaaS): the tip of the iceberg (End-user perspective)
Layers

Software as Services (SaaS): the tip of the iceberg (End-user perspective)

Applications offered by service providers and residing in the cloud

- Pay per use basis
- Accessible by end-users (and eventually other applications)
- An example:
  - Remedyforce for IT helpdesk management
Layers

Platforms as a Service (PaaS): immersed part I (Service provider perspective)
Layers

Platforms as a Service (PaaS): immersed part I (Service provider perspective)

- Platforms used for the development and management of the applications offered as SaaS to end-users (and other applications)
  - Examples:
    - Google Apps Engine
    - Microsoft Azur
    - Cloud Foundry
    - MapReduce
Layers

Infrastructure as a Service (IaaS): immersed part II: Infrastructure provider perspective
Layers

Infrastructure as a Service (IaaS): immersed part II: Infrastructure provider perspective

Virtualized resources (CPU, memory, storage and eventually service substrates) used (on a pay per use basis) by applications

- Examples
- IBM Blue Cloud
- Amazon EC2
The Horsepower behind the IaaS

Figure 1. A typical DCN structure.

From reference 5
The Horsepower behind the IaaS

Figure 1. Generic architecture for cloud networking.

Taken from reference 6
The horsepower behind the IaaS

- Virtual machines (VMs) running on server blades
- Virtual switches
- Top of rack (ToR) switches – aggregation switches
  - End of Rack (EoR) switches – chassis switches might all be used
- Core switches
- Data center gateways
- IP/MPLS network (Internet or private networks)
On cloud Networking

- Intra data center networking
- Inter data center networking
On cloud Networking
(Intra data center networking)

Figure 4. Example of multipath routing between three servers A, B, and C.

Taken from reference 7
Cloud Types
Types of Clouds

Public cloud:

- Resources offered to the general public
  - No initial capital investment required from the service providers that wish to offer services using a public cloud
    - Ex: Content Delivery Networks (CDNs) built on top of public storage clouds
  - On the other hand:
    - Less control over data, network and security
      - In CDNs for instance there might be possibility of surrogate servers in some countries due to the lack of coverage by storage cloud
Types of Clouds

Private cloud:

- Exclusive use by a given organization
  - Might be built and managed by the organization or external providers
    - High control over security, performance reliability and others
  - However:
    - Require high initial investment cost
Types of Clouds

Hybrid cloud:
- Combination of public and private cloud
  - The “best” of the 2 worlds
    - Tries to address the limitations of public and private clouds
  - Key issue:
    - Best split between public and private components
Types of Clouds

Virtual private clouds:

- Alternative for getting the “best” of the 2 worlds
  - Runs on top of public clouds
  - Leverages virtual private network technics to get more control over:
    - Topology
    - Security
    - And others …
Beyond functional challenges / characteristics
Beyond the Functional Challenges

Key functional challenges
- Multiple tenancy
- Scalability
- Elasticity
- Rapid provisioning of services and applications
- Pay per use

...
Beyond the Functional Challenges

Examples:

- **Availability**
  - Which level of outage is acceptable?
    - Depend on users and / or applications
    - An example of cloud with very stringent availability requirement:
      - Telco cloud
  - For examples of outage of known cloud products (e.g. Amazon S3, Google Apps Engine) see reference [3]
    - Note: The figures are relatively old
Beyond the Functional Challenges

Examples:
- Data lock in
  - Most cloud products still rely on proprietary APIs / protocols
    - Interoperability and portability issues
    - Numerous cloud standardization bodies are now tackling the issues, eg.
      - IEEE, ITU-T, NIST, DMTF (de jure)
      - Open Stack, Cloud Foundry (de facto)
Beyond the Functional Challenges

Examples:

- **Security**
  - Most cited objection against cloud adoption
    - Security threats from inside the cloud and outside the cloud
  - Primary mechanism used today:
    - virtualization
      - Prevent to some extent against users attacking each other and users attacking the cloud infrastructure thanks to isolation
On Cloud Based Applications Provisioning
cloud based applications provisioning

Which (end-user) applications could be provisioned using cloud paradigm?
- Almost any application
  - Some examples:
    - Scientific applications
    - Multimedia applications
    - Internet of Things applications
    - Telecommunications applications
cloud based applications provisioning

Expected benefits (Sample)
- Multiple tenancy
- Scalability
- Elasticity
- Rapid provisioning of services and applications
- Pay per use
cloud based applications provisioning

Eventual constraints (Sample)
- Availability
- Security
- Data lock in

...
On Scientific Applications in Clouds

- Computing intensive (e.g. Simulations in physics)
  - Require a lot of horsepower that could be provided by cloud IaaS
- Work done so in the area:
  - PaaS to enable rapid provisioning
    - Mapreduce programming model
      - Hadoop (Apache) and Disco (Nokia) implementations
On Multimedia Applications in Clouds

- Multimedia Conferencing Applications
  - Multimedia conferencing
    - Conversational exchange of multimedia (e.g. voice, video) between than 2 participants
      - Signalling
      - Media handling
      - Control
      - Basis of numerous applications
      - Most notable: multiparty multimedia games
On multimedia conferencing applications

- An example of multiparty multimedia games: Massively Multiplayer Online Games (MMOGs)
  - Large scale distributed applications
    - Thousands of concurrent players and game entities
    - Implemented today using client server paradigm
      - E.g. World of Warcraft with more than 10,000 computer
  - Cloud based implementations are now emerging and could solve issues such as scalability, elasticity, rapid game development and so on ...
On Multimedia Applications in Clouds

Another example of multimedia applications: Content Delivery Networks (CDNs)

- Architecture
  - Origin servers
  - Surrogate servers

- Key issues that cloud based approach might solve:
  - Scalability
  - Elasticity
  - ...

On Internet of Things Applications in Clouds

Internet of Things (IoT): Wikipedia view
On Internet of Things Applications in Clouds

Two approaches:

- Use cloud IaaS for storage and post processing of collected data (e.g. Wireless sensor data)
- Apply cloud fundamentals (e.g. virtualization) to IoT, e.g. deployment of new applications on existing wireless sensor networks
  - More research required
The End