
# Overview of Cloud Computing

## (ENCS 691K – Chapter 1)

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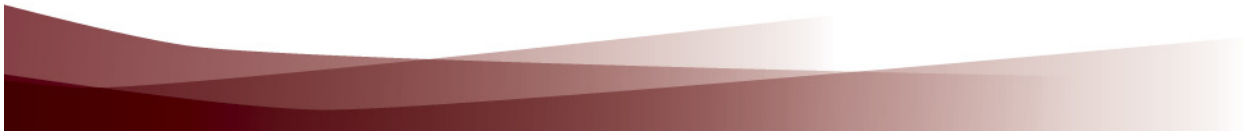

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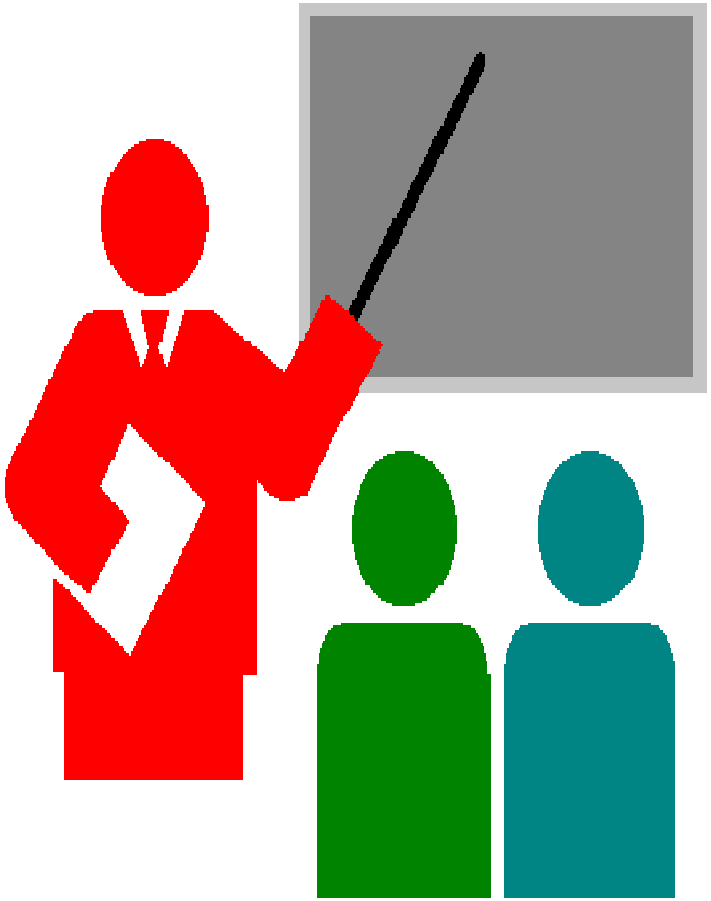

- Towards a definition
- Enabling technologies
- Cloud Layers
- Cloud Types
- Beyond the functional challenges
- Cloud based applications provisioning

# References


1. L.M. Vaquero et al., A Break in the Clouds: Towards a Cloud Definition, ACM SIGCOM Computer Review, January 2009

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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]

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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.

# 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 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

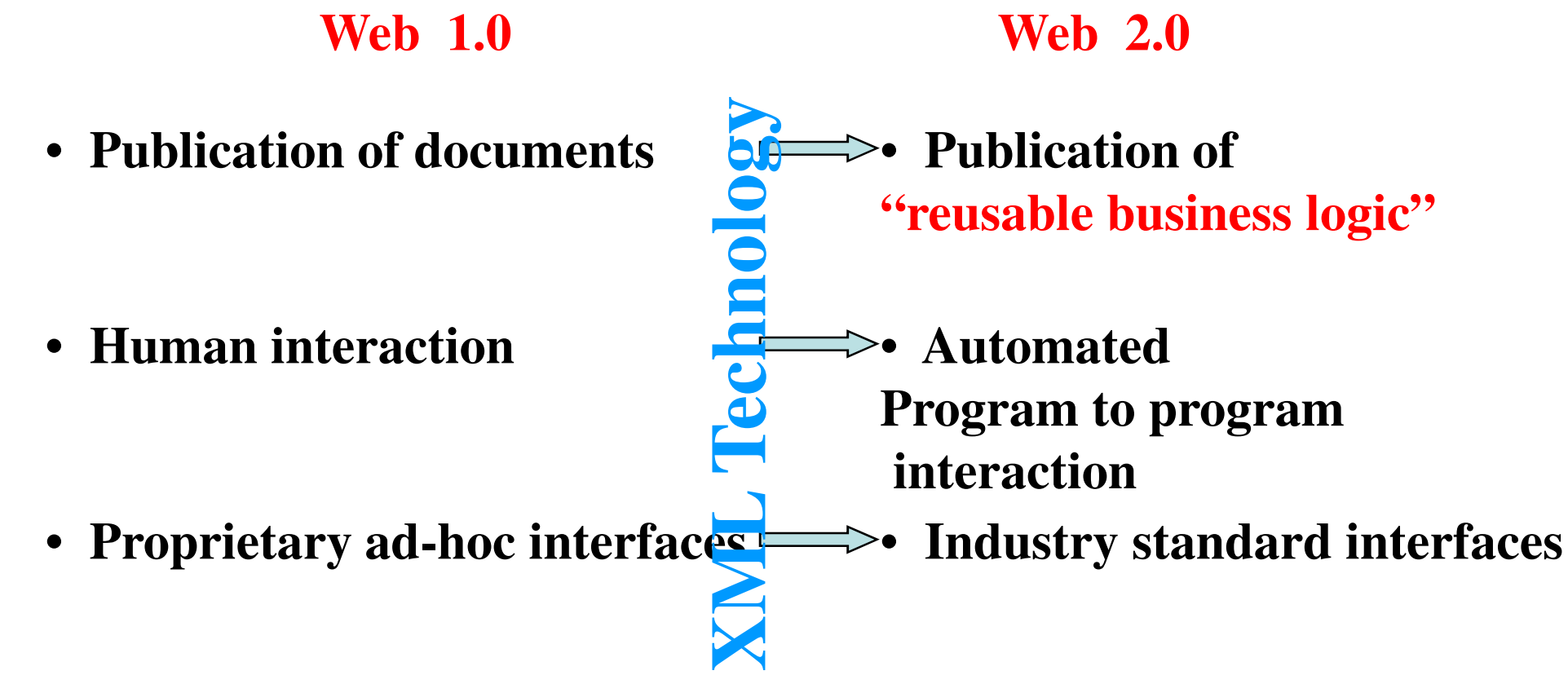
**Web services**

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

**Key enabler for:**

- Rapid applications and services provisioning

# On Web Services



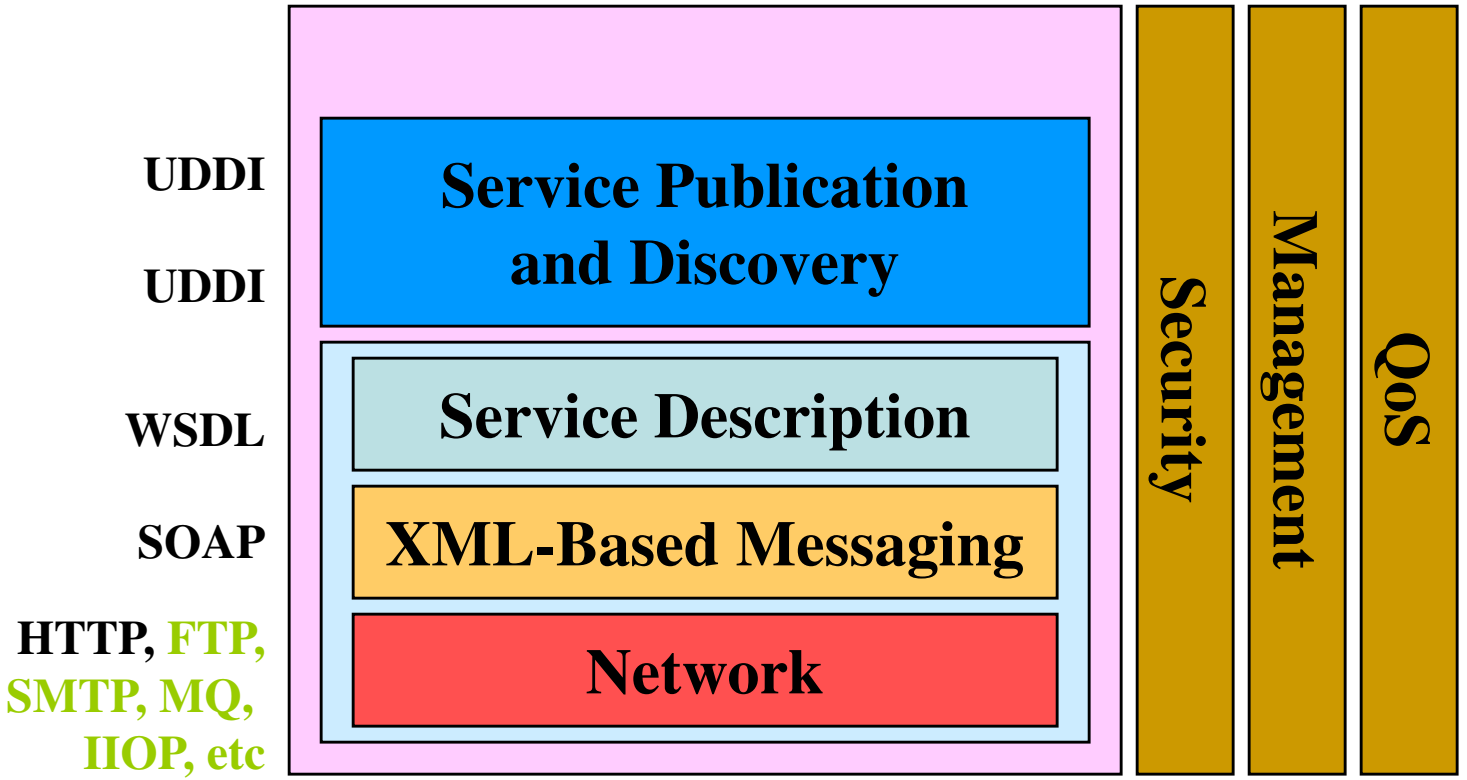

**Note: There are other technologies such as JSON that may be used**

# 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



# 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

# Key Enabling Technologies

**Utility computing:**

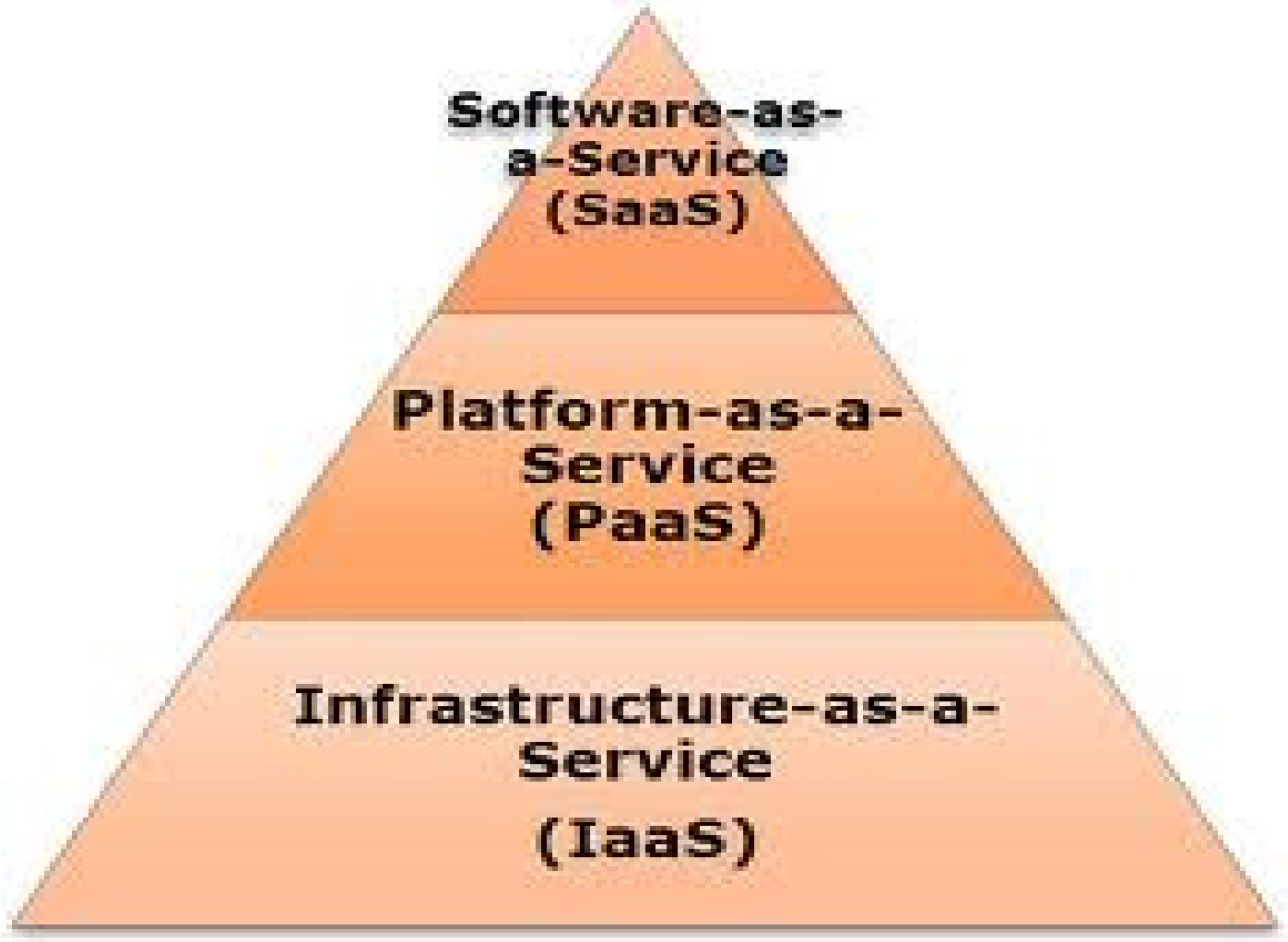
- Provisioning of resources on-demand and charging based on usage instead of a flat rate

**Key enabler for:**

- Pay per use

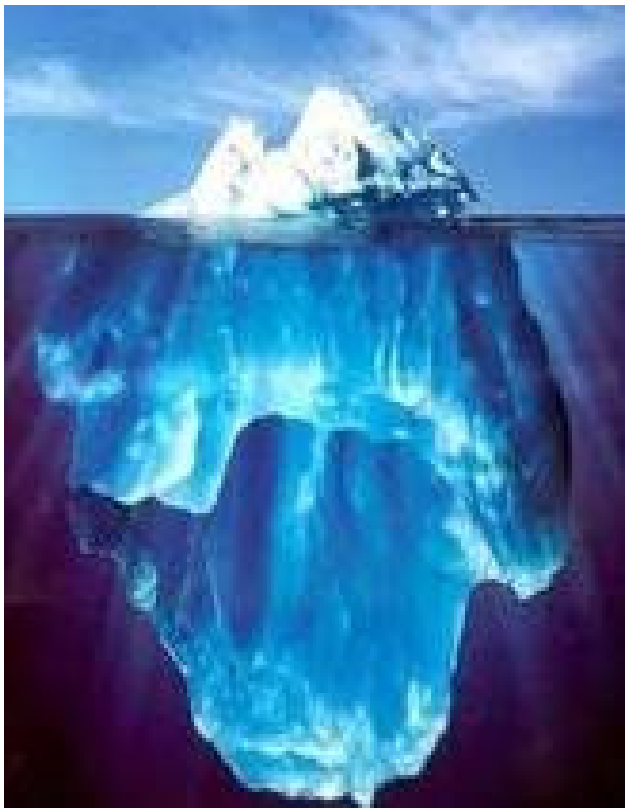

# Cloud Layers

# Cloud Layers



# Layers

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



# Layers

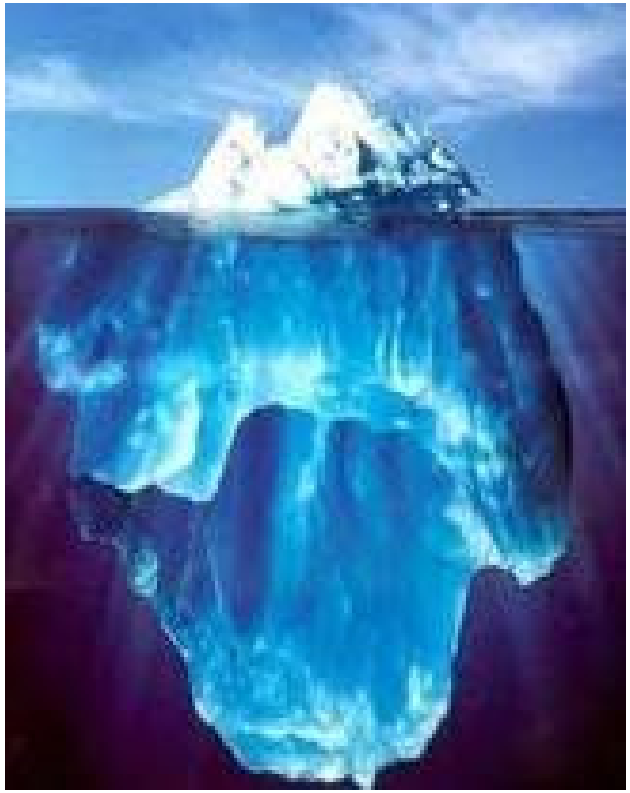
Software as Services (SaaS): the tip of the iceberg (End-user perspective)

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)



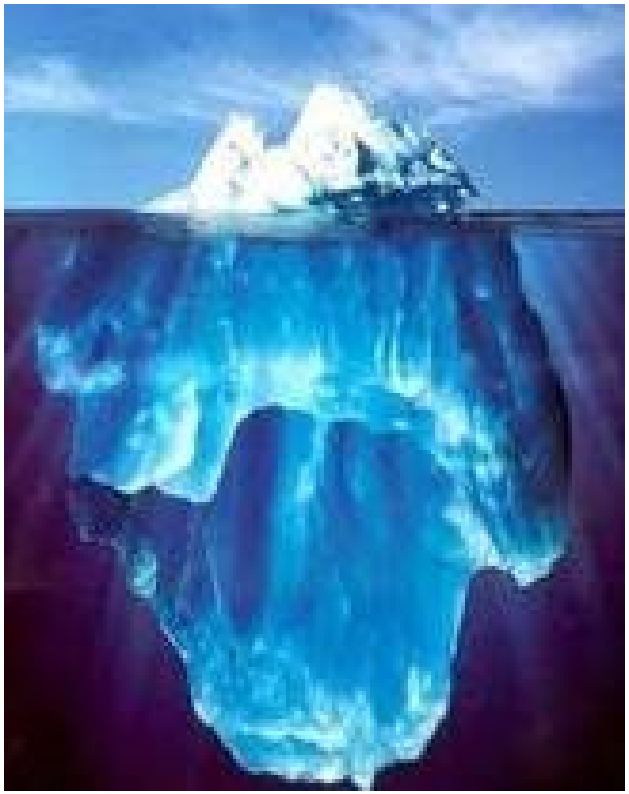
# Layers

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

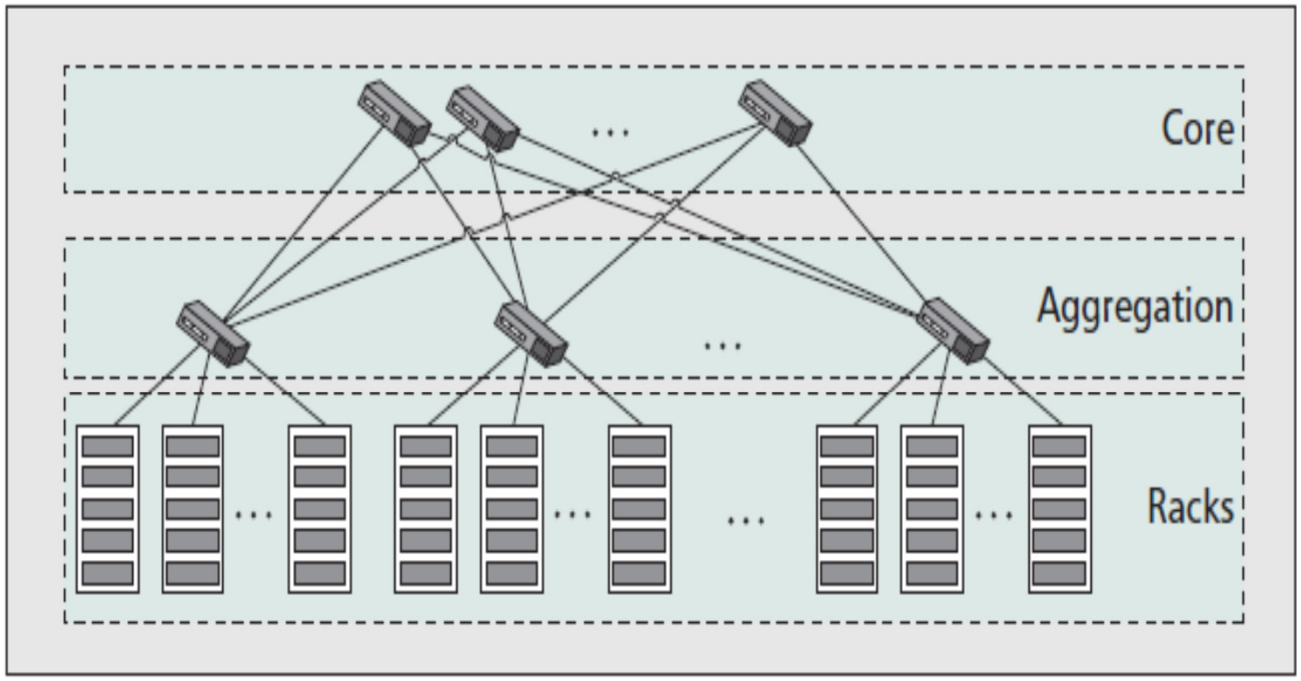



**Figure 1.** *A typical DCN structure.*

From reference 5

# The Horsepower behind the IaaS

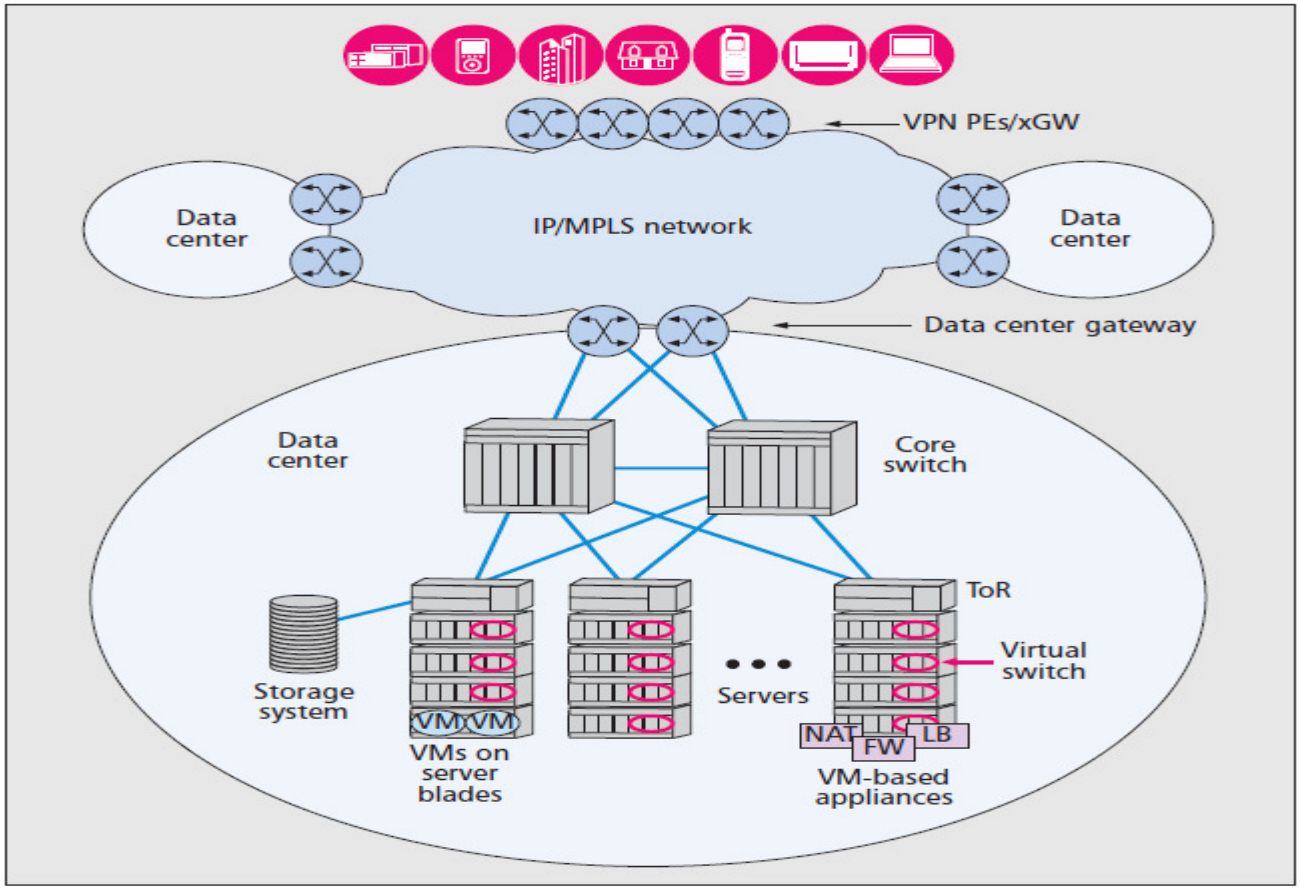



**Figure 1.** *Generic architecture for cloud networking.*

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)

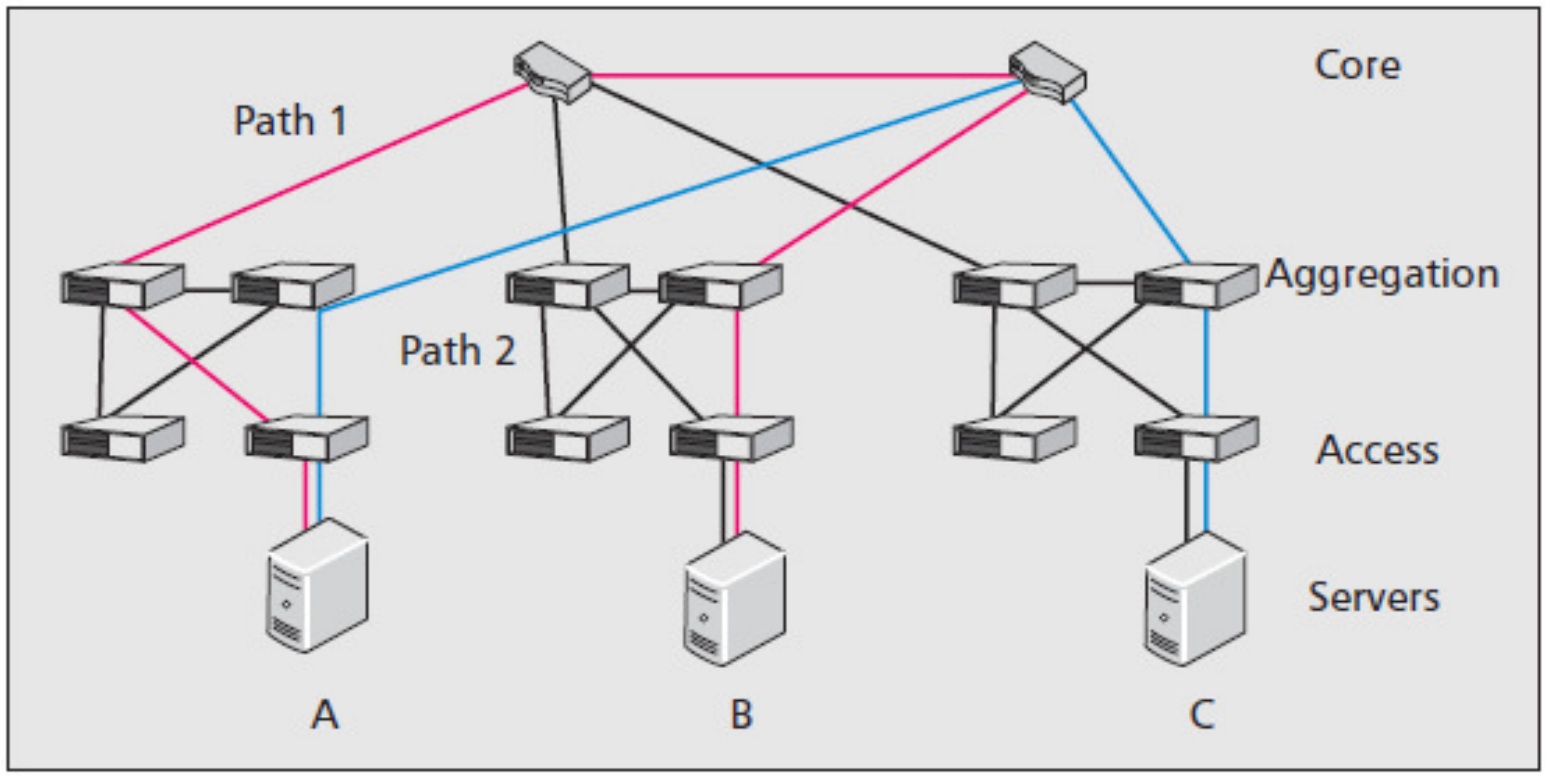



**Figure 4.** *Example of multipath routing between three servers A, B, and C.*

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  Applications in Clouds

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 …

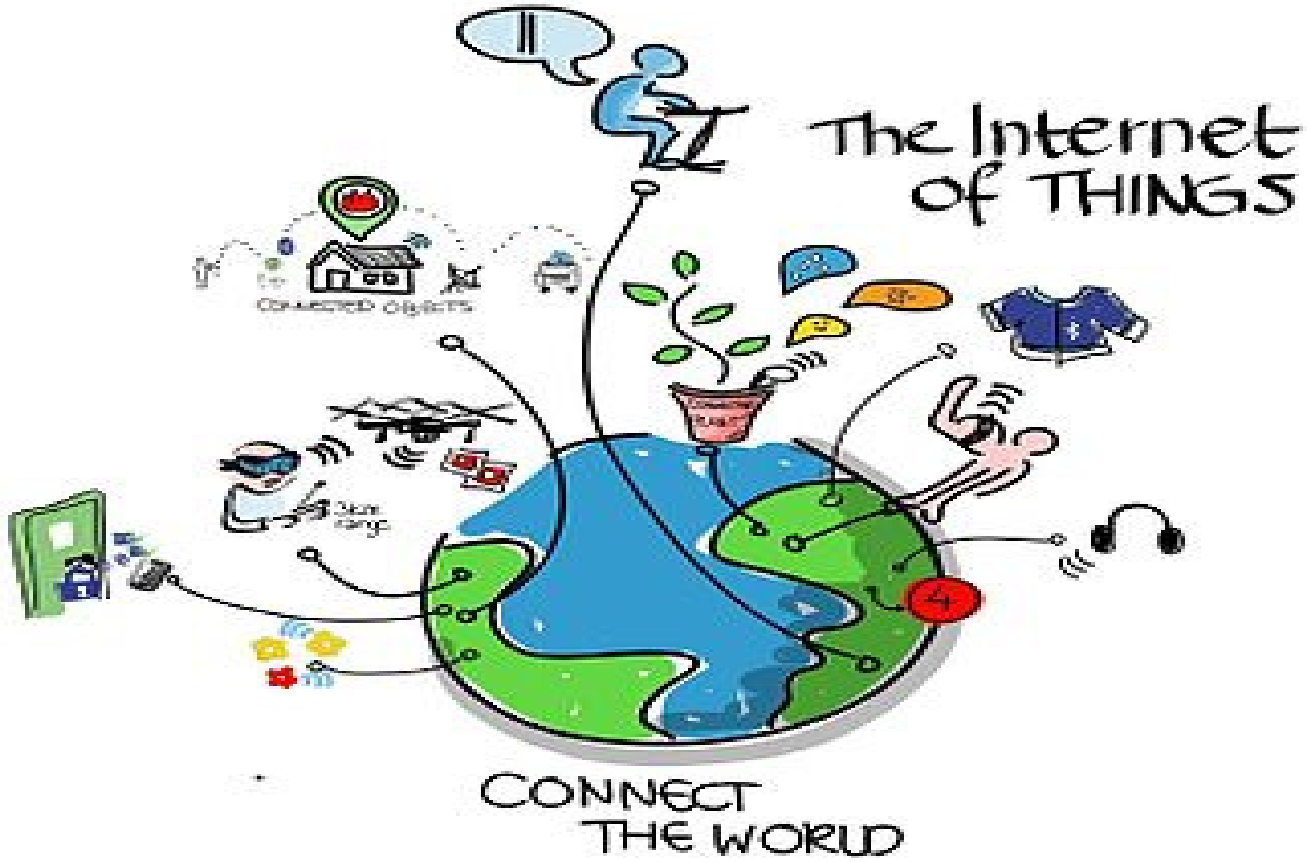
# On Multimedia Applications in Clouds

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 (http://en.wikipedia.org/wiki/Internet_of_Things)



# 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