

Cloud Computing

What is Cloud Computing?

Cloud service models

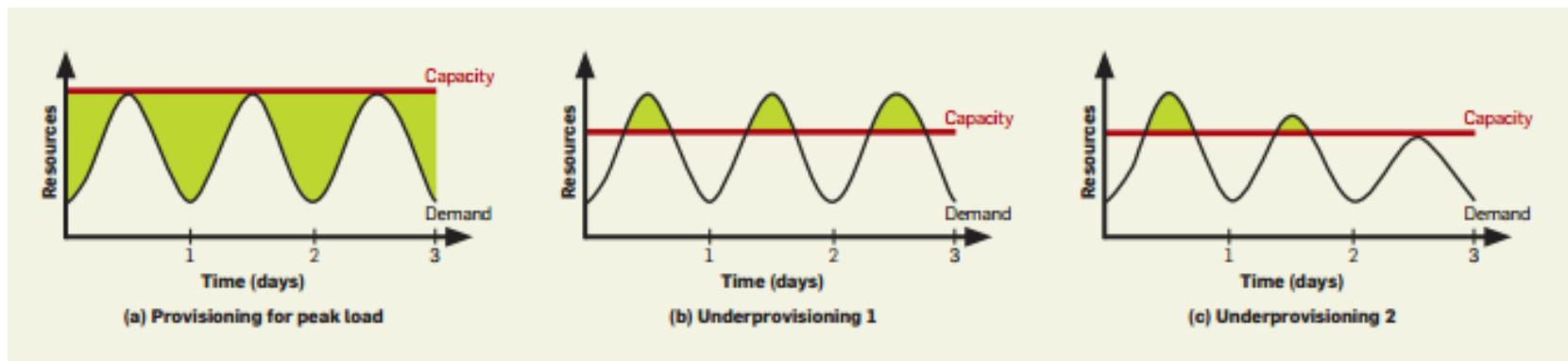
Cloud deployment models

Goals/benefits

Risks/Challenges

Enabling Technologies

MapReduce, Hadoop, EC2, AWS, Microsoft Azure, etc



A View of Cloud Computing, by Armbrust M. et al.,
Communications of the ACM, April 2010.

A good place to start...

NIST Special Publication 800-145

The NIST Definition of Cloud Computing

Peter Mell

Timothy Grance

2 pages

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NIST Definition

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

NIST – US National Institute of Standards and Technologies

Examples:

Azure Linux VM

<https://azure.microsoft.com/en-gb/pricing/details/virtual-machines/linux/>

Azure SQL Database

<https://azure.microsoft.com/en-gb/pricing/details/sql-database/>

Amazon S3 Scalable Storage

<https://aws.amazon.com/s3/?hp=tile&so-exp=below>



Essential Characteristics (NIST)

1. On-demand self-service
2. Broad network access
3. Resource pooling
4. Rapid elasticity
5. Measured service



Essential Characteristics (NIST) - I

On-demand self-service

consumer can unilaterally provision computing capabilities

- e.g. server time and network storage

automatically without human interaction with service provider

Broad network access

Capabilities are available over the network

Accessed through standard mechanisms

Heterogeneous clients

- e.g., mobile phones, tablets, laptops, and workstations

Resource pooling

Storage, processing, memory, network bandwidth

Provider's computing resources pooled

- Serve multiple consumers using a multi-tenant model
- Resources assigned and reassigned according to consumer demand

Location independence

- Customer has no control or knowledge of physical location of resources
- But specification of location possible (e.g., country, state, or datacenter)



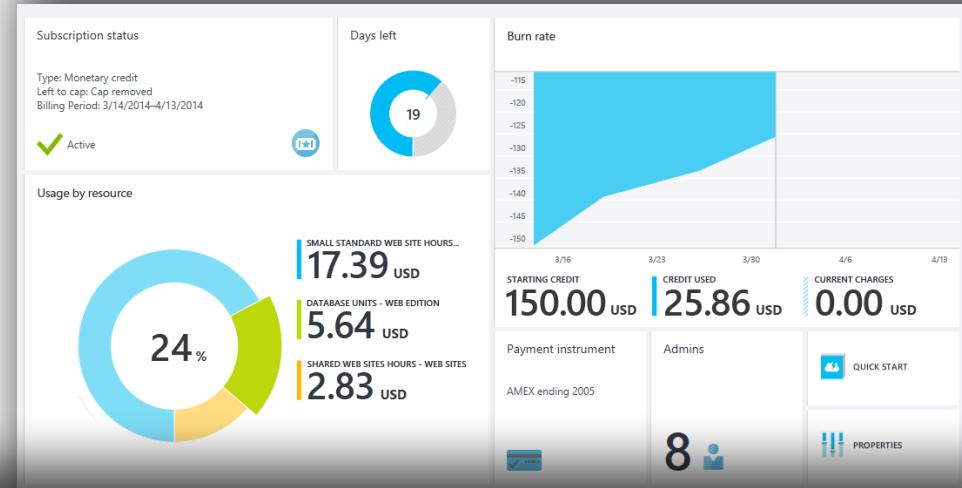
Essential Characteristics (NIST) - II

Rapid elasticity

Capabilities can be elastically provisioned and released

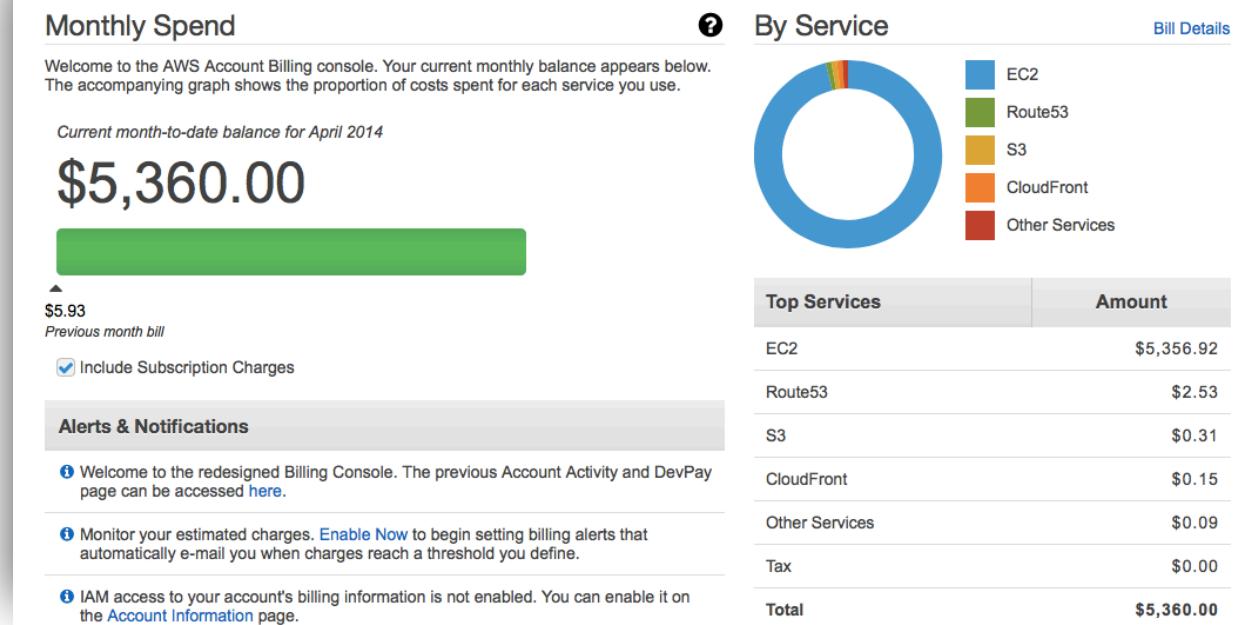
Ideally automatically in response to demand

Resources/capabilities appear unlimited

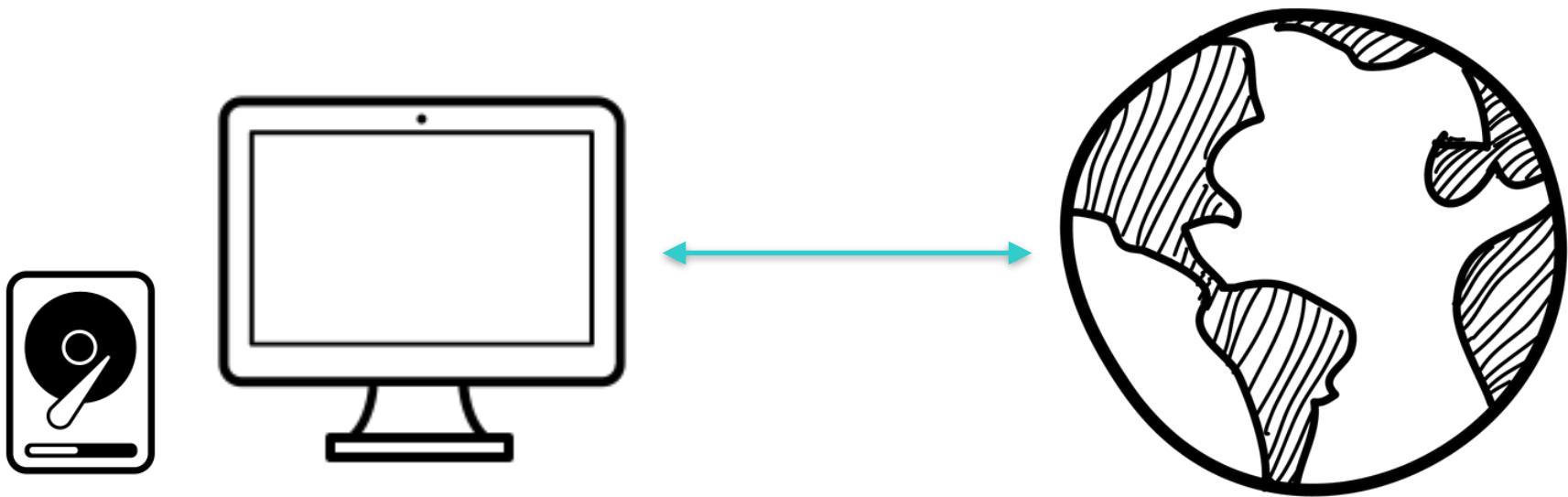


Measured service

Usage measured
Pay-per-Use model



DIY Model

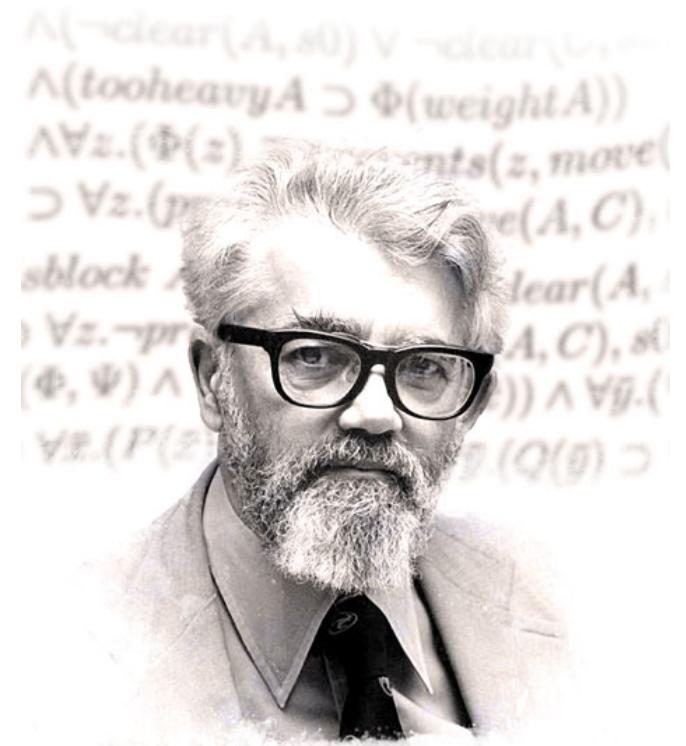


History of Cloud Computing

John McCarthy 1957 – time-sharing on IBM servers

Idea to sell resources through utility business model

Utility computing - provisioning model in which a service provider makes computing resources and infrastructure management available to the customer as needed, and charges them for specific usage rather than a flat rate.



Build up

- Web hosting
- Application Service Providers
- Volunteer Computing
- Online file sharing
- Social networks



Cloud Deployment Models

Deployment model represents a specific type of cloud environment, distinguished by ownership, size and access:

Public cloud

Community cloud

Private cloud

Hybrid cloud



Public cloud

Publicly accessible cloud environment

Owned by a third-party provider

It exists on the premises of the cloud provider

Examples

- Amazon Elastic Compute Cloud (EC2)
- IBM's Blue Cloud
- Google AppEngine
- Windows Azure Services Platform

Community cloud

The cloud infrastructure is provisioned for **exclusive use** by a **specific community** of consumers from organizations that have **shared concerns**

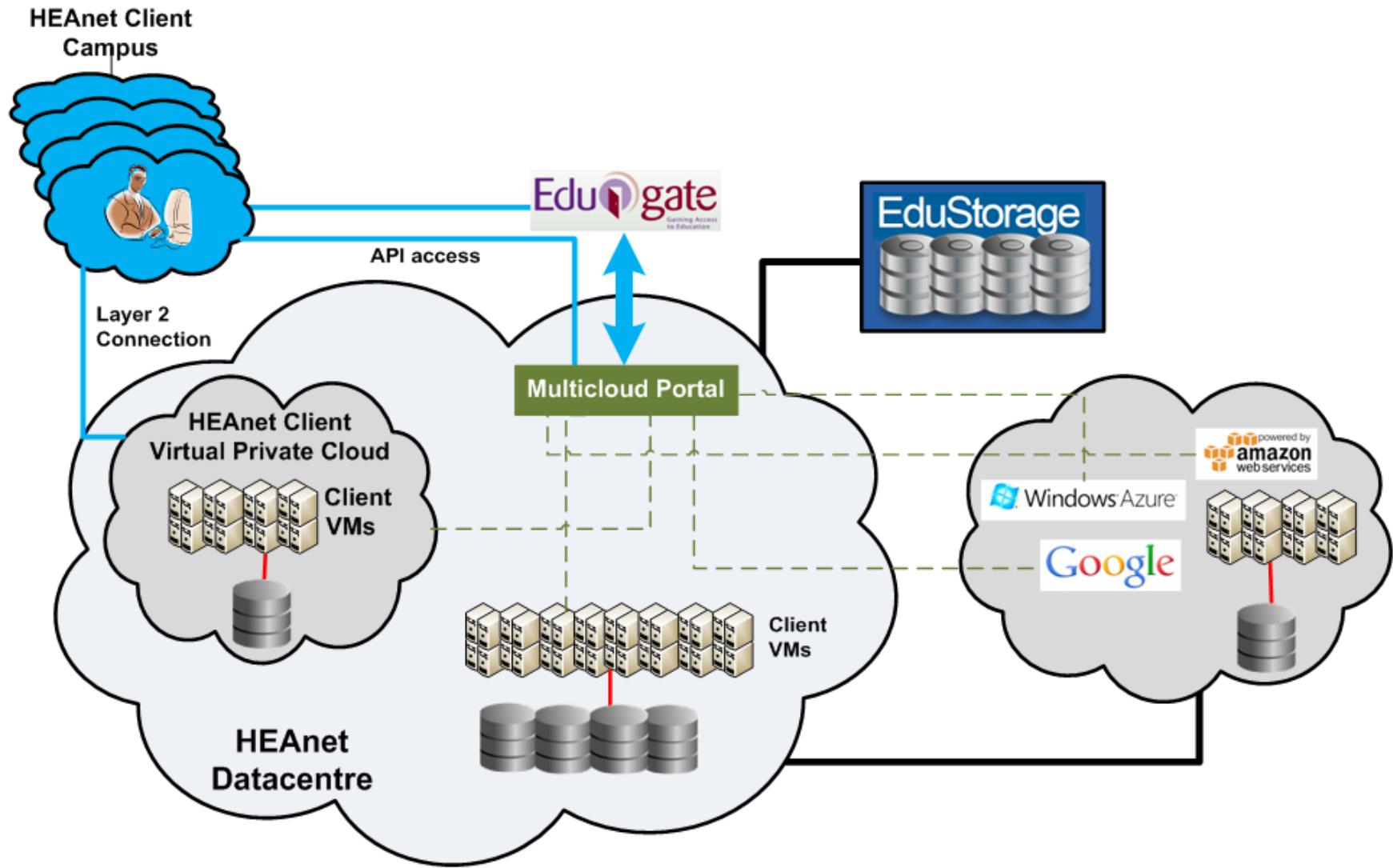
(e.g., mission, security requirements, policy, and compliance considerations).

It may be owned, managed, and operated by one or more of the organizations in the community, a third party

It may exist on or off premises.



(Irish) HEA Community Cloud



<http://www.heanet.ie/projects/projects-archive/iaas-cloud>

Private Cloud

Owned by a single organization

Enables use of cloud computing technology as a means of centralizing access to IT resources by different locations/departments

It may be owned, managed, and operated by the organization, a third party, or some combination of them

It may exist on or off premises

eBay has a big one [<link>](#)



Hybrid cloud

The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability

Eg process sensitive data on private cloud and other services on public cloud



Cloud Service Models

Leasing a VM from Microsoft very different to
using Gmail for your mail
or Salesforce for CRM

Cloud Service Models

Applications

Middleware/OS

Servers

IaaS
host



Applications

Middleware/OS

Servers

PaaS
build



Applications

Middleware/OS

Servers

SaaS
Consume



Infrastructure

Platform

Software

Cloud Service Models

Another perspective



SaaS

Software
as a Service



PaaS

Platform
as a Service



IaaS

Infrastructure
as a Service



CONSUME



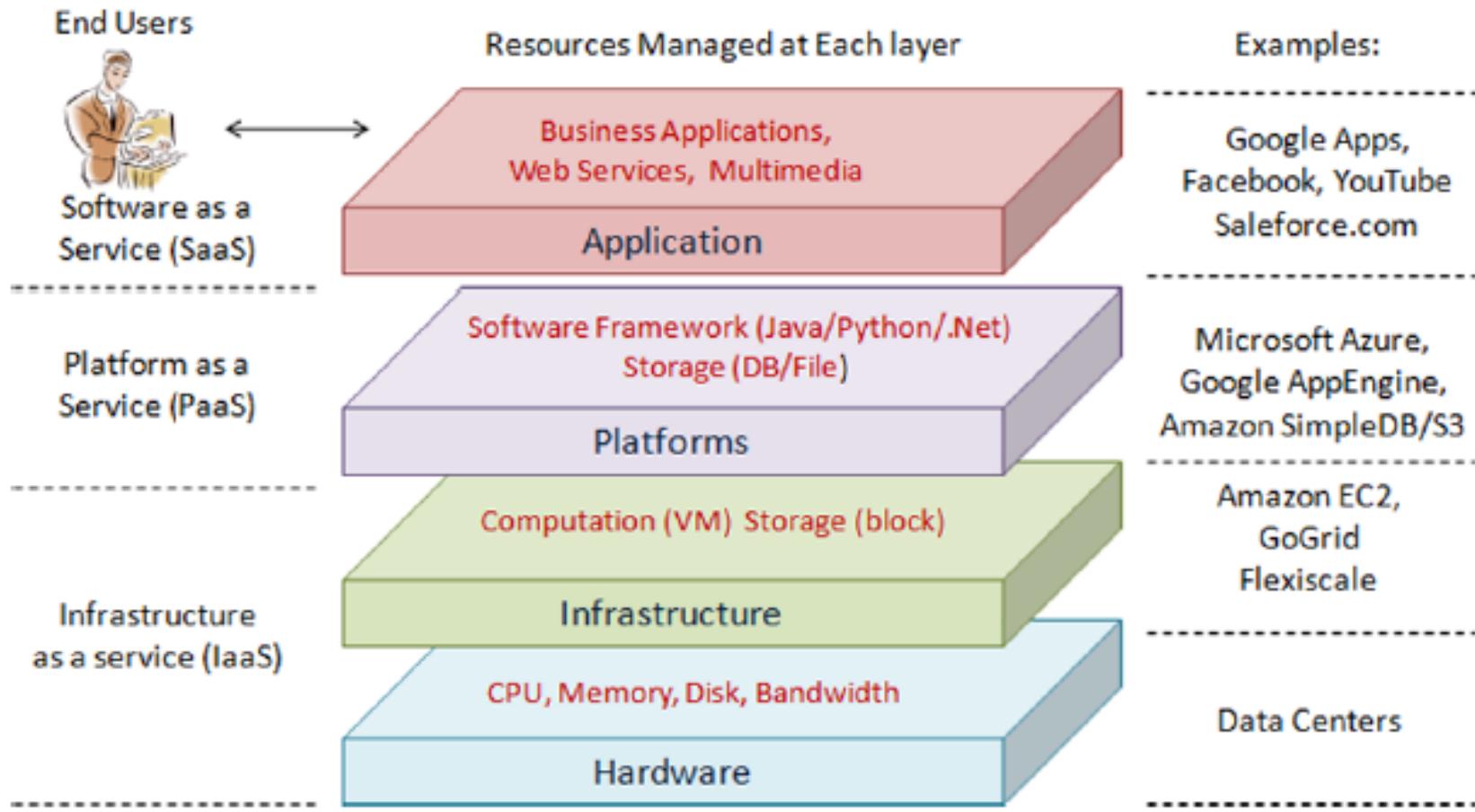
BUILD ON IT



MIGRATE TO IT

Cloud architecture

Yet another picture...



Cloud computing: state-of-the-art and research challenges, Qi Zhang,
Lu Cheng, Raouf Boutaba, J Internet Serv Appl (2010)

Cloud Service Models

Software as a Service (SaaS)

Provider gives user access to applications (software)

'Complete' applications, e.g. mail, photo sharing

Or a program interface (API)

- › e.g. <https://ipfind.co>

User does not control underlying infrastructure (OS, servers, storage)

Platform as a Service (PaaS)

Consumer can deploy applications

Consumer does not manage underlying infrastructure (OS and below)

Consumer controls application

Infrastructure as a Service (IaaS)

Fundamental computing resources

- › Processing, storage, networks

Consumer may deploy arbitrary software, including OS



IaaS

On-demand provisioning of infrastructural resources

Consumers have a high level of control and responsibility over configuration

Open Source Software

<https://en.wikipedia.org/wiki/OpenStack>



IaaS

IaaS storage - accessible online and presented to customers as a set of storage pools or buckets, accessible using rich interfaces such as programming APIs, web interfaces, or command-line tools.

IaaS Computing – computational resources as VMs (CPUs, RAM)

IaaS Network – load balancing, DNS



IaaS

Example pricing models:

IaaS storage

\$/size of stored data,
\$/amount of incoming data traffic,
\$/amount of outgoing data traffic,
\$/number of specific http requests

IaaS Computing

\$/year + \$/hours of services

IaaS Network

\$/hours of service (only when service is used)/month
+ \$/amount of consumed bandwidth (GB) /month



IaaS

Pros: Avoid capital expenditure on hardware and human resources; reduced ROI risk; low barriers to entry; streamlined and automated scaling

Cons: Business efficiency and productivity largely depends on the vendor's capabilities; potentially greater long-term cost; centralization requires new/ different security measures



IaaS Cloud Provider Perspective

Virtual servers:

Provide standardized configurations defined by: OS, primary memory capacity, processing capacity, virtualized storage capacity

Eg 1GB increments for memory/storage

Ability to take snapshots of virtualized servers to record its current state, memory and configuration ->backup, replication



IaaS Cloud Provider Perspective

Scalability and Reliability

Scalability automatic via **vertical scaling** through VIM (virtual infrastructure manager) or **horizontal scaling** using resource replication, to provide resource pool and use load balancer mechanism to distribute the workload

IaaS Cloud Provider Perspective

Monitoring (**pay-per-use or time-based billing**)

Virtual Server Lifecycle – uptime, allocation of resources etc

Data Storage – tracking and assigning storage capacity to storage devices on virtual servers

Network Traffic – inbound and outbound volume of traffic; **QoS** (Quality of Service) metrics: response time

Failure Conditions – ensure **SLA** (service level agreements), provide warnings

SaaS Consumer Perspective

Consumer can

- Managing security-related configurations
- Availability and reliability options
- Usage cost
- Managing user accounts, profiles, access authorisation
- Selecting and monitoring SLAs
- Selecting manual and automated scalability options

When its free, sometimes “*the consumer is the product*”



Cloud Computing Benefits

Consumer

- Increased focus on business and the main product
- Faster time-to-market - reduced set up time
- Reduced development cost
- Reduced operational cost – no installations/upgrades
- Higher scalability/elasticity, availability, reliability

Service Provider

- Better hardware utilization
- Higher revenues
- Bigger software markets
- Activities monitoring
- Better release management



Risks and Challenges

- Standards
- Dependability
- On a given cloud operator
 - Limited portability between operators
 - Transparency
- Cloud operator making changes without notifying clients
 - Security
- Increased vulnerabilities
 - Network Connections
 - Availability
 - Legislation
- Future?



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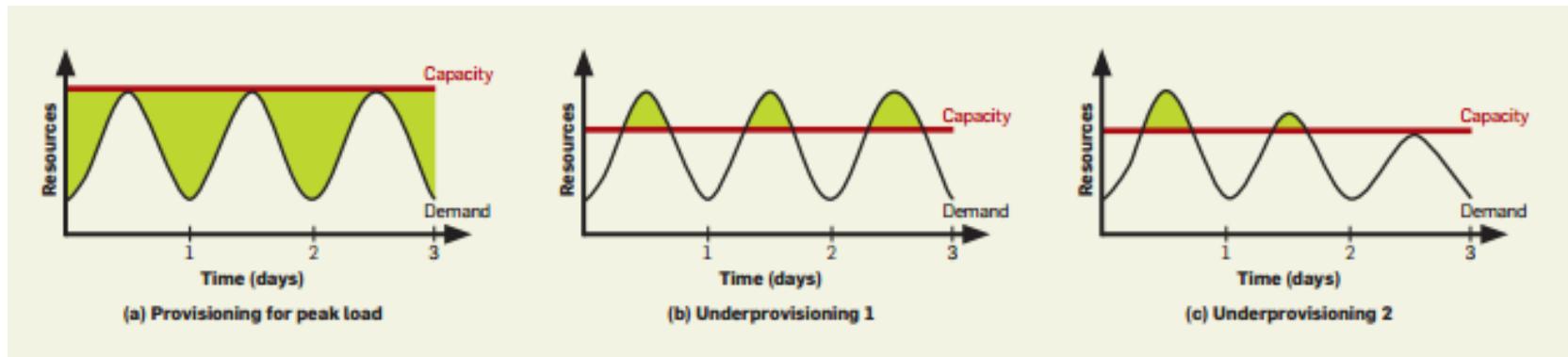
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