

Welcome to

Networking Technologies for Cloud Computing

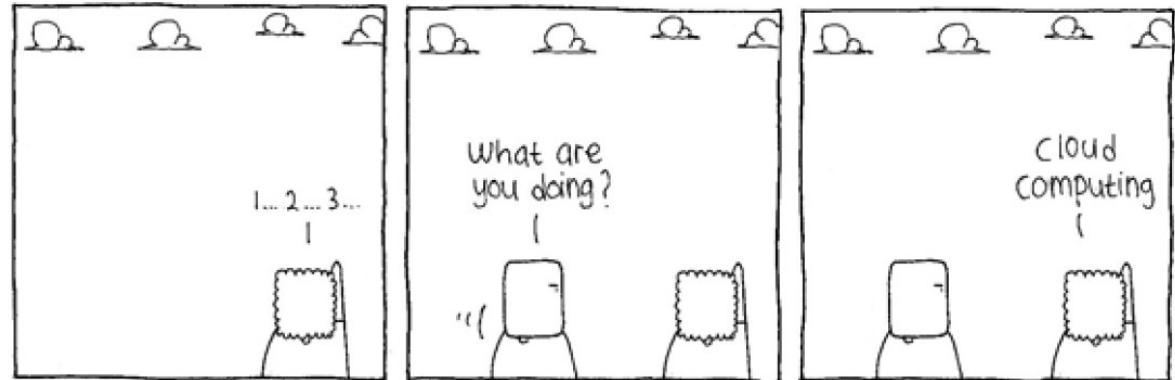
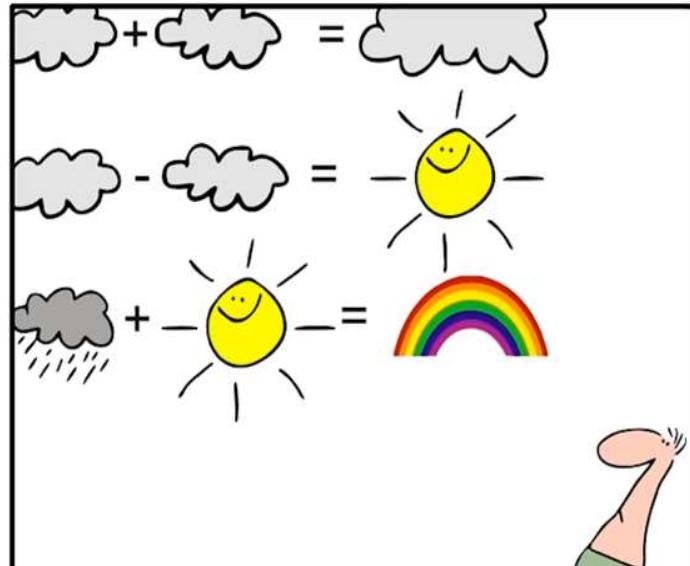
USTC-CYSC6402P
Instructor: Chi Zhang
Fall 2020



Part 2: outline

- Cloud computing: basic concepts
 - a tale of two companies: amazon & google
 - basic definitions of cloud computing
 - history of cloud computing

What is cloud computing?



My Cloud Computing Definition

- Network of Remote Servers
- Accessed via Internet to
 - Store
 - Manage
 - Process

Data

* rather than a local server

Larry on Cloud Computing



The interesting thing about cloud computing is that we've redefined cloud computing to include everything that we already do.

I can't think of anything that isn't cloud computing with all of these announcements

---Oracle CEO
Larry Ellison



ICT as a fashion industry



The computer industry is
the only industry that is
more fashion-driven than
women's fashion.

---Oracle CEO
Larry Ellison

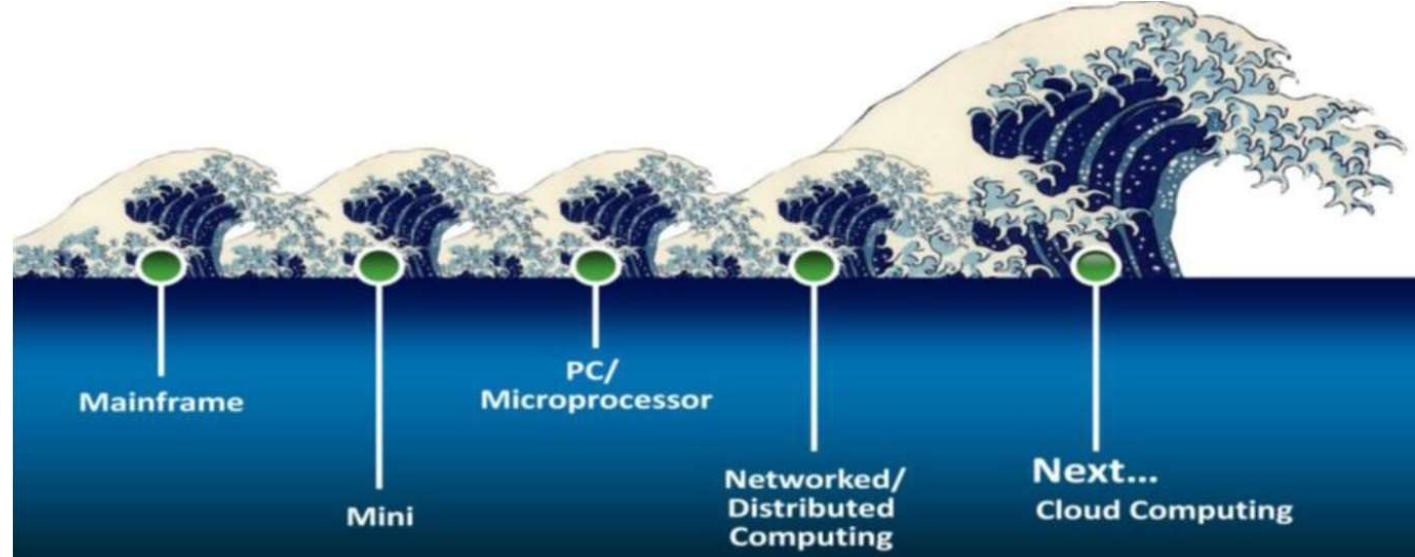


Cloudification is a process

Cloudify, *vt* → Cloudification, *n.*



A tale of two companies



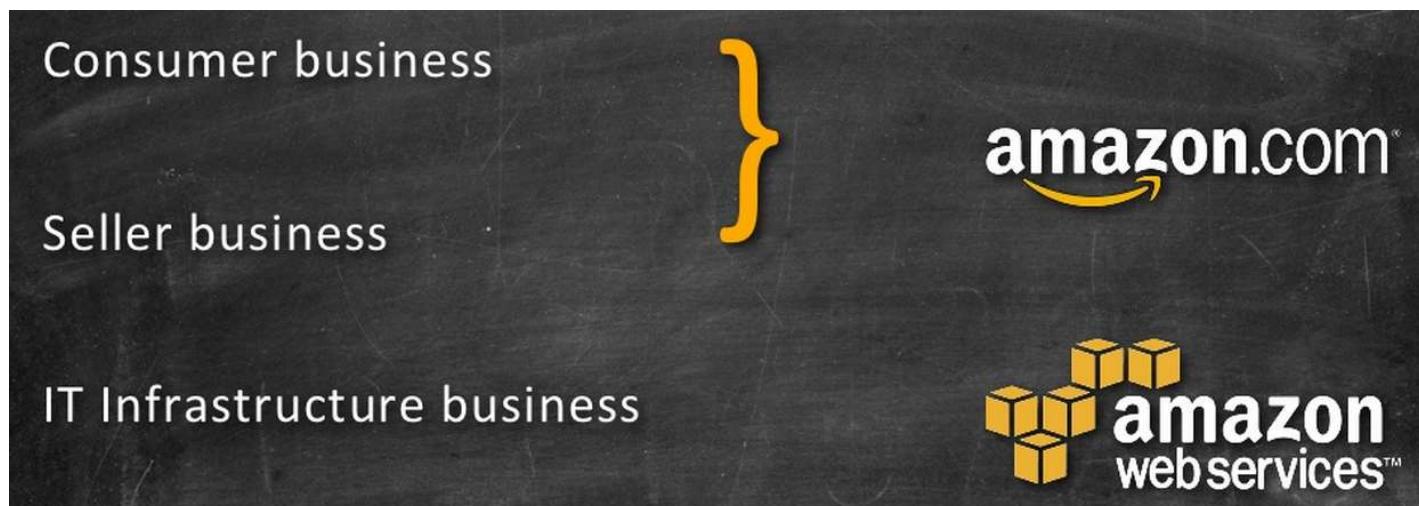
- 不是纯技术推动的范式转移
- 考察两个公司、两个成功发展云计算的案例
- 总结出云计算发展的两个推动力
 - Amazon: 提高资源利用率
 - Google: 完成过去不可能完成的任务



Who is amazon.com?



- amazon.com's three businesses



Amazon web services



https://console.aws.amazon.com/console/home

AWS Management Console > Console Home

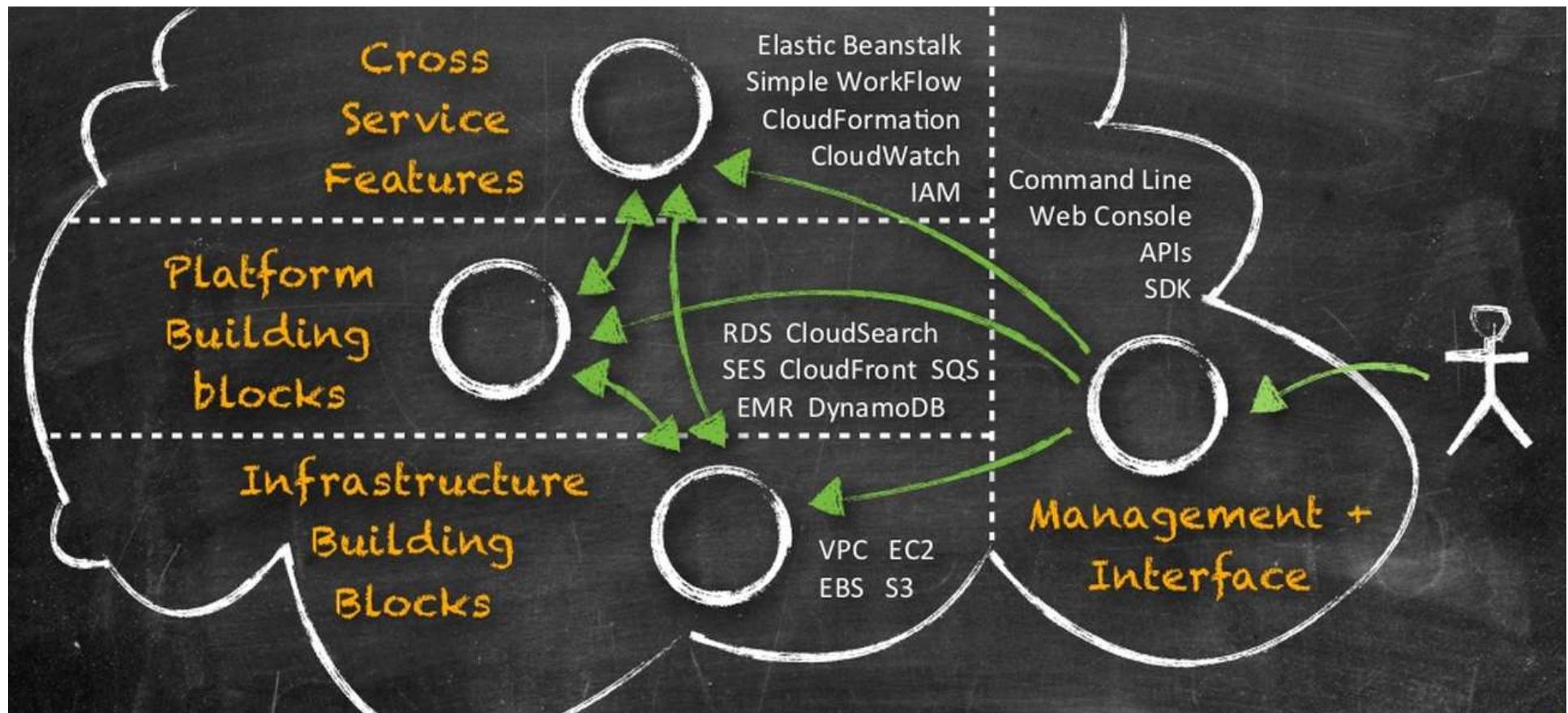
Elastic Beanstalk S3 EC2 VPC CloudWatch Elastic MapReduce CloudFront AWS CloudFormation RDS Amazon ElastiCache SQS Lambda

| Welcome | Amazon Web Services |
|---|--|
| The AWS Management Console provides a graphical interface to Amazon Web Services. Learn more about how to use our services to meet your needs, or get started by selecting a service. | CloudFormation Templated AWS Resource Creation |
| Getting started guides | CloudFront Global Content Delivery Network |
| Reference architectures | CloudWatch Resource & Application Monitoring |
| Free Usage Tier | DynamoDB NEW Predictable and Scalable NoSQL Data Store |
| Set Start Page | EC2 Virtual Servers in the Cloud |
| Console Home | ElastiCache In-Memory Cache |
| | Elastic Beanstalk AWS Application Container |
| | Elastic MapReduce Managed Hadoop Framework |
| | IAM Secure AWS Access Control |
| | RDS Managed Relational Database Service |
| | Route 53 Scalable Domain Name System |
| | S3 Scalable Storage in the Cloud |
| | SES Email Sending Service |
| | SNS Push Notification Service |
| | SQS Message Queue Service |
| | SWF NEW Workflow Service for Coordinating App Components |
| | Storage Gateway NEW Integrates on-premises IT environments with cloud storage |
| | VPC Isolated Cloud Resources |

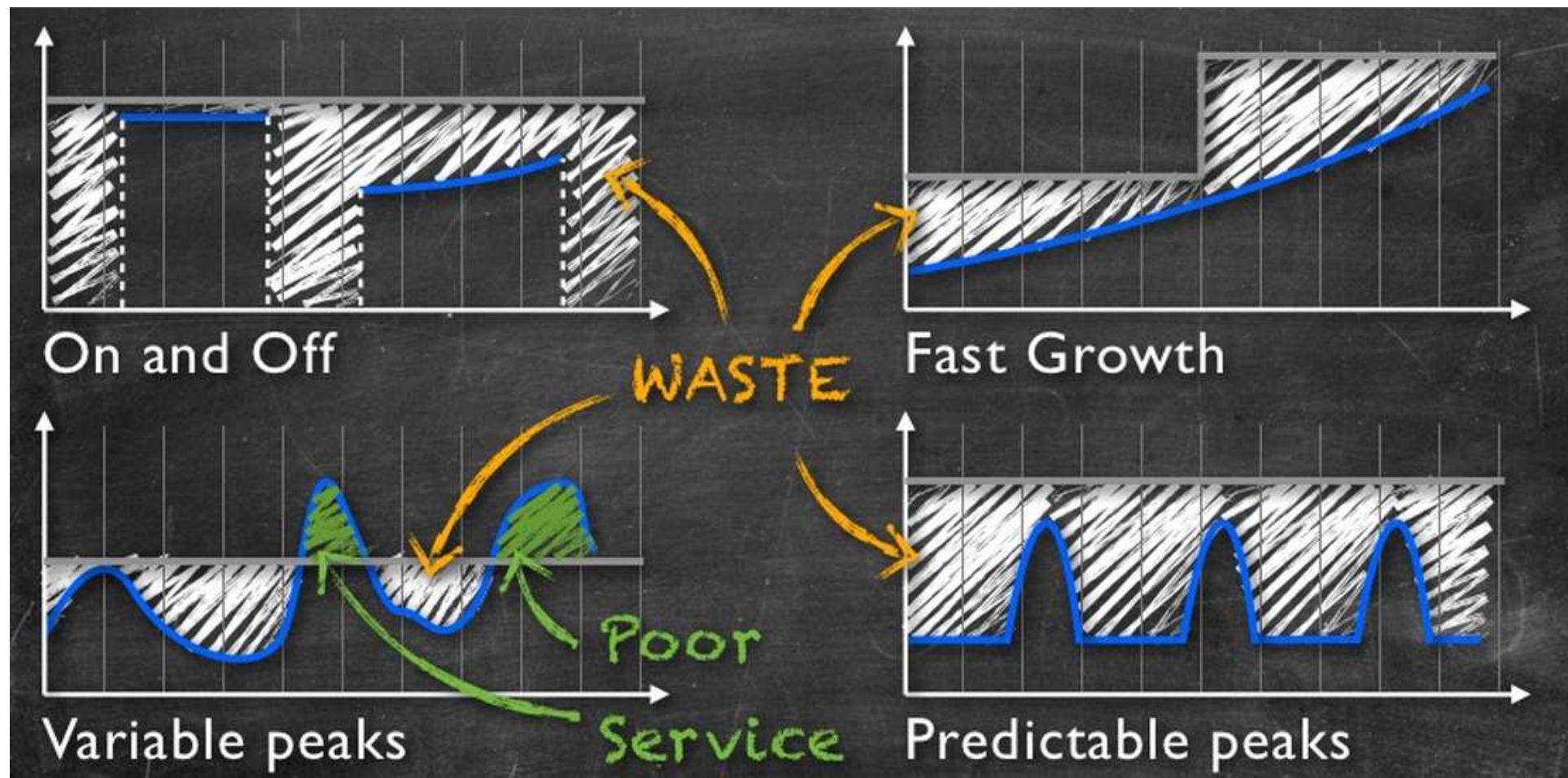
Global AWS infrastructure



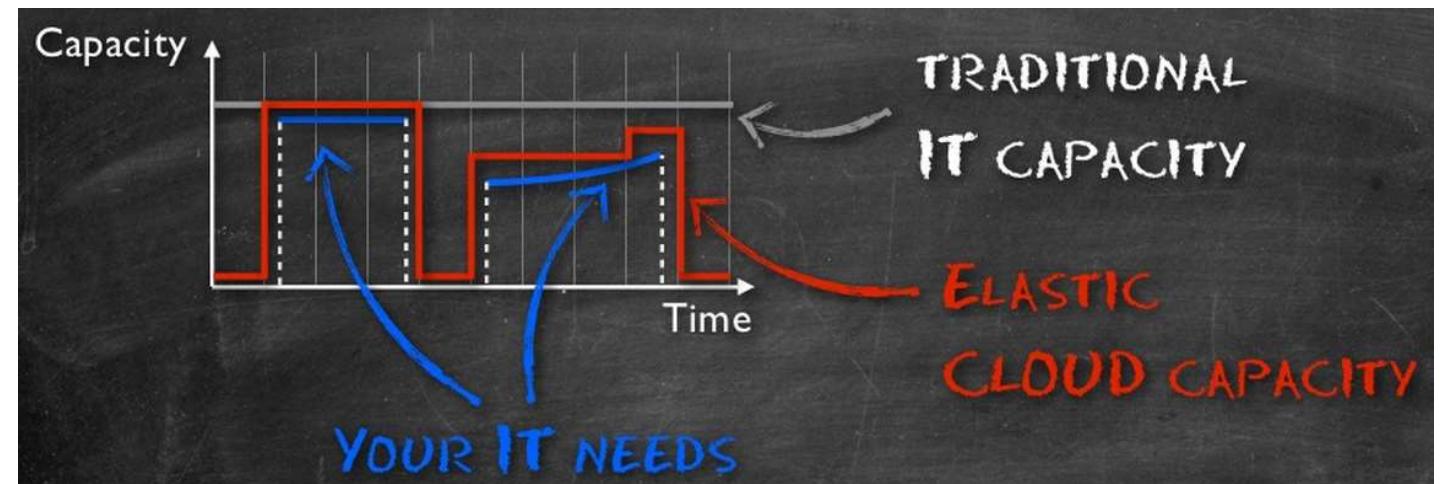
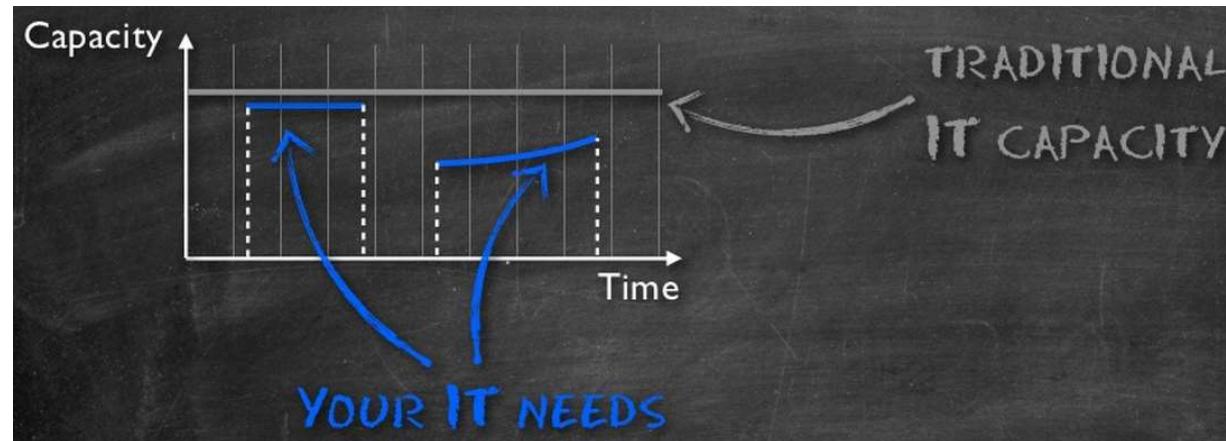
AWS cloud services



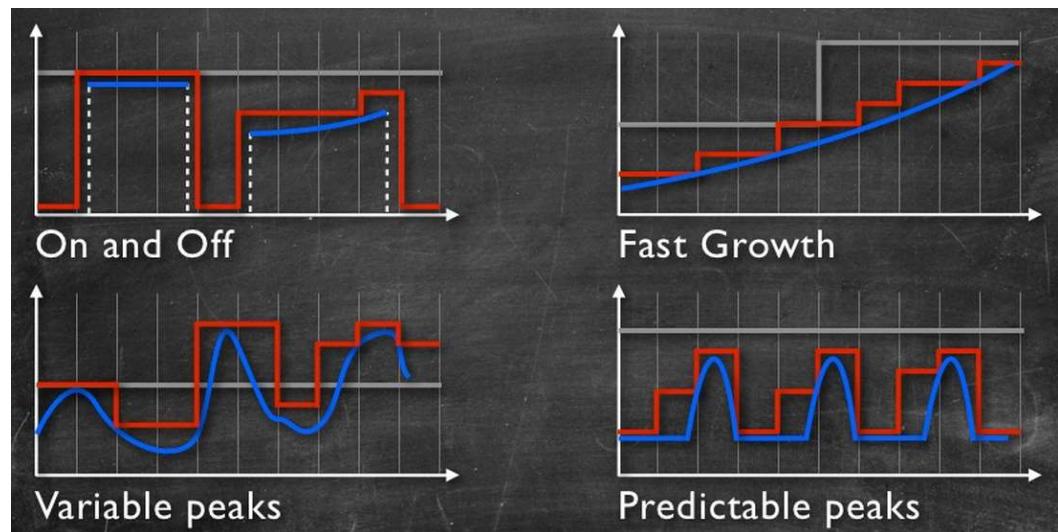
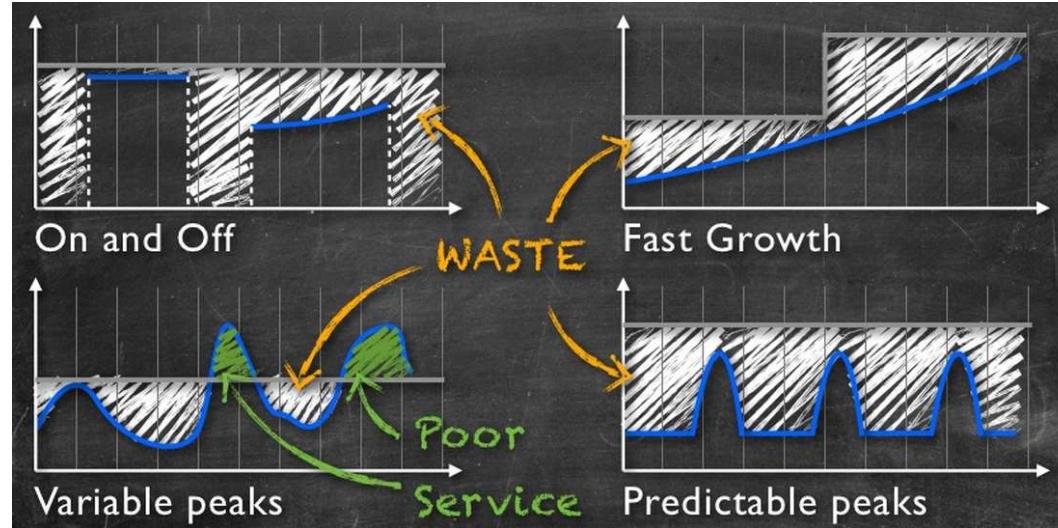
IT usage patterns: traditional



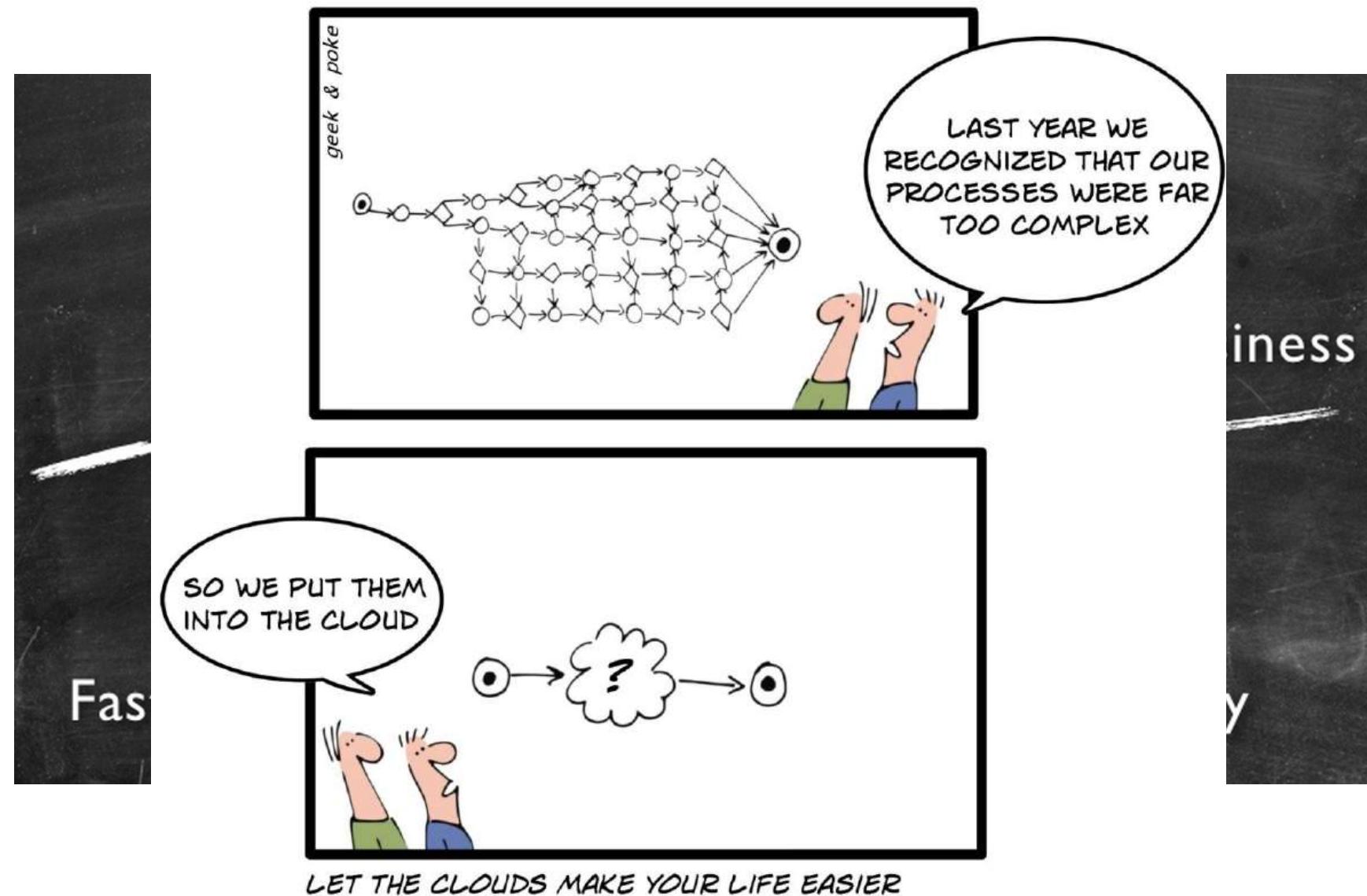
IT usage patterns: cloud computing



IT usage patterns: cloud computing



Business Benefits of Cloud Computing



What do customers run on AWS?

- Enterprise applications



- Media and web applications



- Big data, HPC, analytics



- Archive, disaster recovery



- Mobile and games



Cloud computing in China

- For *individuals*: network bandwidth problem
- For *small and medium-sized enterprises*: perfect match!
- For *big companies*: security & privacy problem



2013年6月5日~7日 国家会议中心·北京 18

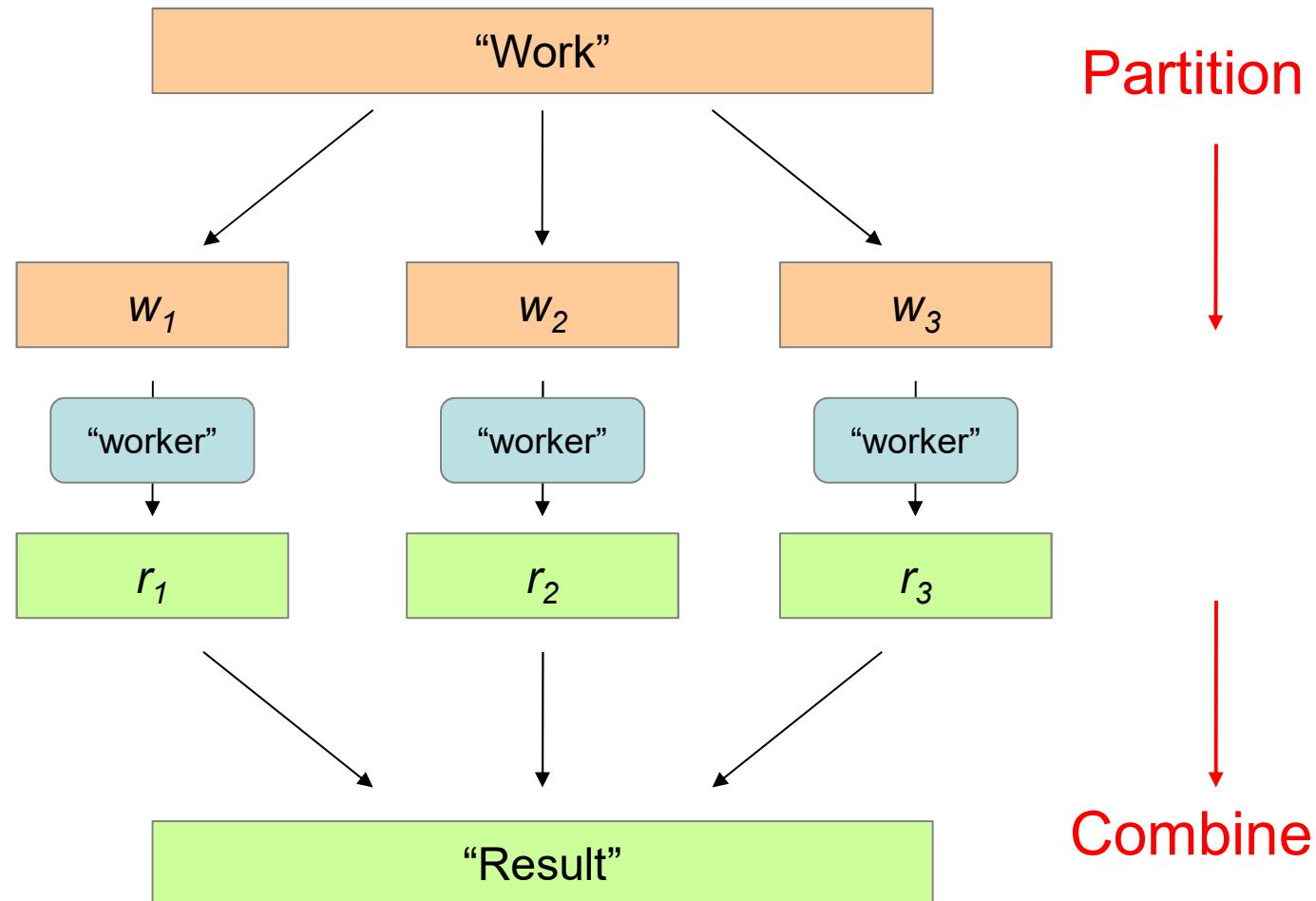
Google Search



How Google Search Engine Works?

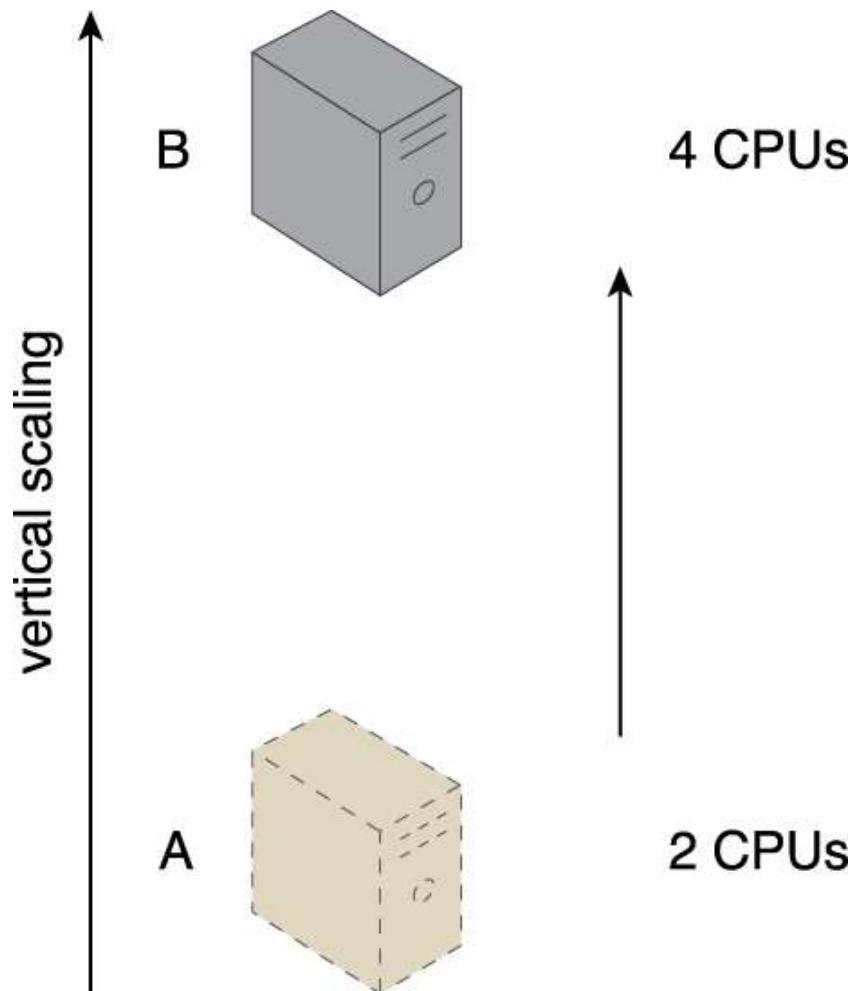


MapReduce: Divide and Conquer



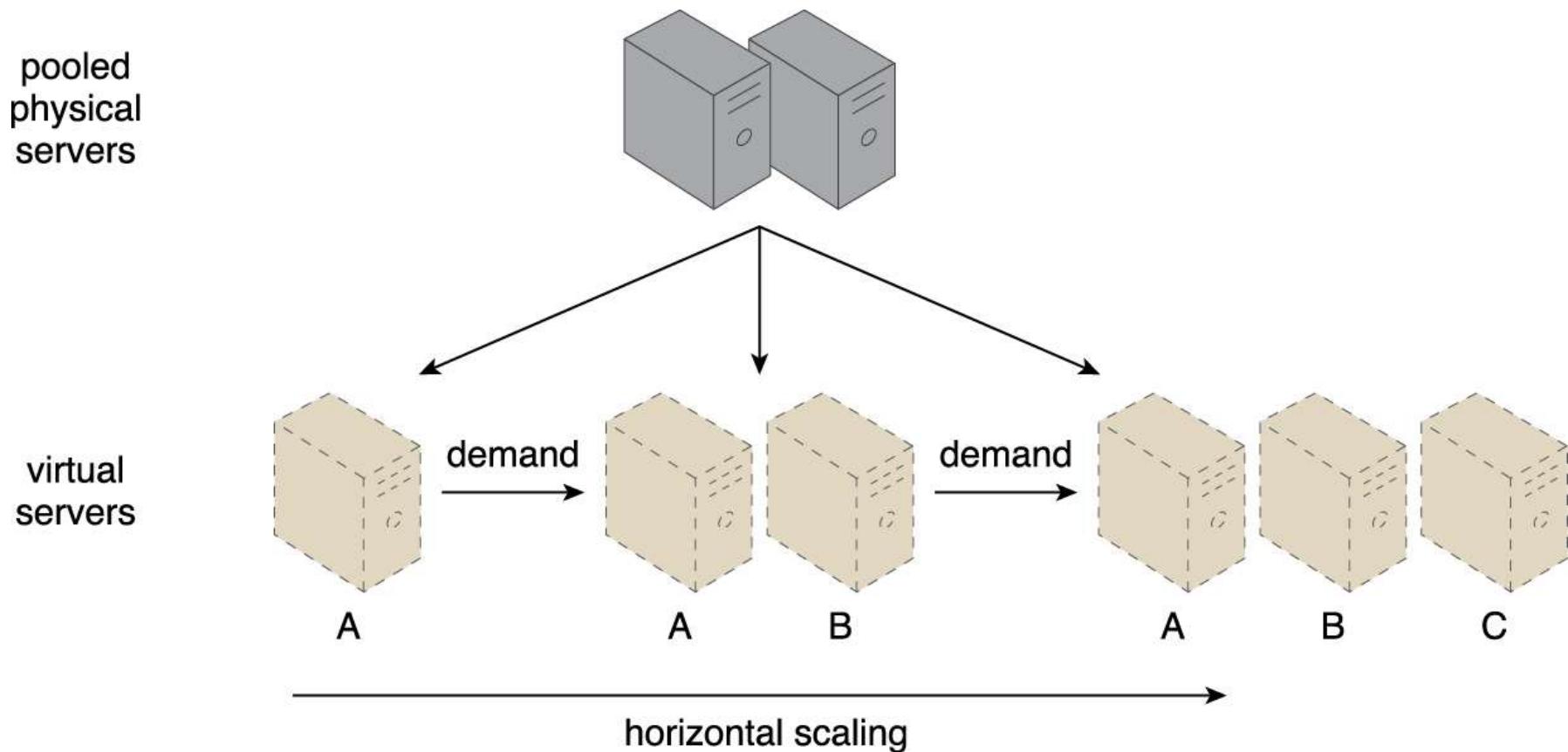
Scalability-1

- To **vertically scale up** is to increase overall application capacity by increasing the resources within existing nodes.



Scalability-2

- To **horizontally scale out** is to increase overall application capacity by adding nodes.



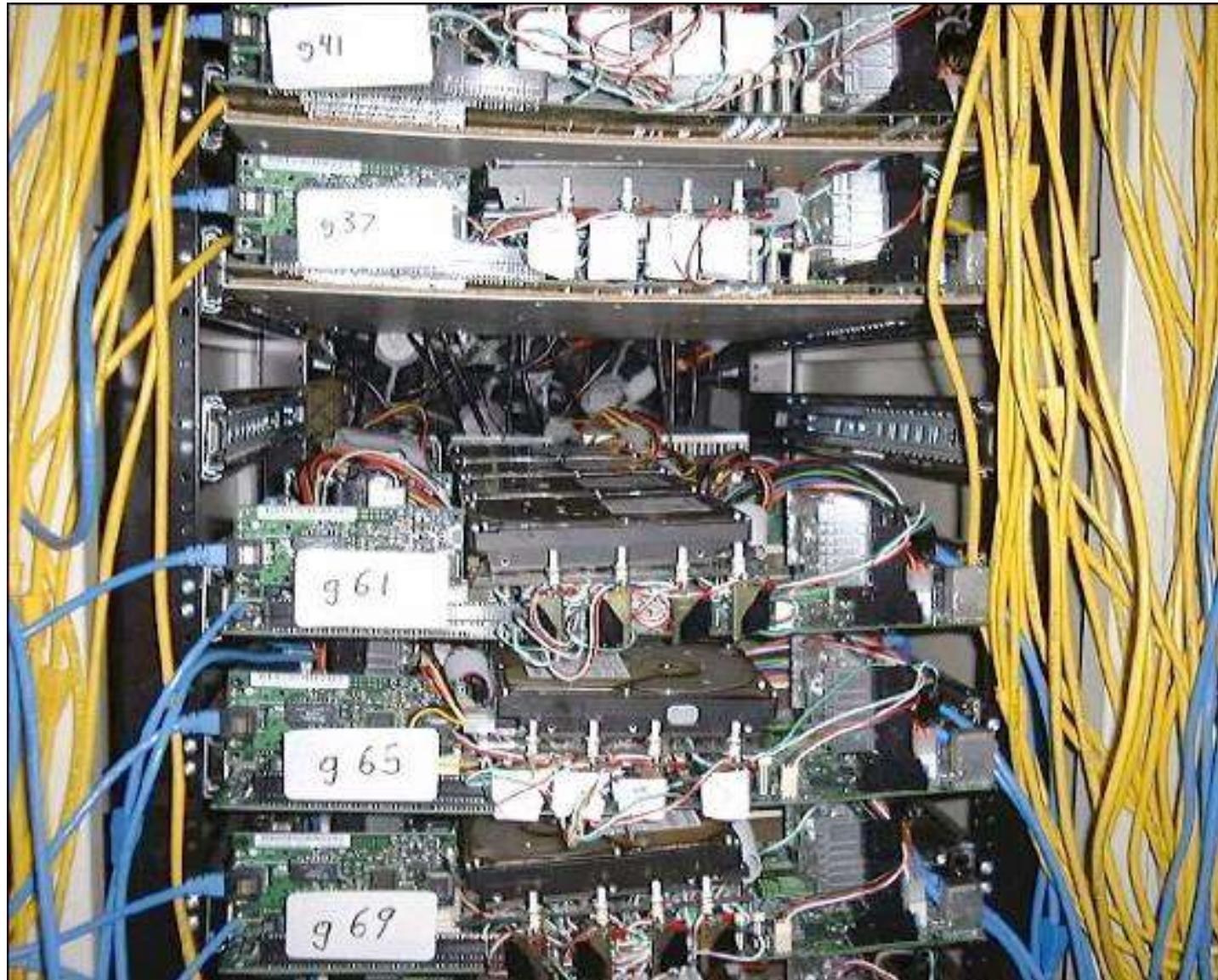
Hardware design philosophy

- Prefer low-end server/PC-class designs
 - Build lots of them!
- Why?
 - Single machine performance is not interesting
 - Even smaller problems are too large for any single system
 - Large problems have lots of available parallelism
 - Lots of commodity machines gives best performance/\$

Google 1997 @ Stanford



Google 1999



Google Data Center 2001



Google Data Center 2008



Data Center as Infrastructures



Google's 36 world wide data centers (2008)

Today's agenda

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My cloud computing definition

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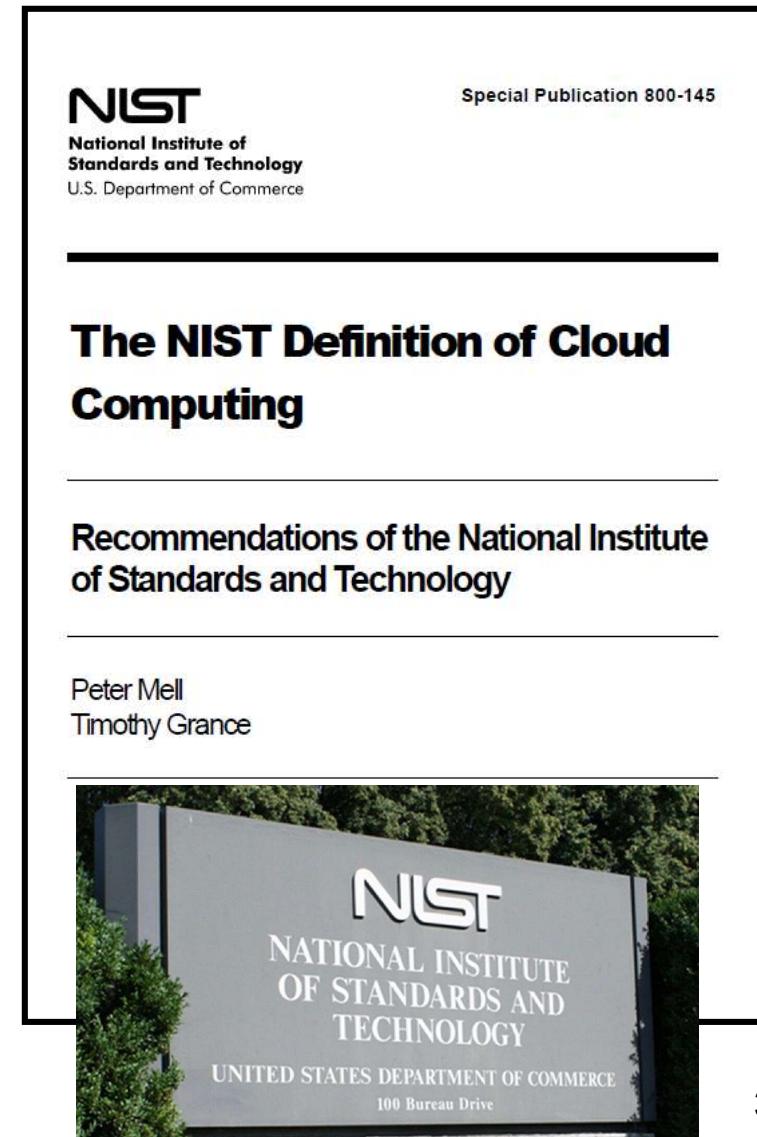
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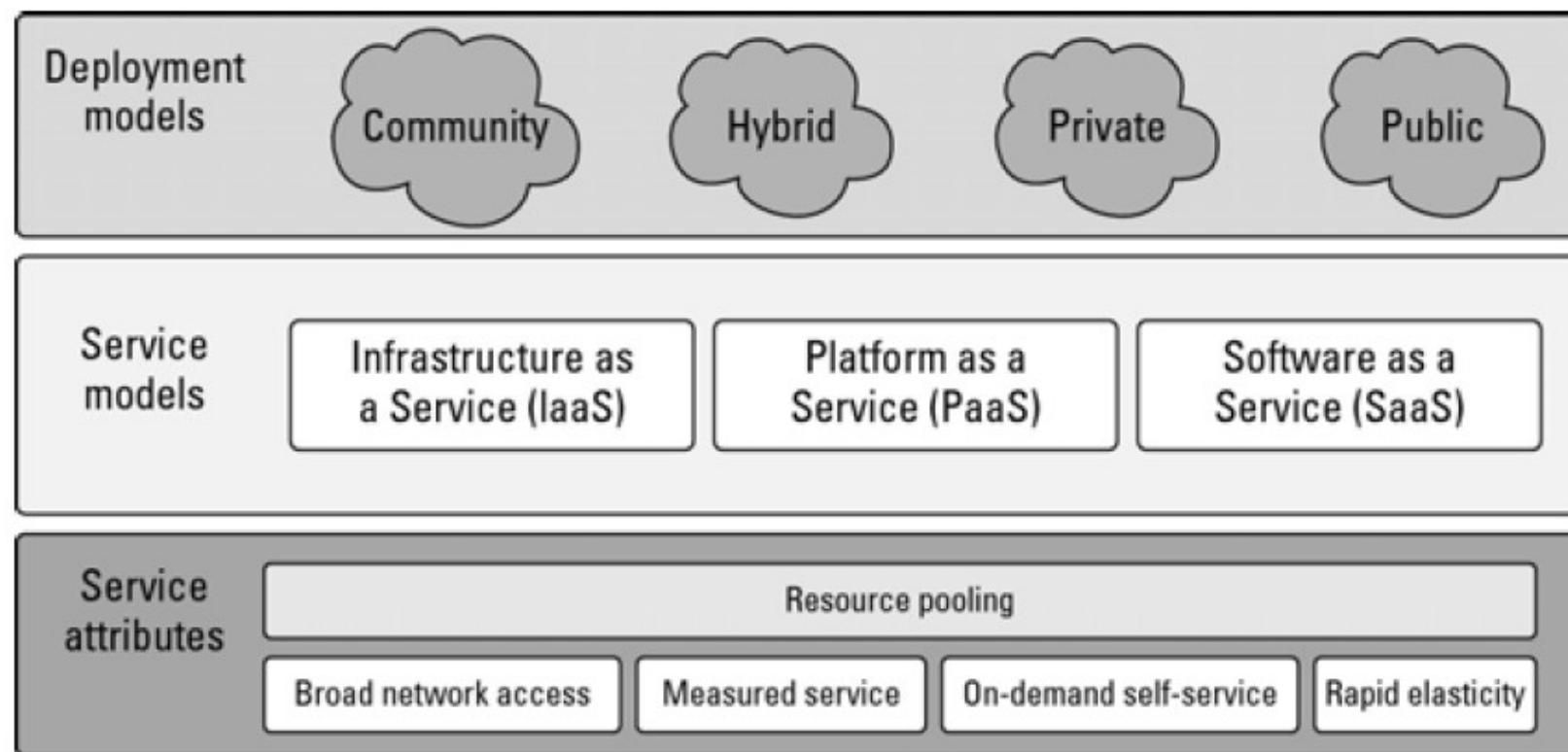
NIST definition of cloud computing

- 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.
- This cloud model is composed of *five essential characteristics, three service models, and four deployment models*



NIST definition of cloud computing

- NIST cloud model is composed of *five essential characteristics, three service models, and four deployment models*



Cloud computing characteristics

Common Characteristics:

Massive Scale

Resilient Computing

Homogeneity

Geographic Distribution

Virtualization

Service Orientation

Low Cost Software

Advanced Security

Essential Characteristics:

On Demand Self-Service

Broad Network Access

Rapid Elasticity

Resource Pooling

Measured Service

Essential characteristics

Broad Network Access

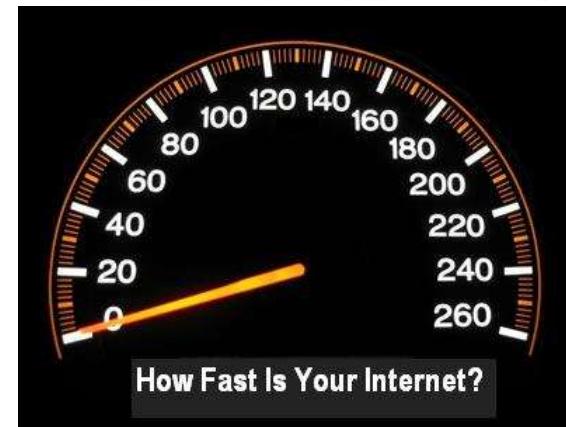


Definition

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs).

NIST

- Network is essential to consume the service
- Endpoints can be of any type:
 - ▶ Smartphone, tablet, notebook, laptop, desktop, server, other applications



Essential characteristics

Resource Pooling

Definition

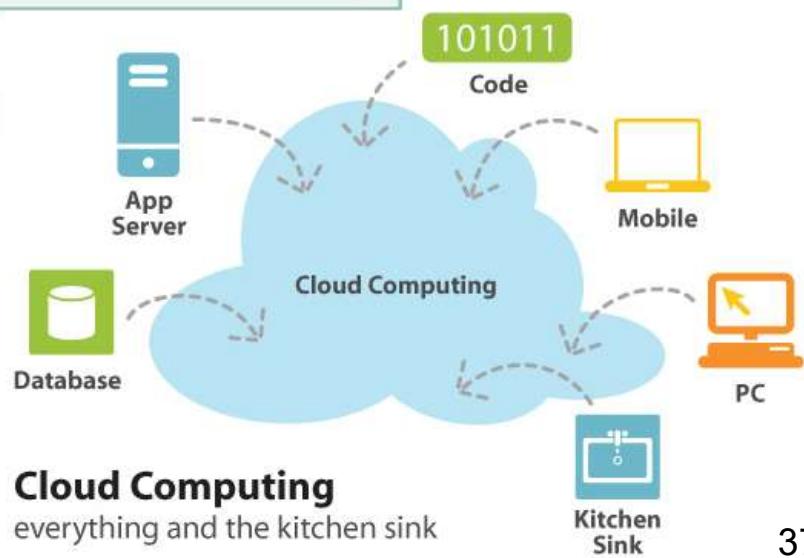
The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

NIST



Shared Resources

- Infrastructure and services run on shared physical devices (e.g., multi-tenant)



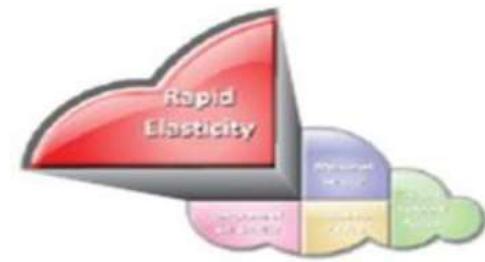
Essential characteristics

Rapid Elasticity

Definition

Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in.

NIST



- Capacity can be scaled up, down, in, or out dynamically
- Scaling is immediate
- Licensing is also built to scale
- Underlying hardware can be anywhere geographically

Essential characteristics

On Demand-Self Service

Definition

A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

NIST



- On-Demand
 - ▶ Customers incur no infrastructure capital costs and are charged an Operational Expense (OPEX)
 - ▶ Workload forecasting unnecessary
 - ▶ Demand trends are predicted managed by the provider
 - ▶ The underlying hardware may be anywhere geographically
- Self-service
 - ▶ Resources directly/indirectly reserved by the customer via a web based portal and appropriate APIs

Essential characteristics

Measured Services

Definition

Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).

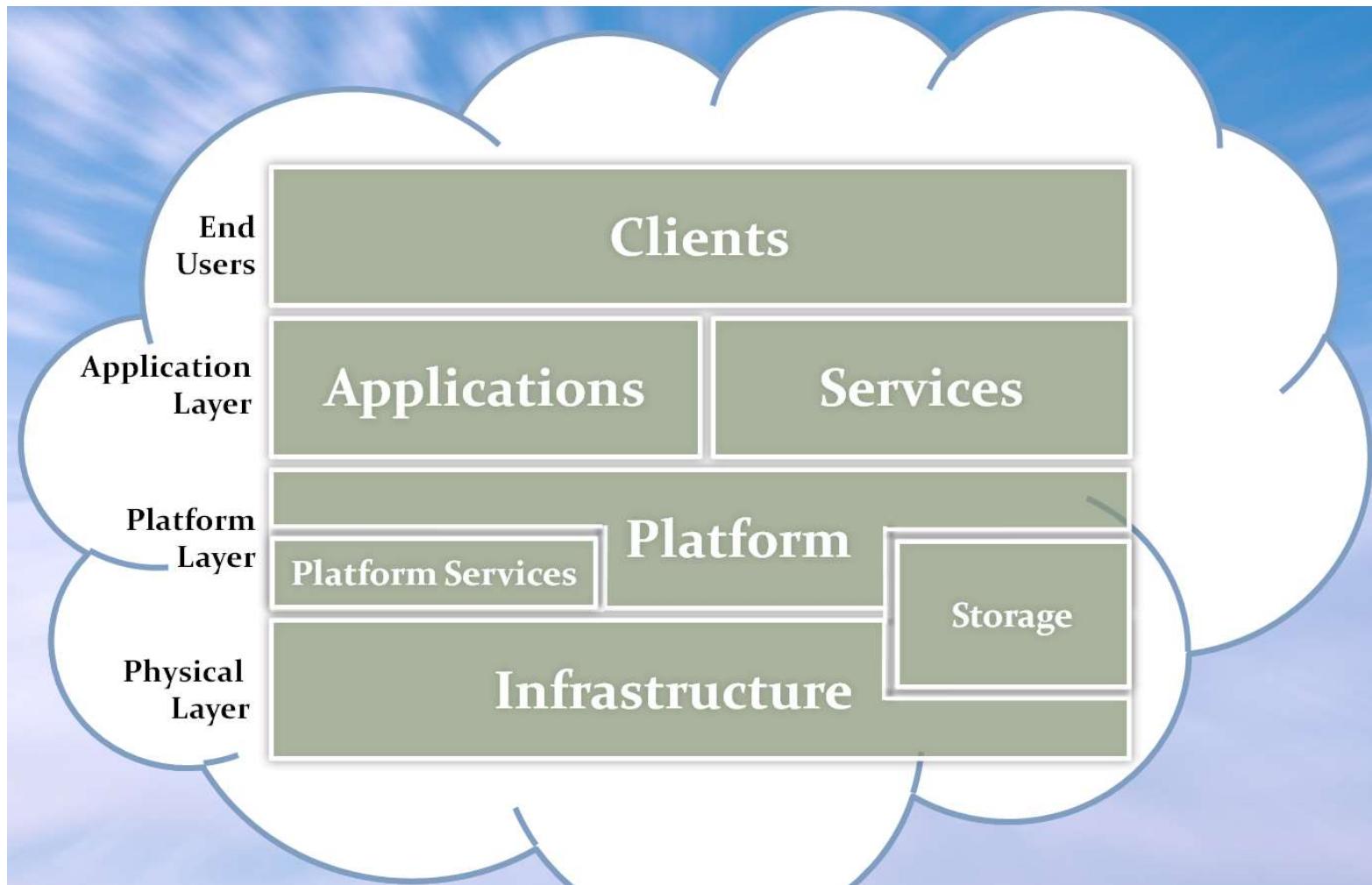
Resource usage can be monitored, controlled, and reported providing transparency for both the provider and consumer of the utilized service.

NIST

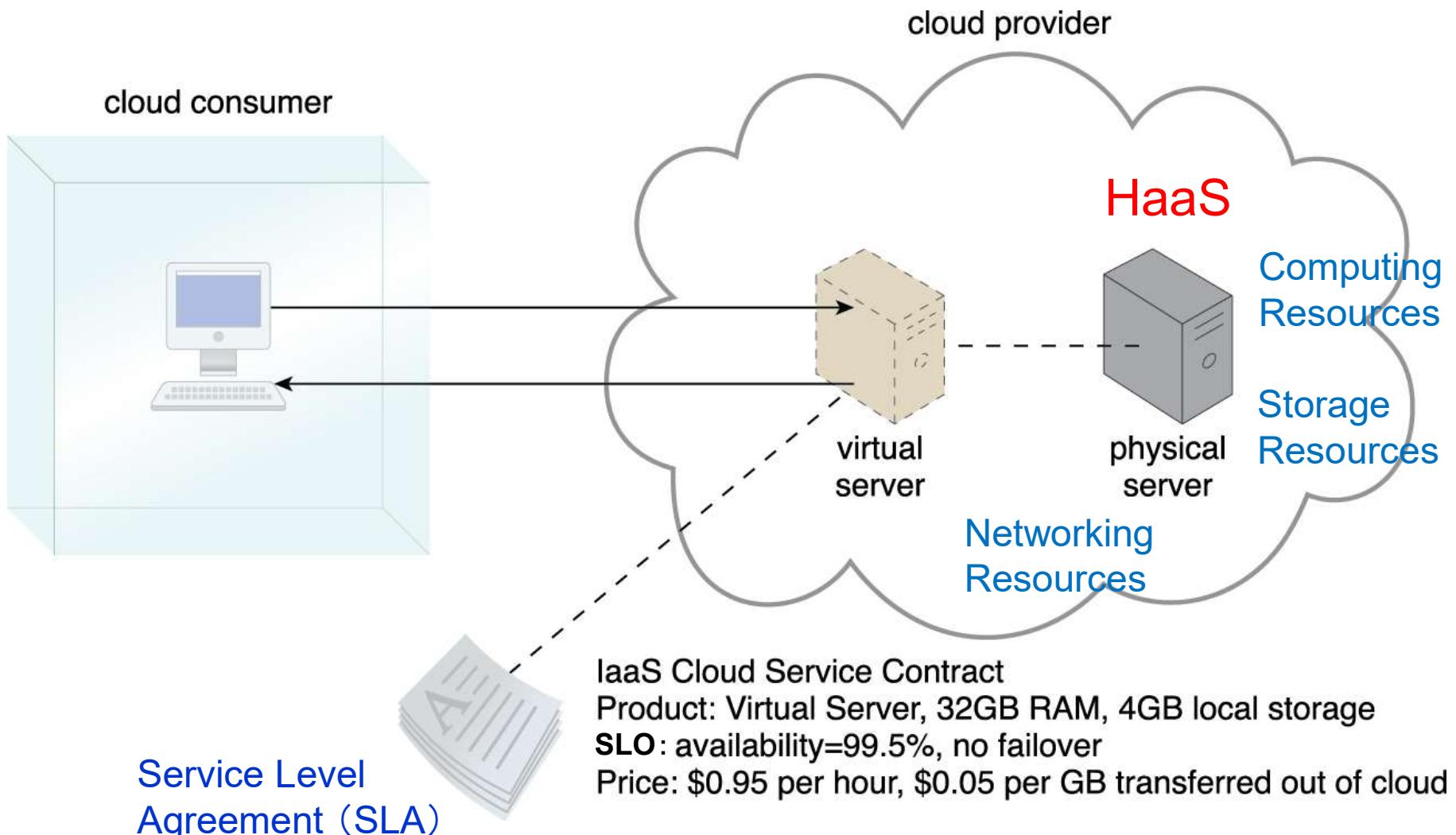


- Infrastructure operational costs incurred on a pay-per-use basis
- Contractual obligations tied to price tiering
 - ▶ No obligation has the highest price

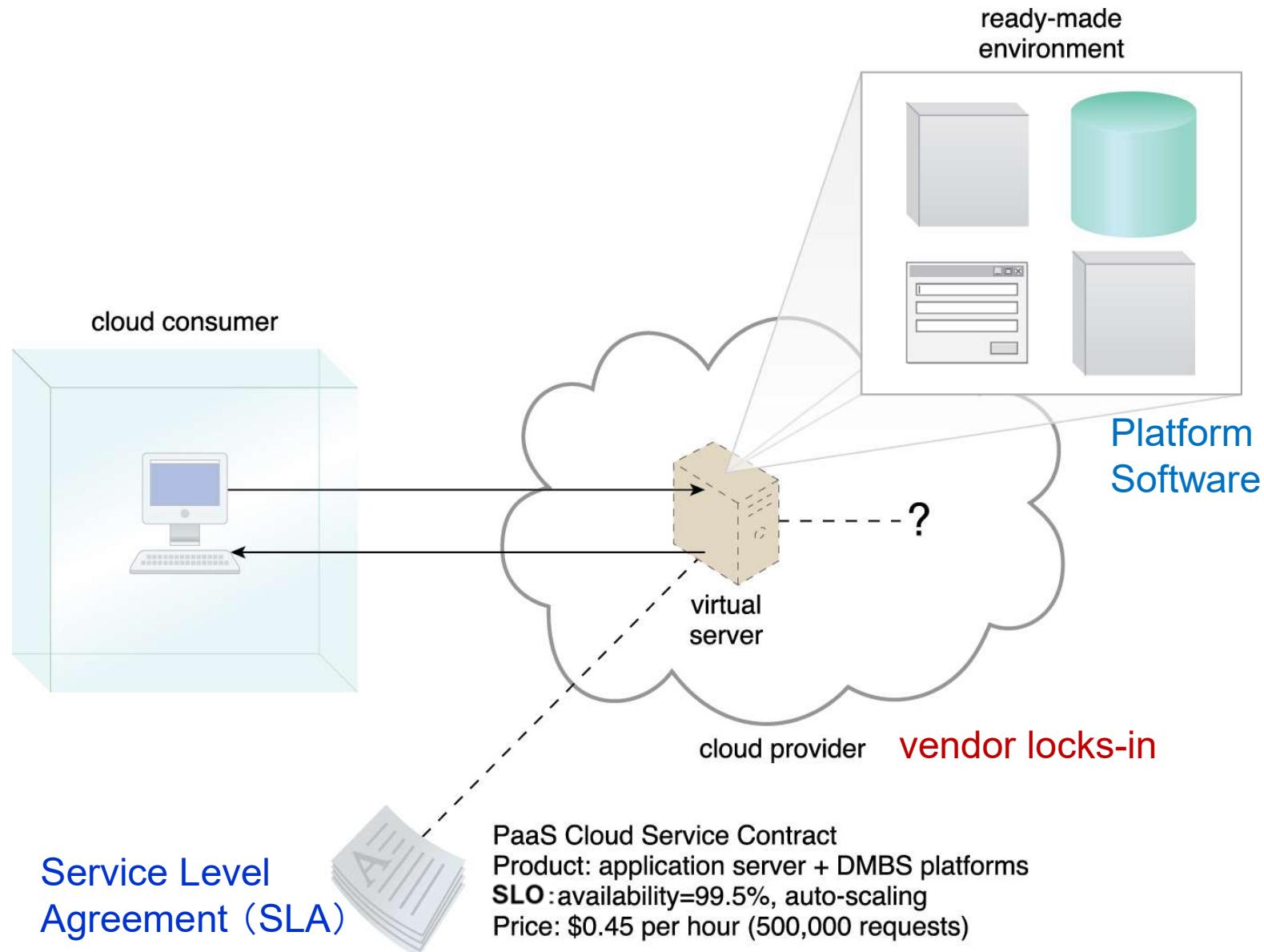
Cloud component



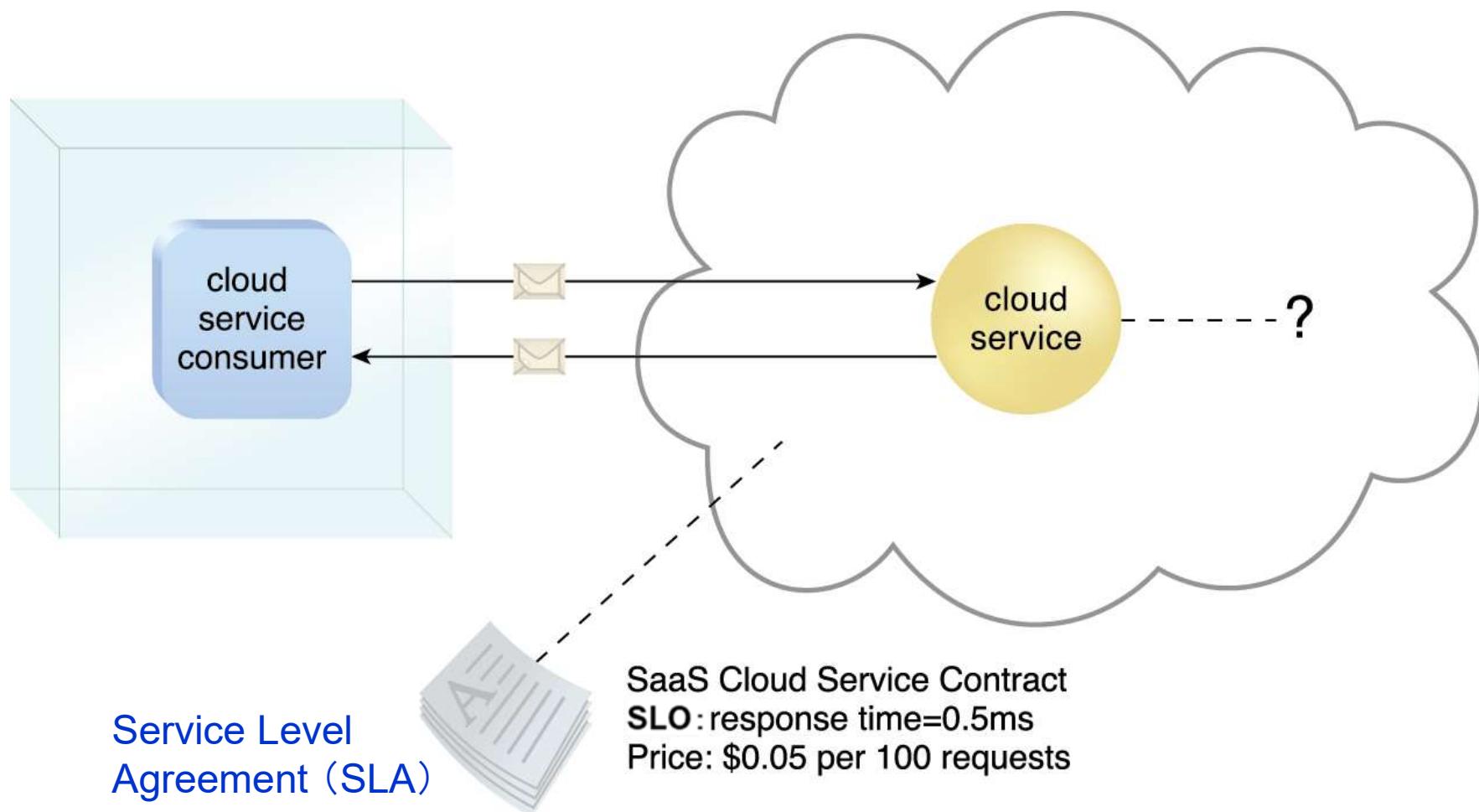
Infrastructure as a Service (IaaS)



Platform as a Service (PaaS)



Software as a Service (PaaS)



Cloud service models

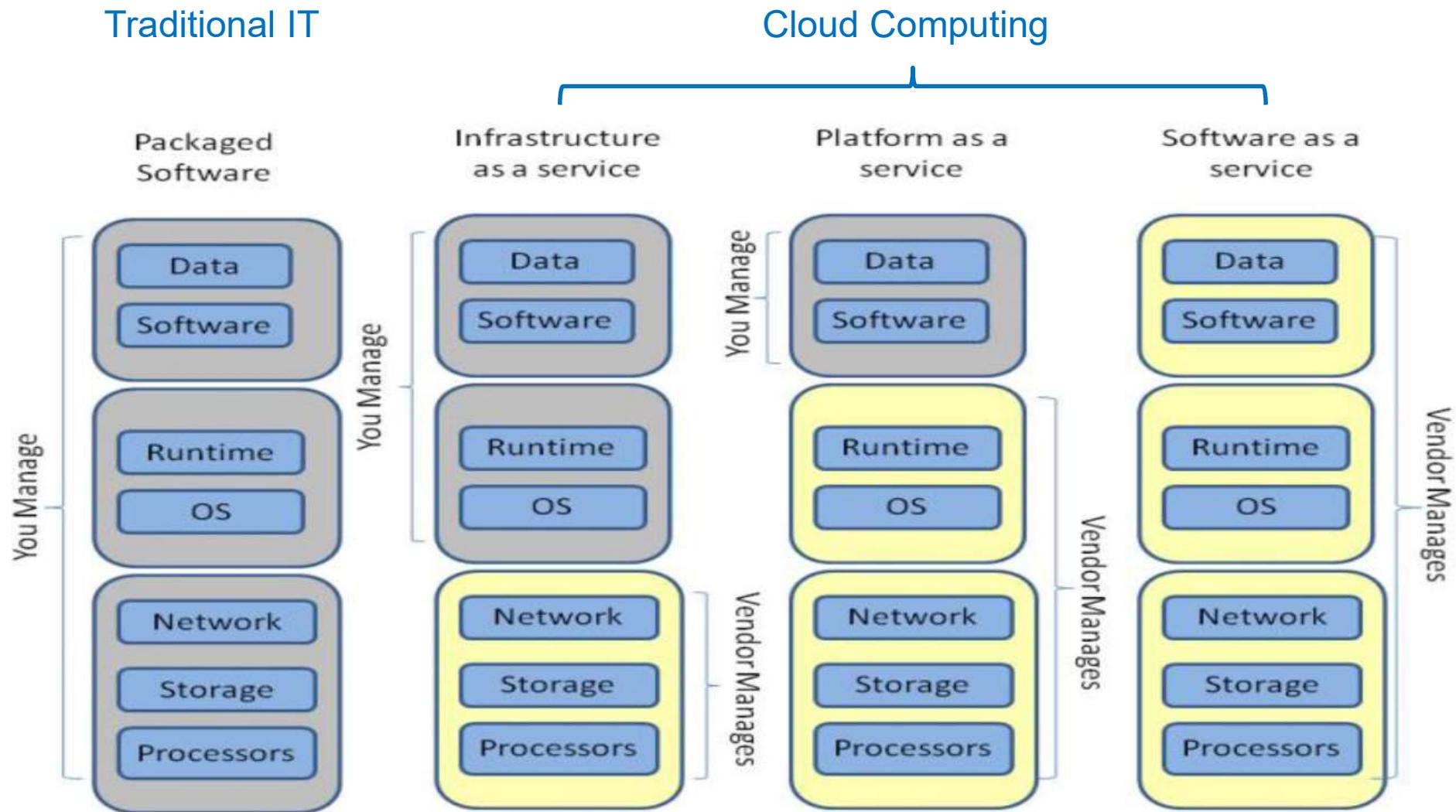
Compute + Storage Clouds
enables
+ Network

Cloud Infrastructures
enables

Cloud Platforms
enables

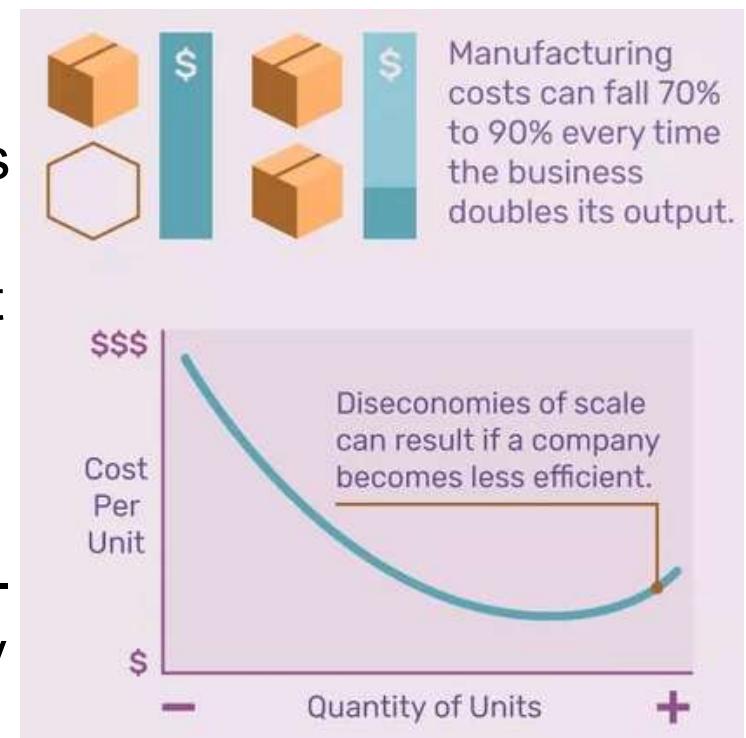
Cloud Applications

Customer vs. service provider



Economies of scale

- In microeconomics, **economies of scale** are the cost advantages that enterprises obtain due to their scale of operation (typically measured by amount of output produced), with cost per unit of output decreasing with increasing scale.
- Economies of scale in 2006 for medium-sized datacenter (1000 servers) vs. very large datacenter (50,000 servers).



| Technology | Cost in Medium-sized DC | Cost in Very Large DC | Ratio |
|----------------|------------------------------|-------------------------------|-------|
| Network | \$95 per Mbit/sec/month | \$13 per Mbit/sec/month | 7.1 |
| Storage | \$2.20 per GByte / month | \$0.40 per GByte / month | 5.7 |
| Administration | ≈140 Servers / Administrator | >1000 Servers / Administrator | 7.1 |

Economies of scale: analogy

Private
(On-Premise)



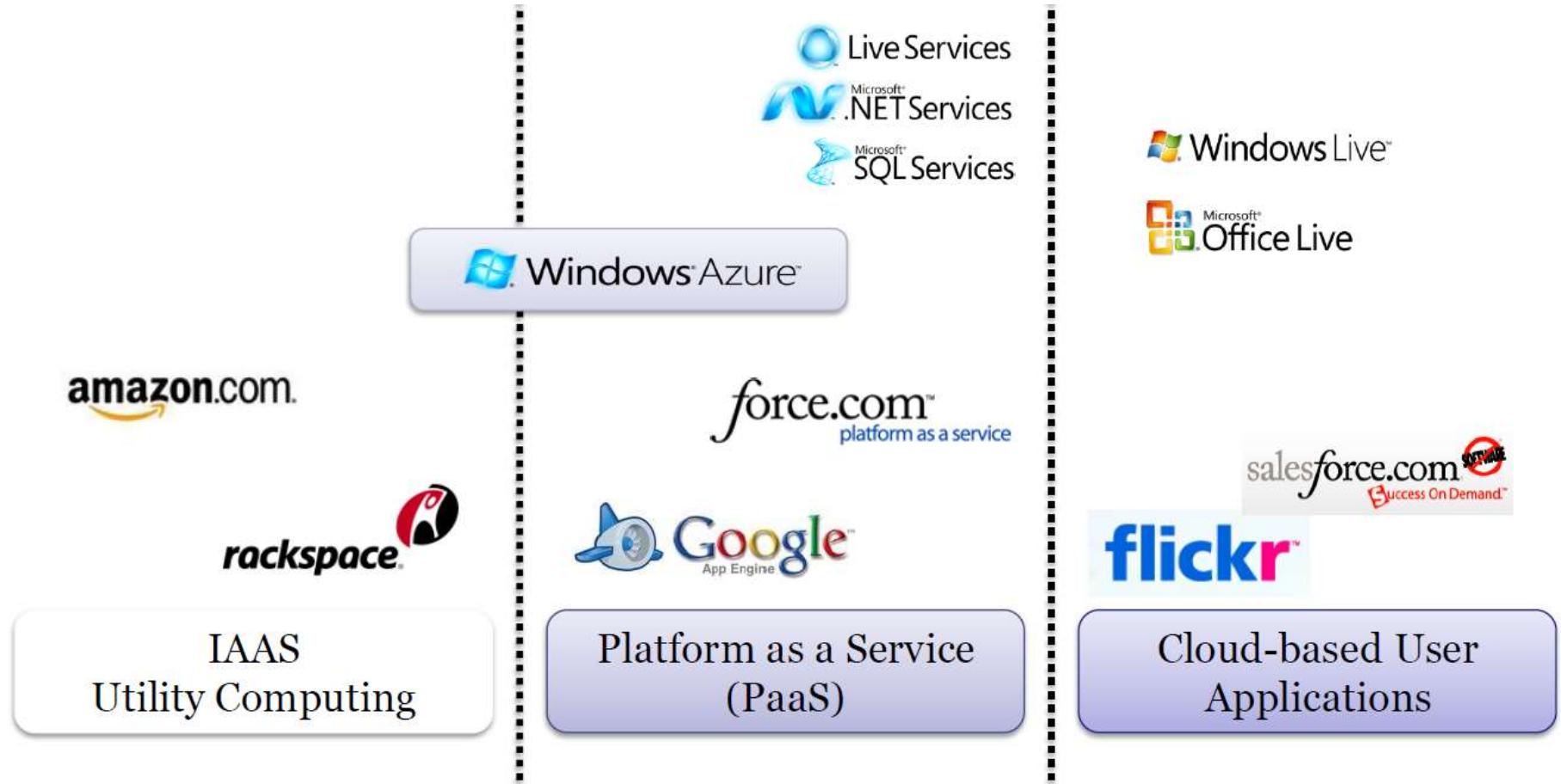
Infrastructure
(as a Service)



Platform
(as a Service)



Simple service map



“X” as a Service

Infrastructure as a service (**IaaS**)

Platform as a service (**PaaS**)

Software as a service (**SaaS**)

Network as a service (**NaaS**)

Storage as a service (**StaaS**)

Desktop as a service (**DaaS**)

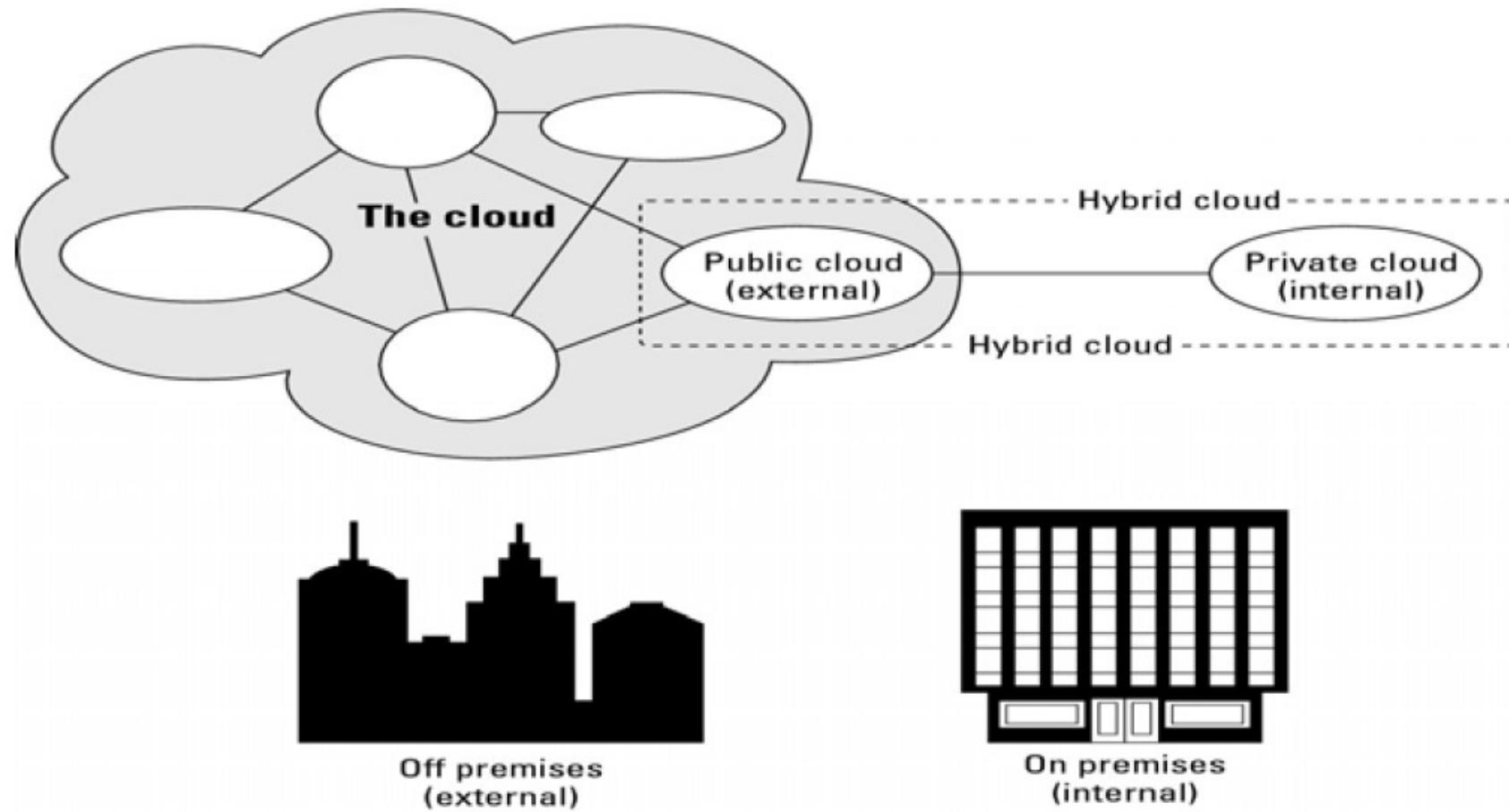
Security as a service

Data as a service

Database as a service

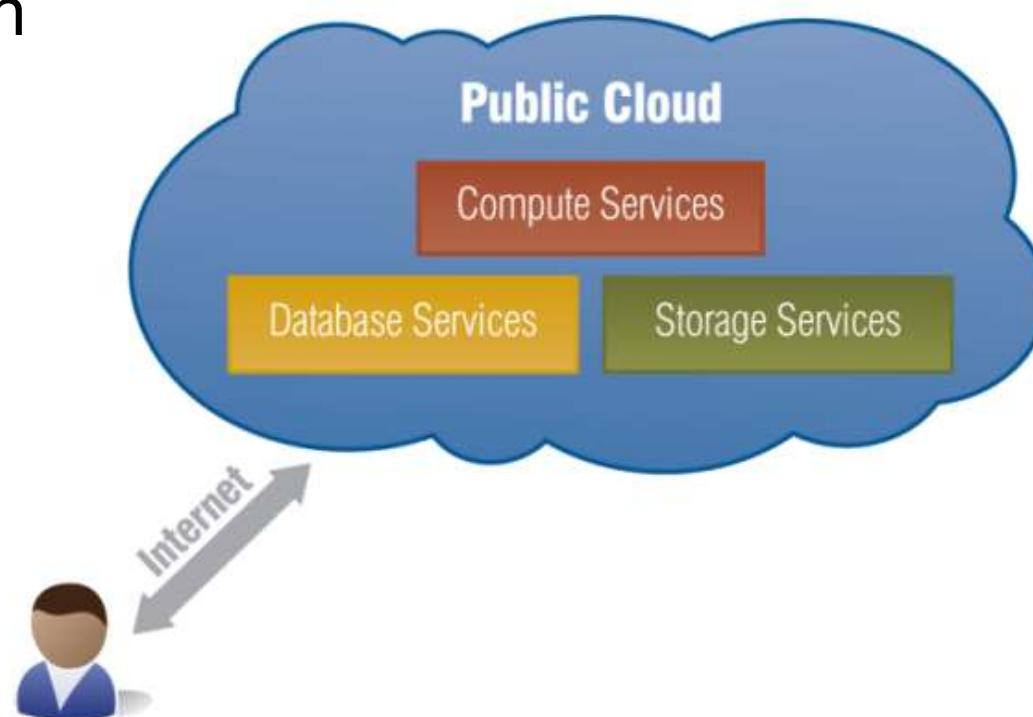
Communication as a service

Cloud deployment models



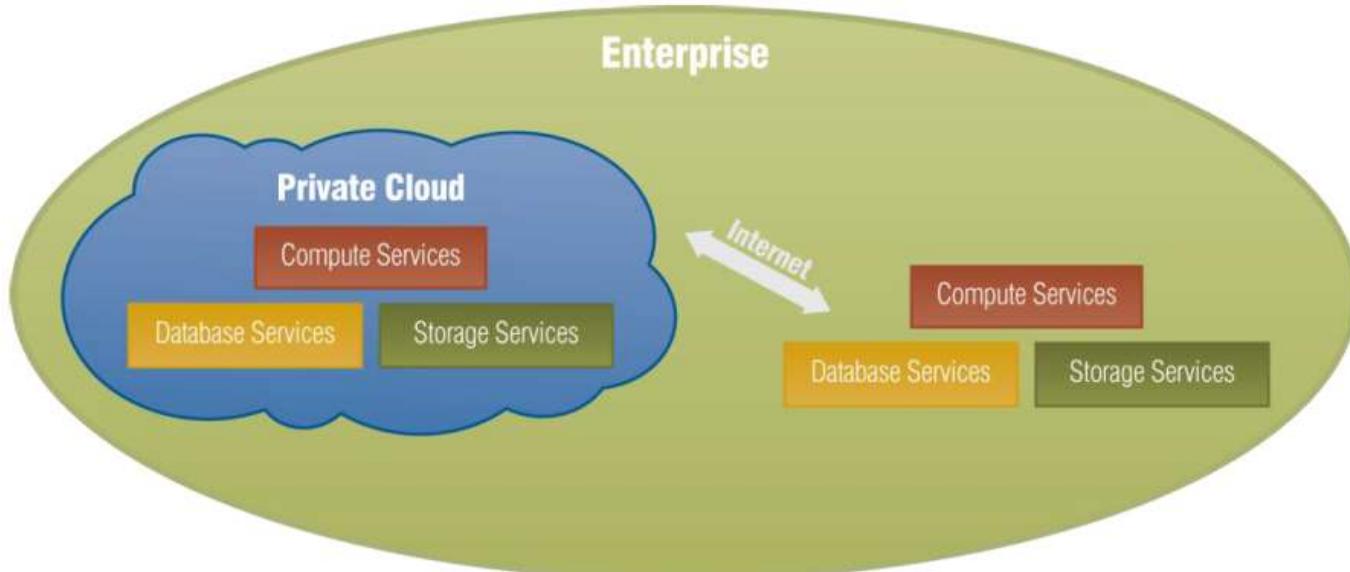
Public cloud

- Definition: the services are delivered to the client via the Internet from a third party service provider.
- Example: Amazon



Private cloud

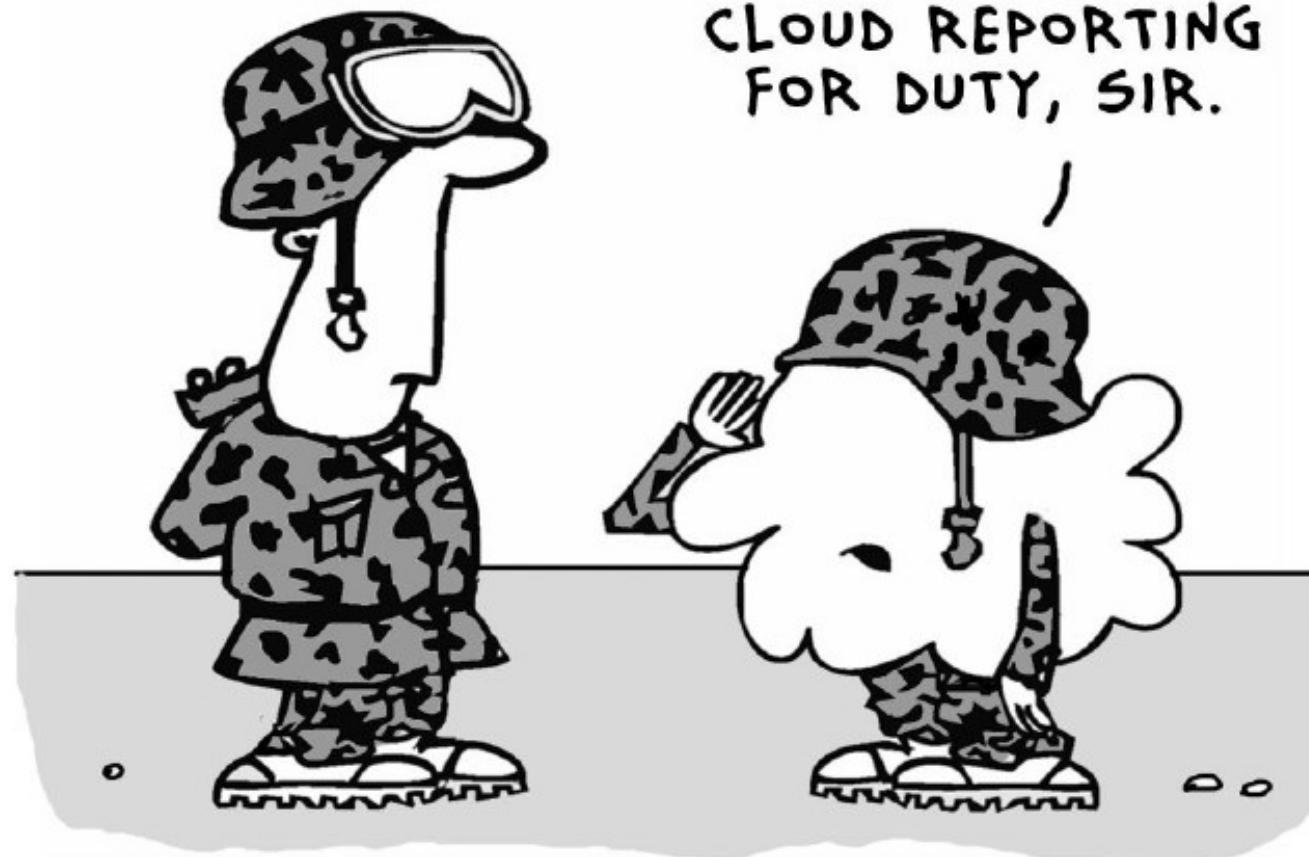
- Definition: these services are managed and provided within the organization. There are less restriction on network bandwidth, fewer security exposures and other legal requirements compared to the public Cloud.
- Example: HP Data Centers



Public cloud or private cloud?

US MILITARY TO USE
CLOUD TECHNOLOGY

PRIVATE
CLOUD REPORTING
FOR DUTY, SIR.



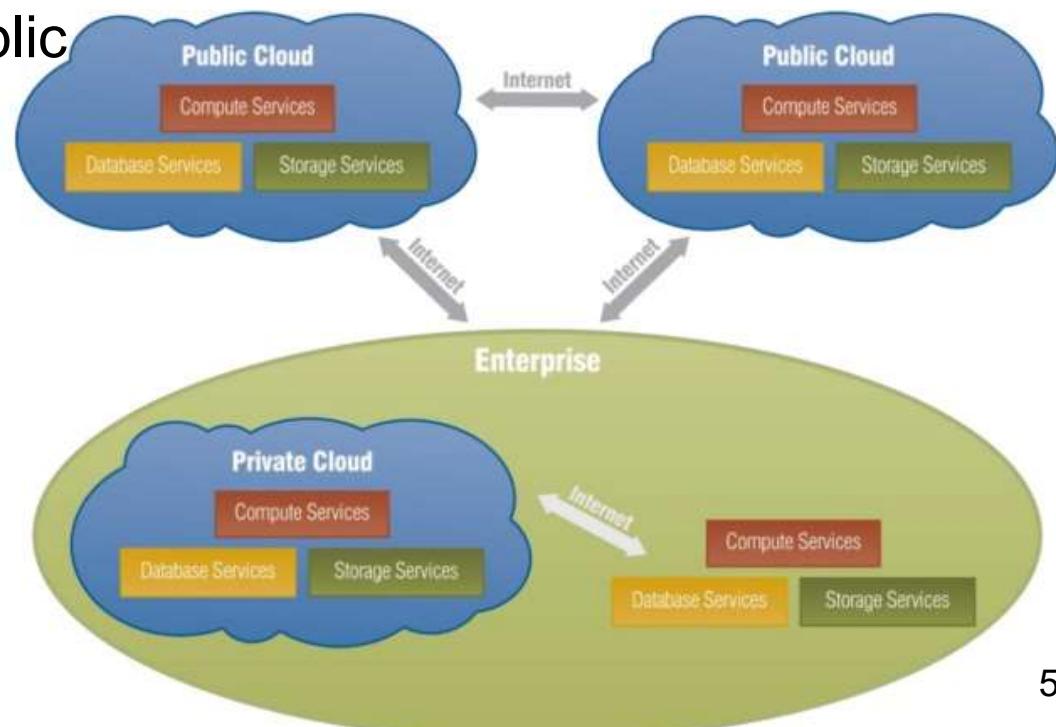
Community cloud

- Definition: Infrastructure shared by several organizations, targeting a specific community
- It may be for one organization or for several organizations, but they share common concerns such as their mission, policies, security, regulatory compliance needs, and so on. A community cloud may be managed by the constituent organization(s) or by a third party.



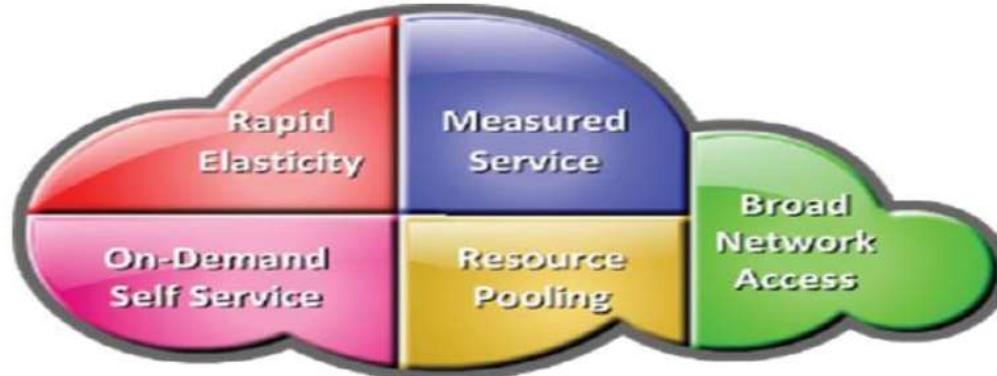
Hybrid cloud

- Definition: there is a combination of services provided from public and private clouds.
- Example:
 - ERP in Private cloud
 - Sales & Email on public



Summary: 5-4-3 definition

5 Essential Characteristics :



4 Deployment Models:

- Private cloud
- Public cloud
- Community cloud
- Hybrid cloud

3 Service Models:

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

Open standard

- Without standards, the industry creates proprietary systems with vendor lock-in, sometimes referred to as “*stovepipe*” clouds.
- Because clients do not want to be locked into any single system, there is a strong industry push to create *standards-based clouds*.
- *OpenStack* is an industry group seeking to create open cloud standards based on Rackspace.com and NASA technologies.
<http://www.openstack.org/>
- *Eucalyptus* is a Linux-based software platform for creating cloud computing IaaS systems based on computer clusters
<http://open.eucalyptus.com/>
- The IEEE Technical Committee on Services Computing sponsors a conference in this area called *CLOUD* and has some working groups and publications in this area. <http://tab.computer.org/tcsc/>

Open standard revolutions

- **Open Compute Project (OCP)**

- Users of data center HW solutions such as FaceBook start dictating their specifications AND are willing to open up these specifications so as to ensure multiple sourcings



- **OpenStack**



- Provides an open-source core for building cloud data center management software suite, and a set of APIs for third-party plug-ins to team up and form end-to-end solutions

- **Open Networking**

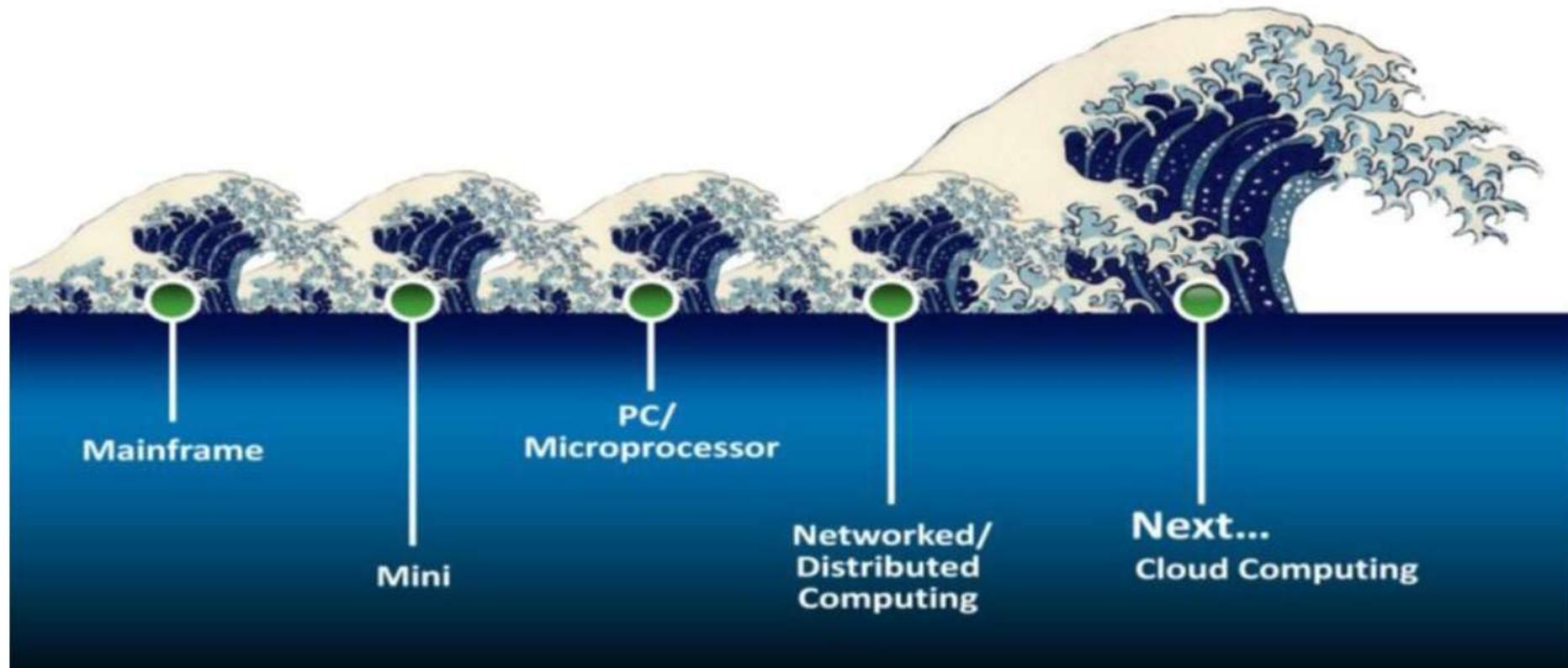


- Decouples control plane from data plane to break the conventional vertically integrated business model in network switch/router/appliance industry, and move to “standard data plane and diversified control plane” model

Today's agenda

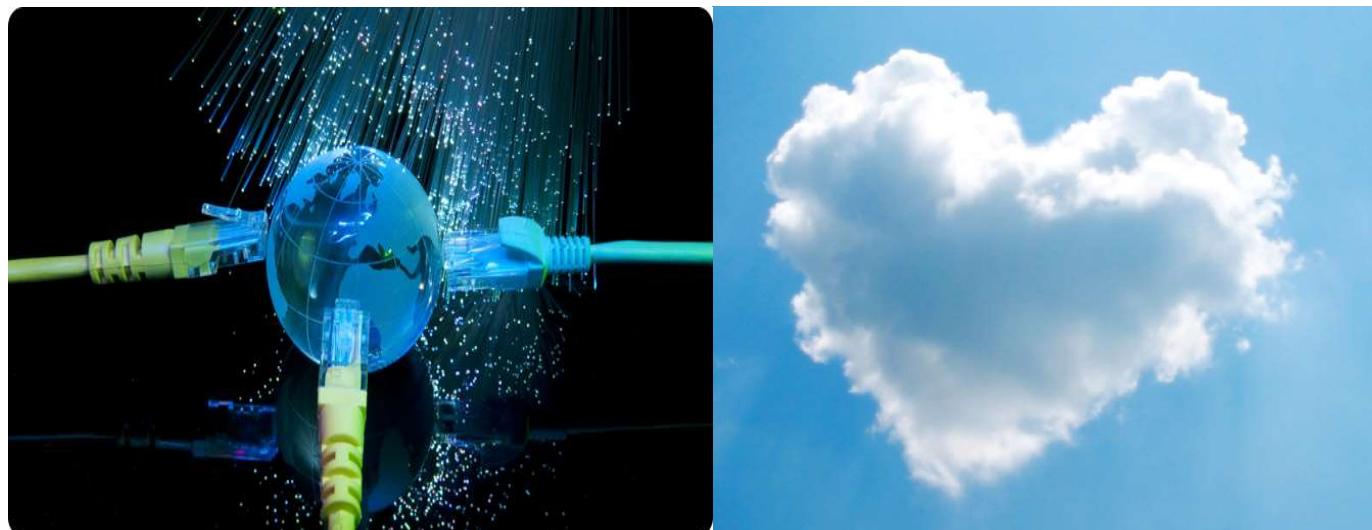
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History of ICT techniques

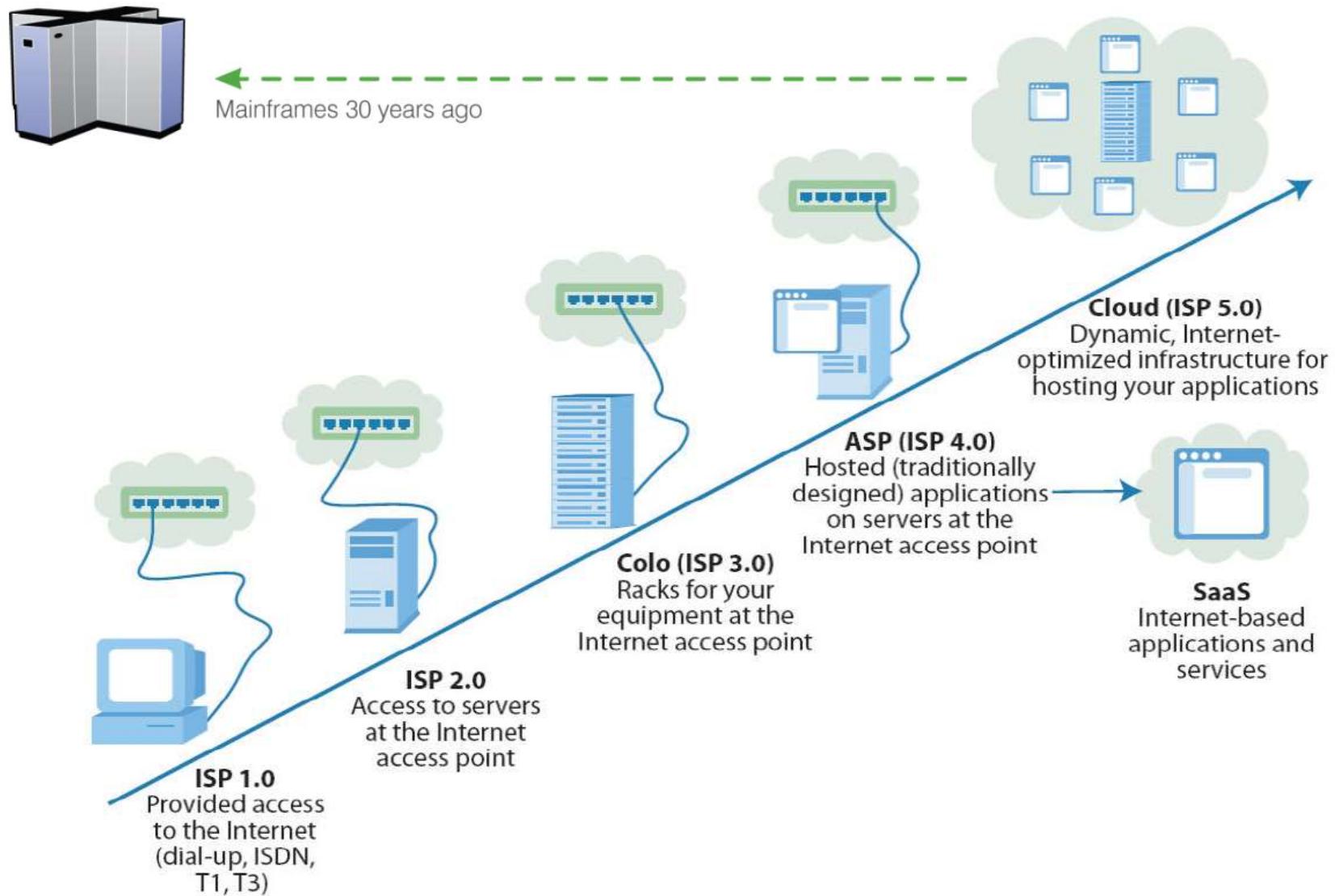


Something old, something new

- Cloud computing is a **revolutionary** way of architecting & providing services based on **evolutionary** technical changes.
- The cloud is something that you have been using for a long time now; it is the Internet.



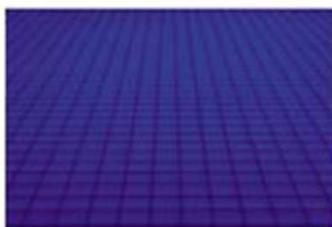
ISP to cloud evolution



Computing techniques

Grid Computing

- Solving large problems with parallel computing
- Made mainstream by Globus Alliance



Utility Computing

- Offering computing resources as a metered service
- Introduced in late 1990s



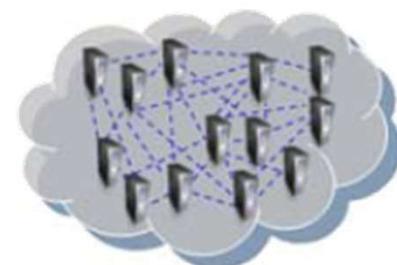
Software as a Service

Network-based subscriptions to applications
Gained momentum in 2001



Cloud Computing

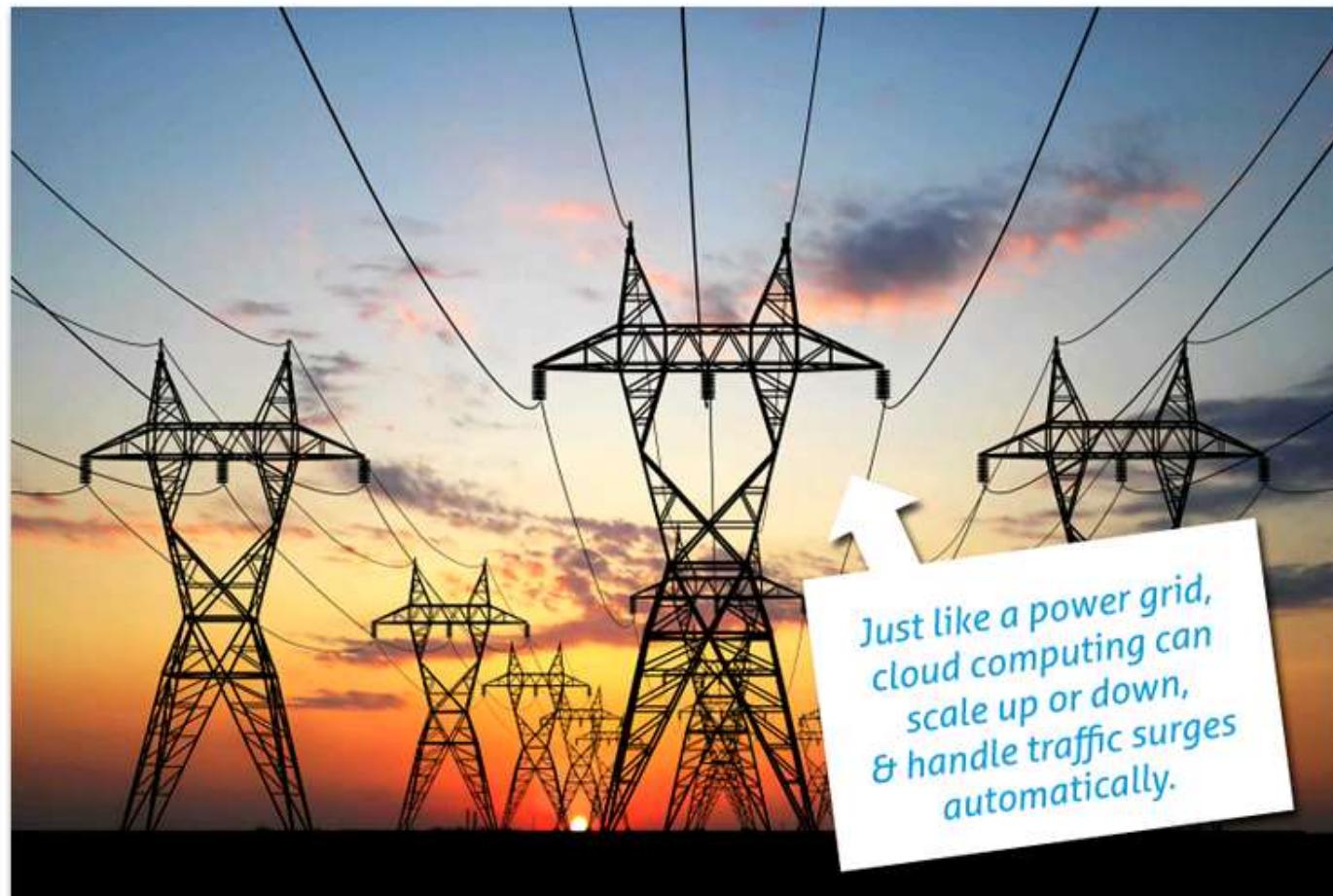
Next-Generation Internet computing
Next-Generation Data Centers



Utility computing

It's internet based computing that operates like a power grid.

With Cloud computing, you get all of the resources, software and information you need, when you need it – just like the electricity in your home.



IT does not matter

The Big Switch

“We will probably see the spread of ‘computer utilities’ which like present electric and telephone utilities, will service individual homes and offices across the country”

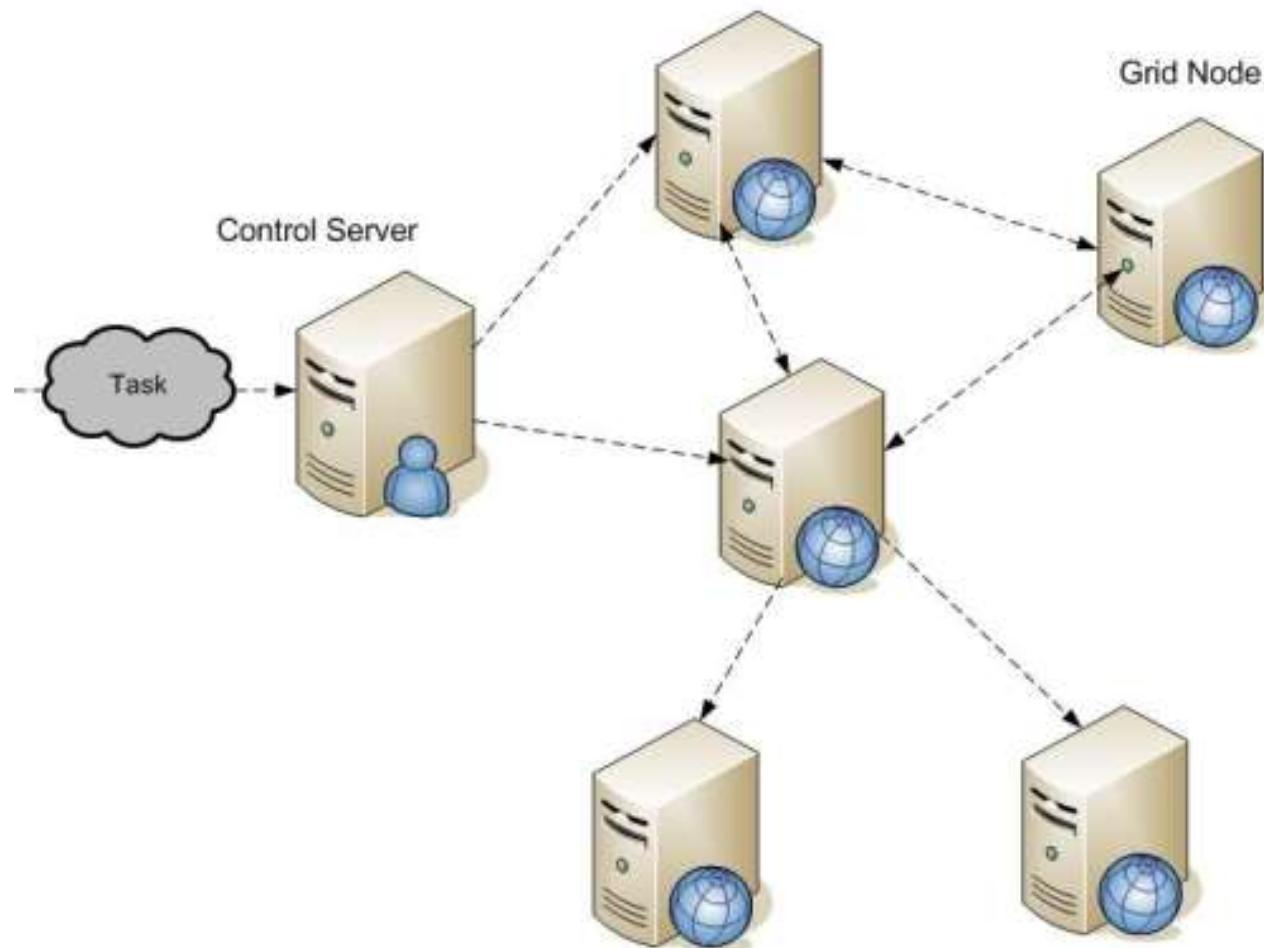
Kleinrock, 1969

“Goodbye ‘World Wide Web.’
Hello ‘World Wide Computer’ ”

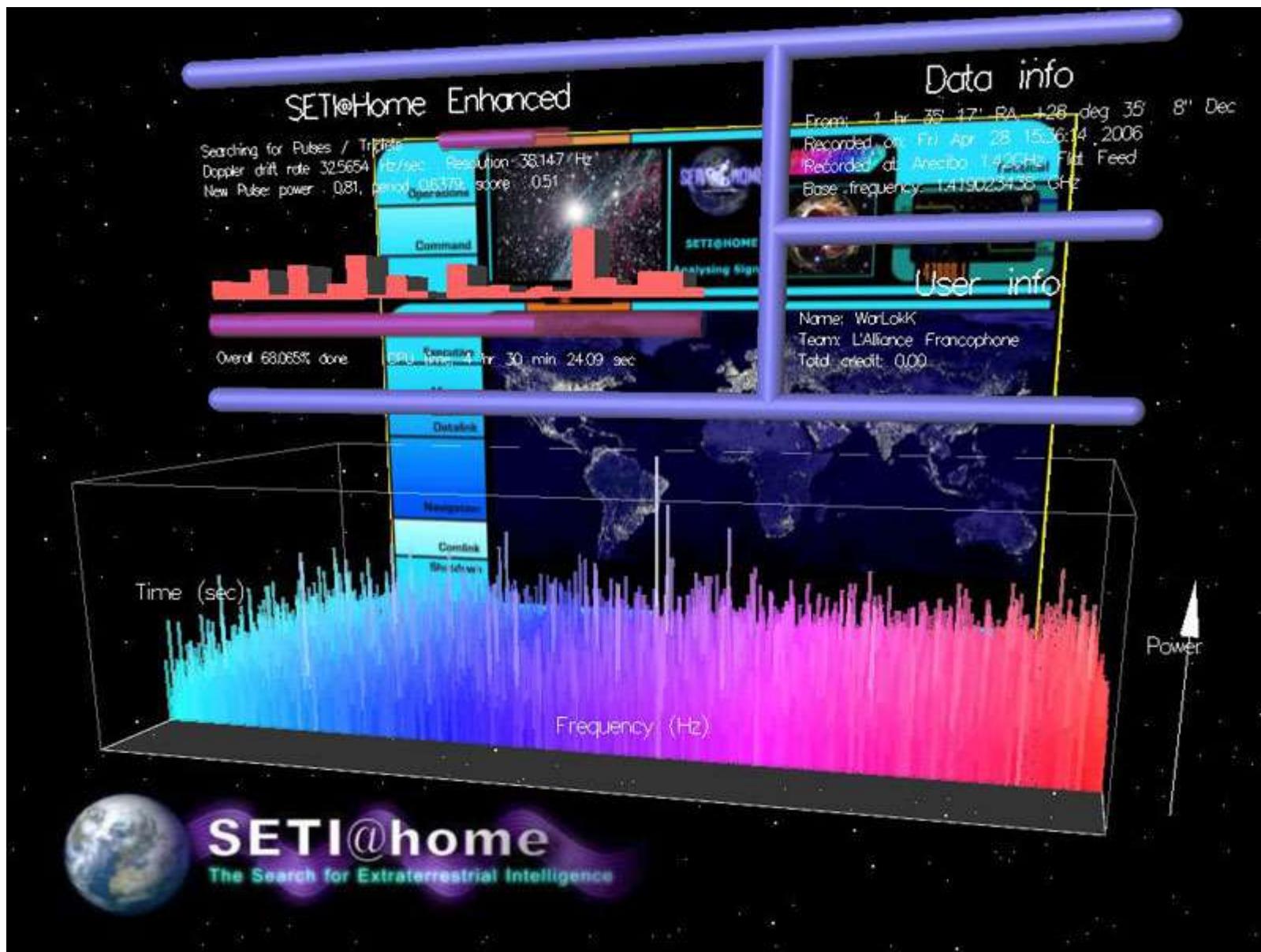
Carr, 2008



Grid computing



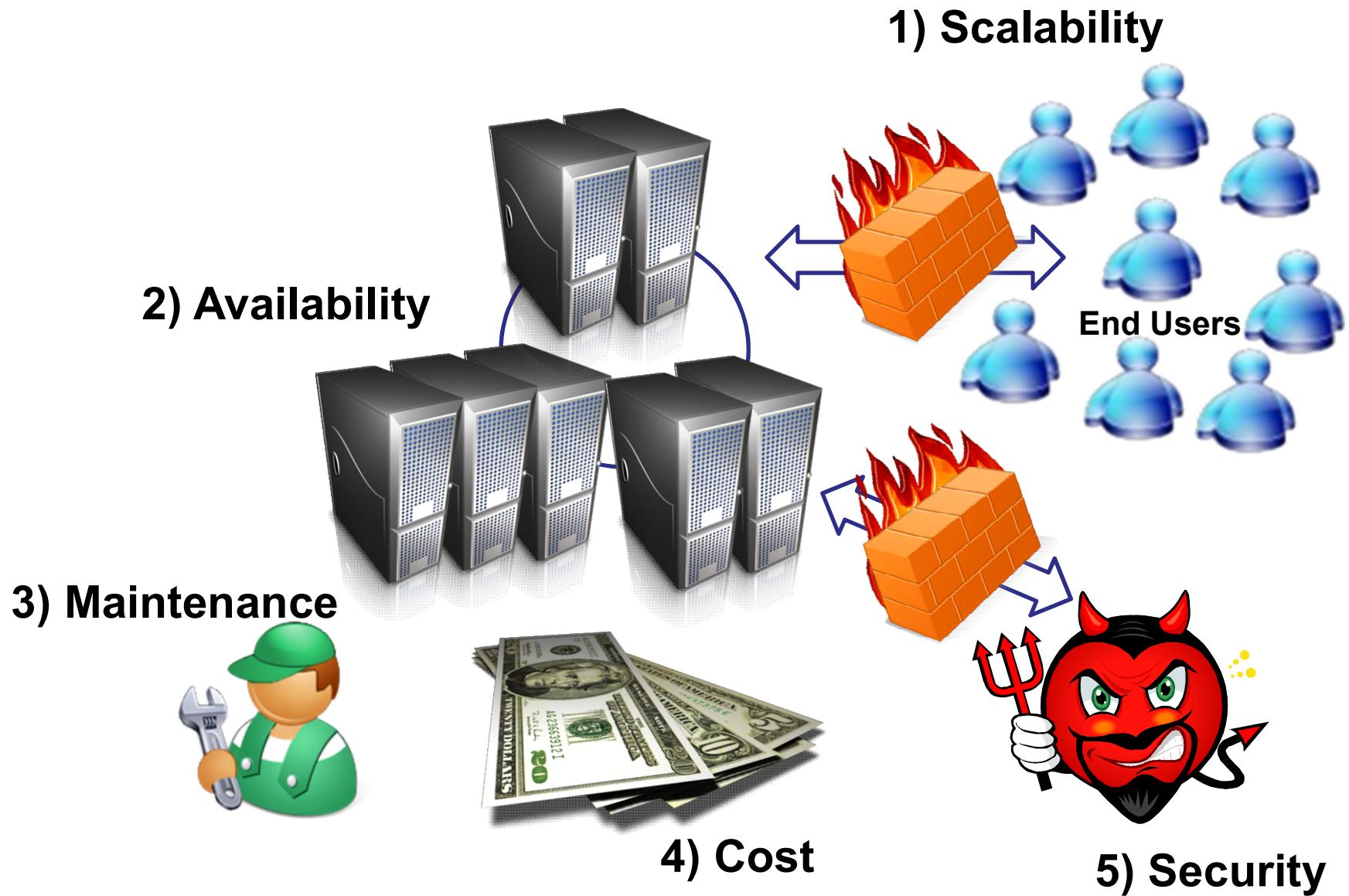
Grid computing



Grid vs. cloud

| | Grid | Cloud |
|------------------------------------|---|---|
| Underlying concept | Utility Computing | Utility Computing |
| Main benefit | Solve computationally complex problems | Provide a scalable standard environment for network-centric application development, testing and deployment |
| Resource distribution / allocation | Negotiate and manage resource sharing; schedulers | Simple user <-> provider model; pay-per-use |
| Domains | Multiple domains | Single domain |
| Character / history | Non-commercial, publicly funded | Commercial |

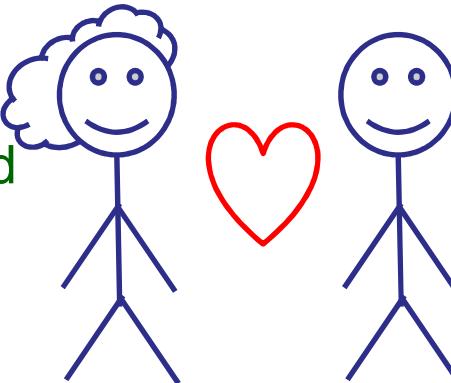
Distributed computing challenges



The birth of cloud computing

Once upon a time...

- I'm Utility Computing
- I package computing resources as a metered service
- I'm economic



- I'm Distributed Computing
- I allow computations to run on several networked computers
- I'm cool!

They fell in love, and had a child...



Cloud Computing

Comparison

