



# Cloud Networking (VITMMA02)

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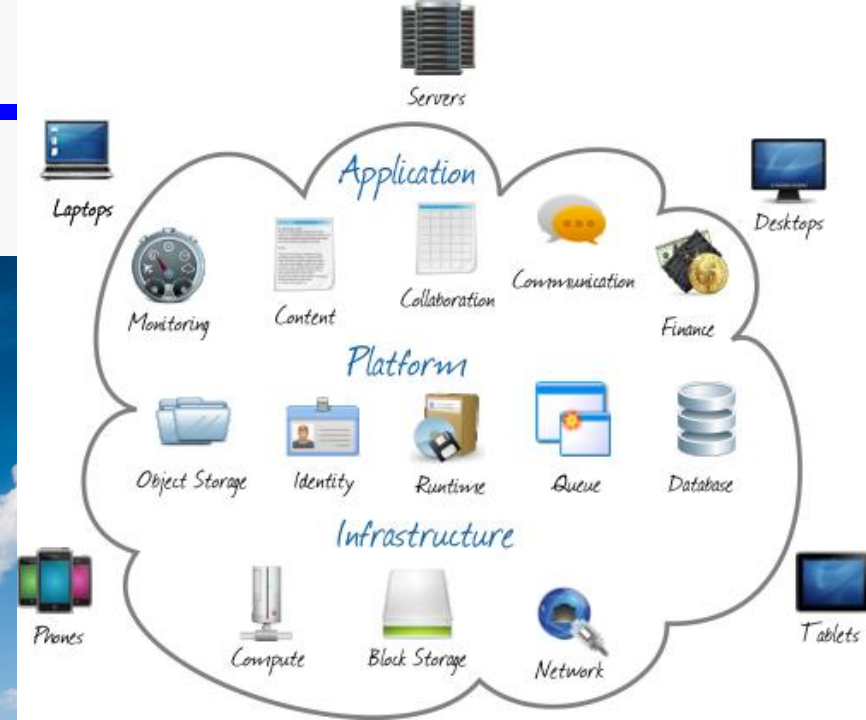
Spring 2019



# Course Info

- » General subject info, requirements:  
<https://portal.vik.bme.hu/kepzes/targyak/VITMMA02/en/>
- » Subject homepage:  
<http://www.tmit.bme.hu/vitmma02?language=en>
- » Course homepage:  
<http://www.tmit.bme.hu/vitmma02-2019-en?language=en>

# Cloud computing





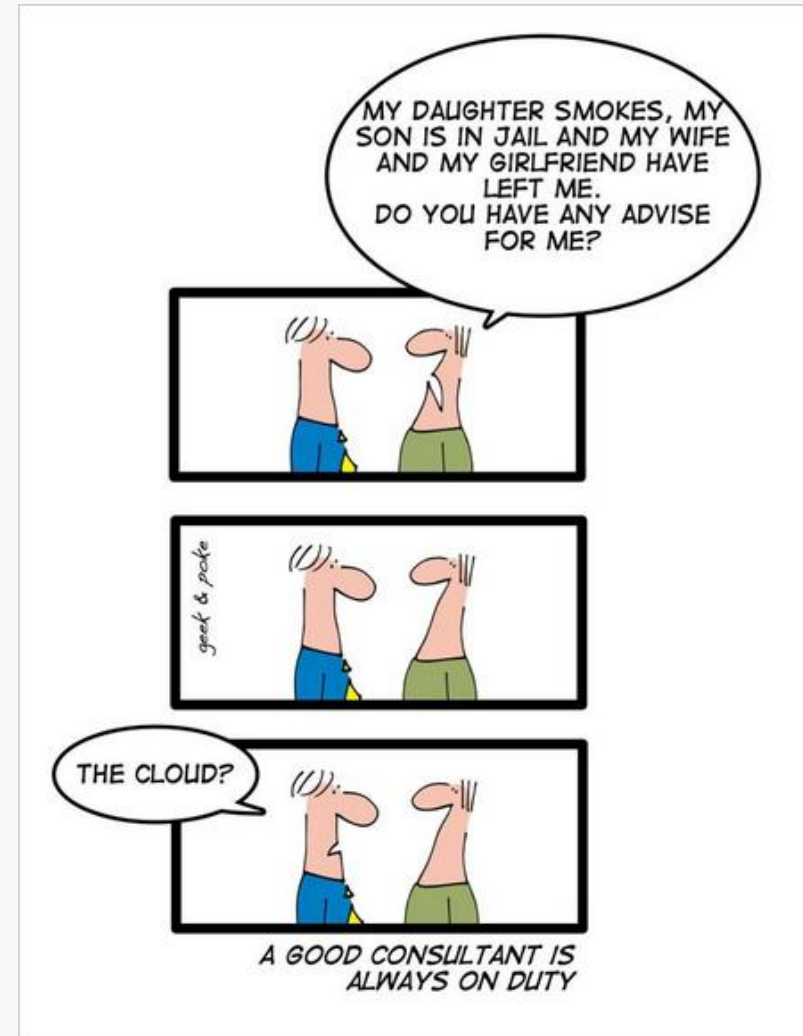
# Definition of Cloud

- » Many characterizations, for example:
  - » using services and applications any time, from anywhere
  - » using information technology with usage based costs
  - » an overall virtualization model from the infrastructure to the applications
  - » using dynamically scalable virtual resources as a service over the Internet
- » Definition of National Institute of Standards and Technology (NIST) /2011. sept./
  - » „ 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.”
  - » 5 key properties            +            3 service models            +            4 deployment models


<ul style="list-style-type: none"><li>» on-demand self-service</li><li>» broad network access</li><li>» resource pooling</li><li>» rapid elasticity</li><li>» measured service</li></ul>	<ul style="list-style-type: none"><li>» Software as a Service</li><li>» Platform as a Service</li><li>» Infrastructure as a Service</li></ul>	<ul style="list-style-type: none"><li>» Private cloud</li><li>» Community cloud</li><li>» Public cloud</li><li>» Hybrid cloud</li></ul>
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# Is it a buzzword to solve everything?

- » “With the cloud, individuals and small businesses can snap their fingers and *instantly set up enterprise-class services.*” -Roy Stephan, 2011
- » Cloud computing is really a no-brainer for any start-up because it allows you to *test your business plan very quickly for little money.*” -Brad Jefferson, Animoto CEO. 2009.
- » Larry Ellison, CEO of Oracle
  - » in 2009: „What do you mean by “cloud computing”?...All the cloud is is computers on a network.  
Our industry is so bizarre. They just change a term and they think they’ve invented technology....You can’t just come up with a [slogan] like “Let’s call that ‘cloud.’” [But] it sure beats innovation.
  - » in 2014: We think these three product areas — database, cloud applications, and engineered systems — will drive Oracle’s growth in calendar 2014.





# Cloud Applications

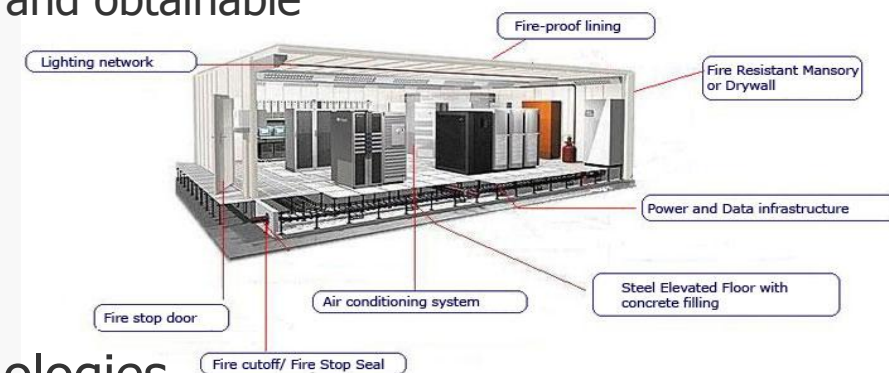
## Cloud-based applications in use



Source: CompTIA, 2018 Trends in Cloud Computing

# Introduction

- » A clear trend: centralizing computing resources in big datacenters
  - » similarly to power-plants
- » Requirements
  - » commodity hardware: relatively cheap and obtainable
  - » place, building
  - » electrical power, cooling
  - » network
- » Cloud concept
  - » efficiency in cost and productivity
  - » remote network access
- » Re-used functions from legacy technologies
  - » parallel processing
  - » distributed systems
  - » usage-based pricing for computing (pay as you go)
- » Possible tasks for a cloud engineer
  - » regular checking and development of cloud infrastructure
  - » development, deployment and management of cloud applications
  - » creation, orchestration and operation of cloud services





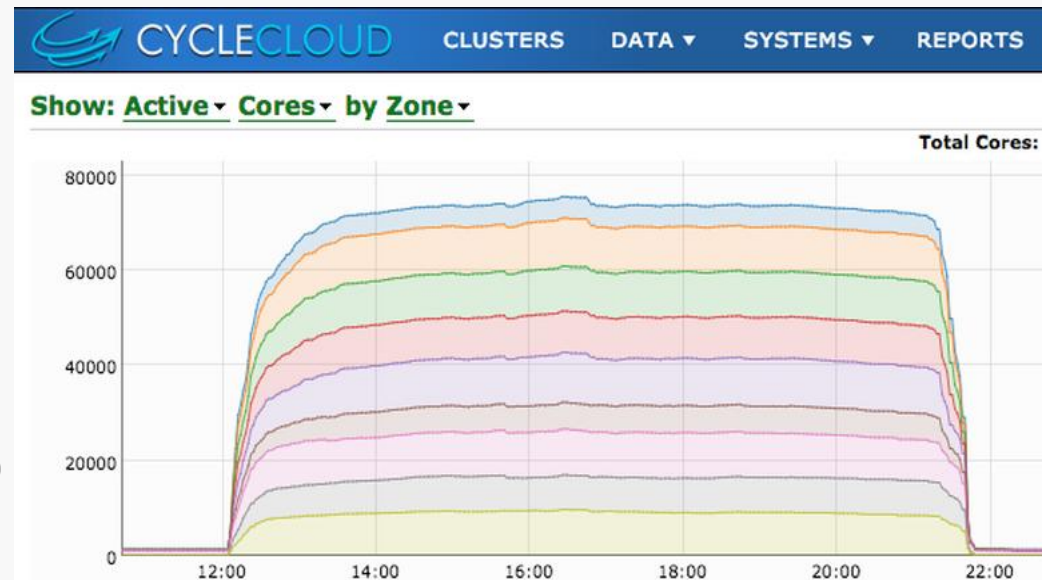
# Properties of a Public Cloud Service

- » It is not owned by You
- » Details of service operation is hidden from the cloud user
  - » no maintenance tasks
  - » You cannot see it 😊
- » Usage-based billing (optionally free)
- » Dynamically scales according to the requirements
  - » scalable, elastic



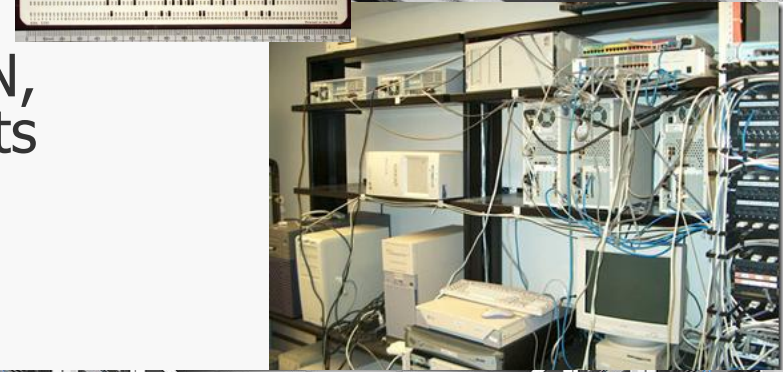
# Advantages

- » Quick server(cluster) creation
- » E.g. Amazon Web Services
  - » a fun cloud run (2014): 70,980 cores on AWS for \$5,593.94  
(<http://www.zdnet.com/article/a-fun-cloud-run-70980-cores-on-aws-for-5593-94/>)
  - » from 0 to 50 000 CPU cores: 23 min
  - » ~ 10 hours runtime
  - » 729 TeraFLOPS cluster
  - » ~ 63. supercomp.
  - » analysis and simulations (MatLab)



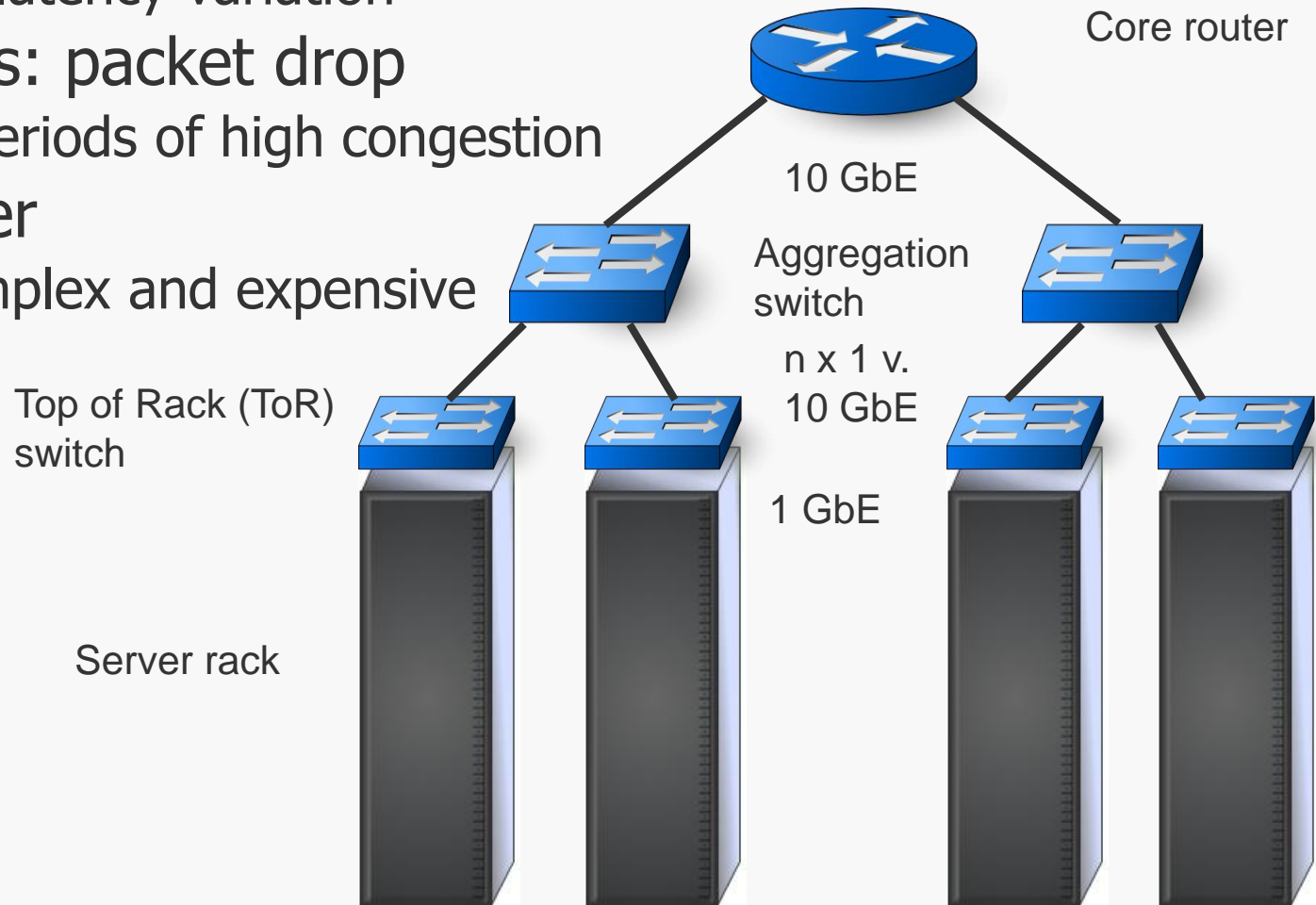
# Generations of Technologies

- » Or: what is new in cloud systems?
- » Data Center Evolution
  - » mainframe era: ~ from the 1960s
    - » 1 mainframe computer: centralized compute and storage, time sharing
    - » punch card, printer, later teletype
    - » thin client
  - » minicomputers connected with LAN, later servers + LAN connects clients too: from 1980s
    - » terminals and servers
    - » distributed compute and storage
  - » enterprise data centers (1990s)
    - » servers in racks
  - » cloud data centers
    - » commodity hardware
    - » horizontal scaling (scale out)



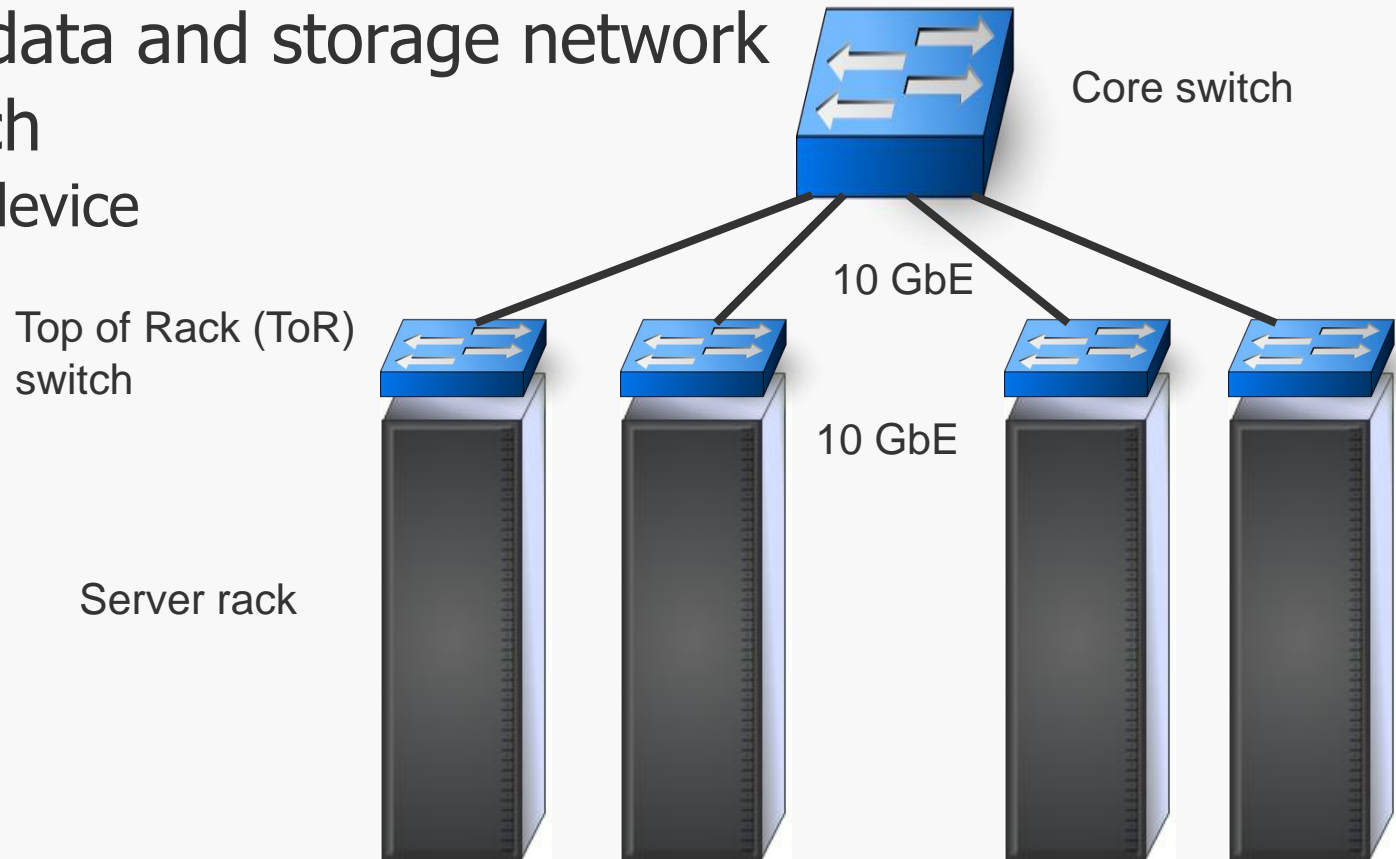
# Enterprise Data Center

- » Traffic between servers over multiple hops
  - » latency, latency variation
- » Traffic loss: packet drop
  - » during periods of high congestion
- » Core router
  - » very complex and expensive



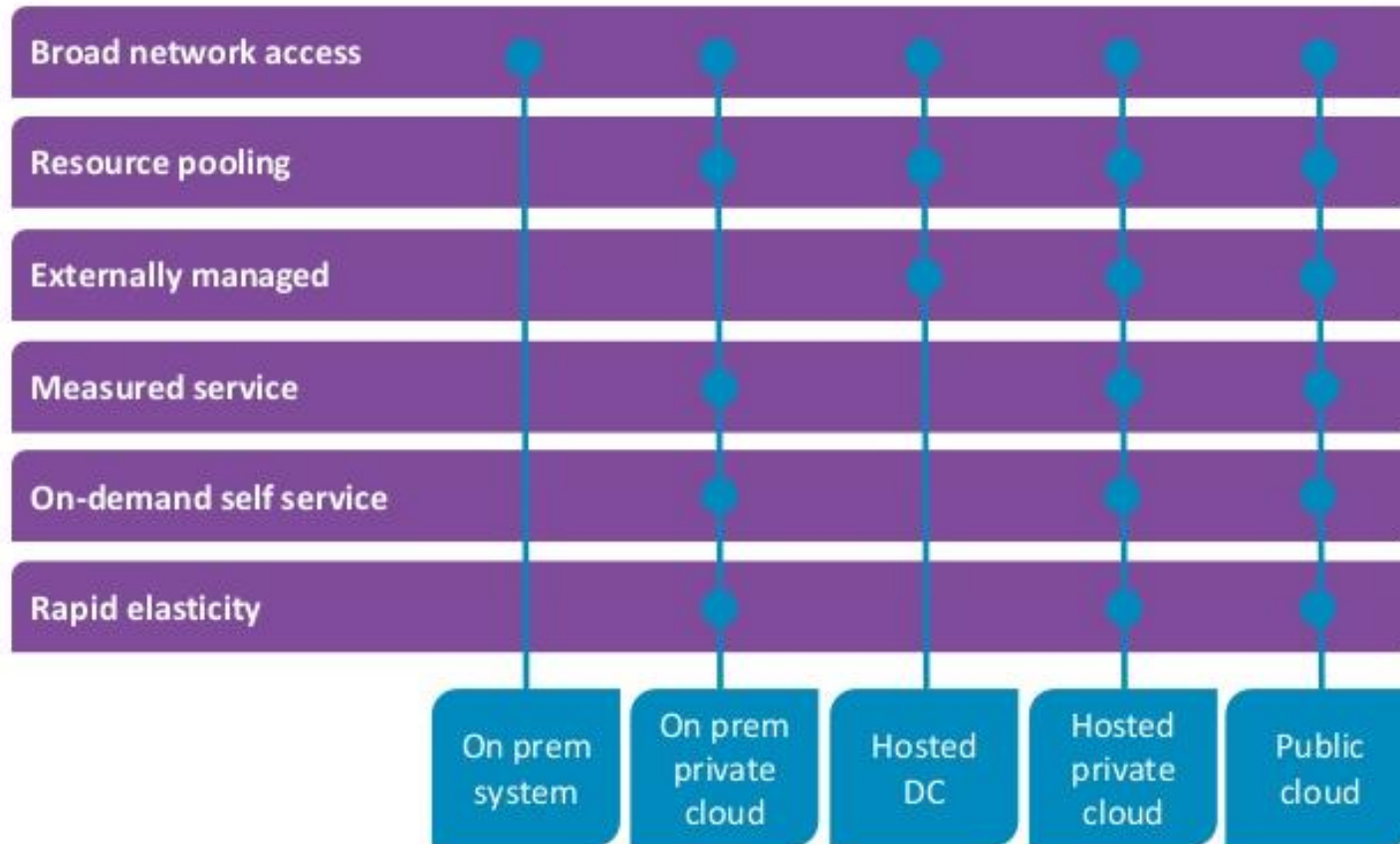
# Cloud Data Center

- » Traffic between servers over few hops
  - » flat(ter) network topology
  - » lower latency and latency variation
- » Common data and storage network
- » Core switch
  - » simpler device





## Characteristics of Typical Computing Models



CompTIA

Source: CompTIA



# Driving Forces

- » Technology
  - » web services and service oriented architecture (SOA)
  - » low server utilization  $\Rightarrow$  virtualization
    - » PCs, servers: 10%-50%
    - » storage: 50%
  - » high speed networks
- » Economies of scale: bulk of devices – lower cost
  - » CPU
  - » servers
  - » storage
- » costs
  - » electrical power
  - » cooling
  - » network access
- » environment-friendly, a.k.a green
  - » consolidation of workloads to avoid idle servers
  - » concentrated energy consumption
- » considered as the first milestone: 2006 opening the access to Amazon web services for outside developers
- » outsourcing processes and information using cloud resources



# Similar Concepts

- » Cluster computing
  - » similar (or identical) computers
  - » in the same place, connected by LAN
  - » operating as powerful supercomputer
- » Grid computing
  - » independent, usually different computers
  - » even at different physical locations
  - » operating as a distributed system
- » Cloud computing
  - » similar (or identical) computers
  - » usually at different physical locations
  - » resources provided as services



# Comparison of Similar Concepts

## Cluster

- » tightly coupled, identical systems (HW and OS)
- » centralized task management and scheduling
- » dedicated low latency and high speed network
- » for solving a specific task

## Grid

- » loosely coupled, different systems (HW and OS)
- » autonomous components with own resource management, distributed control
- » a large task is divided among the components
- » powerful computers
- » connected over the Interneten

## Cloud

- » identical or different systems
- » independent components, resources are managed by a hypervisor (virtual machine manager)
- » numerous different applications running in the same time
- » dedicated low latency and high speed network



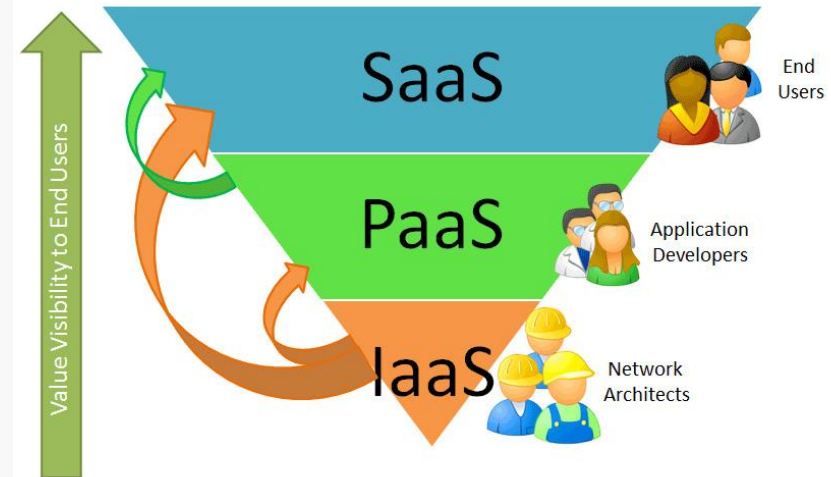
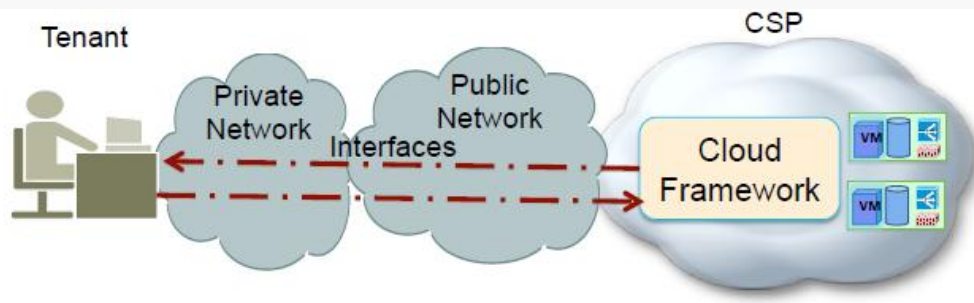


# Cisco Global Cloud Networking Survey 2012

- » applications and services
  - » email and web services
  - » virtual desktop
  - » collaboration tools
  - » storage
- » migration to cloud is getting more and more accepted
  - » cost savings
  - » flexibility
  - » less operational tasks

# Roles

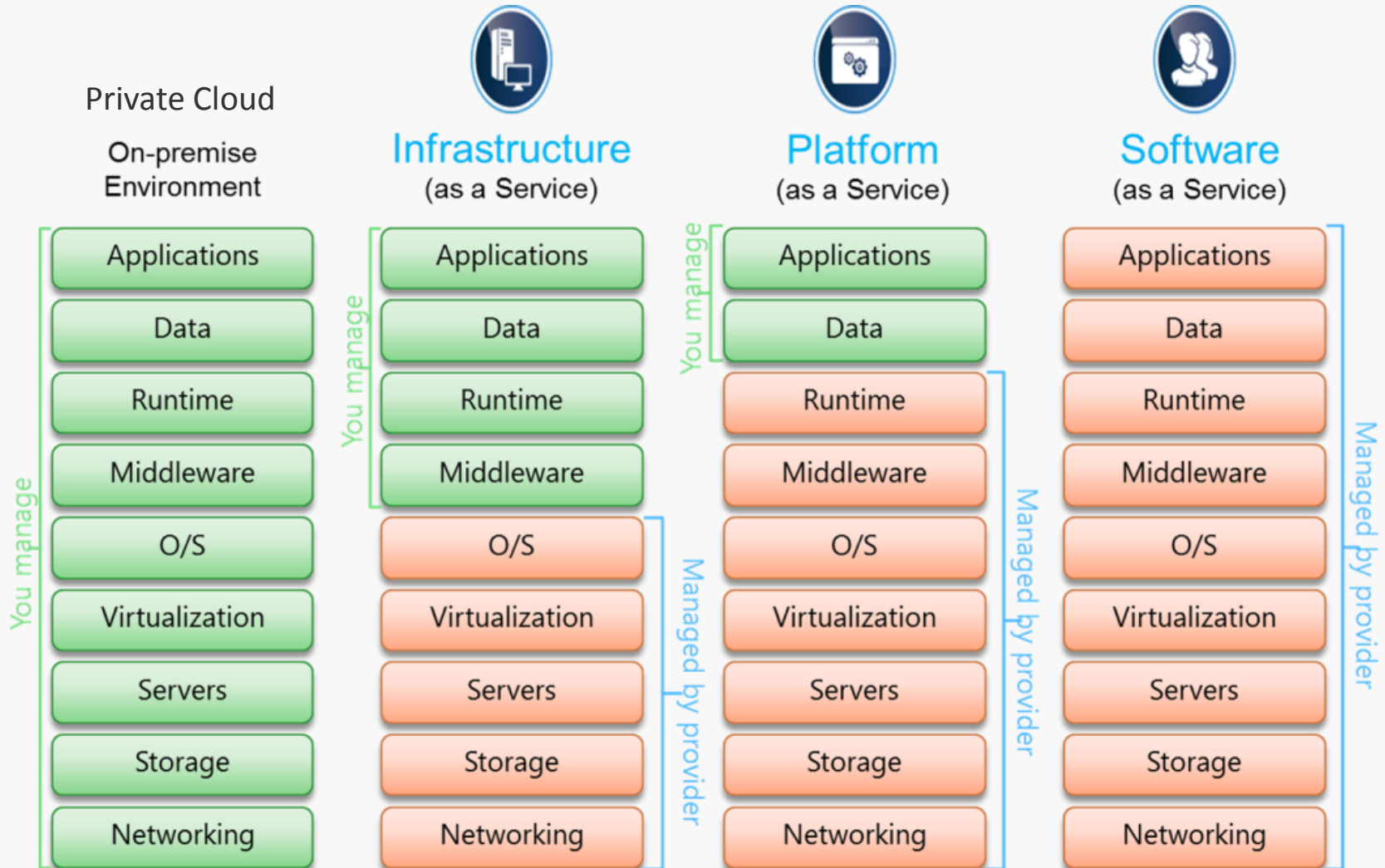
- » Cloud Service Provider – CSP
- » Cloud end-user, tenant, consumer
- » Cloud (networking) designer/engineer/architect
- » Cloud application designer/engineer/architect
- » Cloud administrator, operator



Forrás: <https://jaymanalotoibm.wordpress.com/2013/11/03/delivering-ibm-tririga-from-the-cloud/>



# Responsibilities



Source: <https://www.simple-talk.com/cloud/cloud-development/a-comprehensive-introduction-to-cloud-computing/>



# IaaS

- » Infrastructure aaS: „Hardware“ as a Service
- » Managed environment for existing applications and services
- » Components
  - » server (physical or virtual) – compute resource
  - » storage: disk drive
  - » network + network devices: firewall, load balancer, etc.  
⇒ network architect
- » Providers: e.g. Amazon EC2, S3; Rackspace, Microsoft Azure, Google Compute Engine, etc.



# PaaS

- » Services
  - » „solution stack“: developer, test and runtime environment
  - » OS, developer tools, databases, application servers, webservers all-in-one
- » Access via API (App. Programming Interface)
- » For cloud application developers
  - » full development cycle: source code repository and control, compile, build, test, etc.
- » Built on IaaS
- » Providers: e.g. Microsoft Azure PaaS, Google App Engine, AWS Elastic Beanstalk, Red Hat OpenShift, Cloud Foundry, Heroku
- » typically not portable between different PaaS providers



# SaaS

- » Software application as a Service
  - » a complete solution, product
    - » usually business applications
    - » e-mail, calendar, CRM, office suite, project management, helpdesk, etc.
  - » software licensing model, subscription fee
- » SaaS provider maintains hardware and software
  - » reducing IT operating costs
- » Very few customization options



# \*aaS

## » Generalization

### » Network as a Service

» e.g. Content Delivery Network

### » Data as a Service

» access to analytical data

### » Communication as a Service

» VoIP, IM, videoconference service operated on third party managed HW and SW, e.g. remote PBX

# Public and Private Clouds

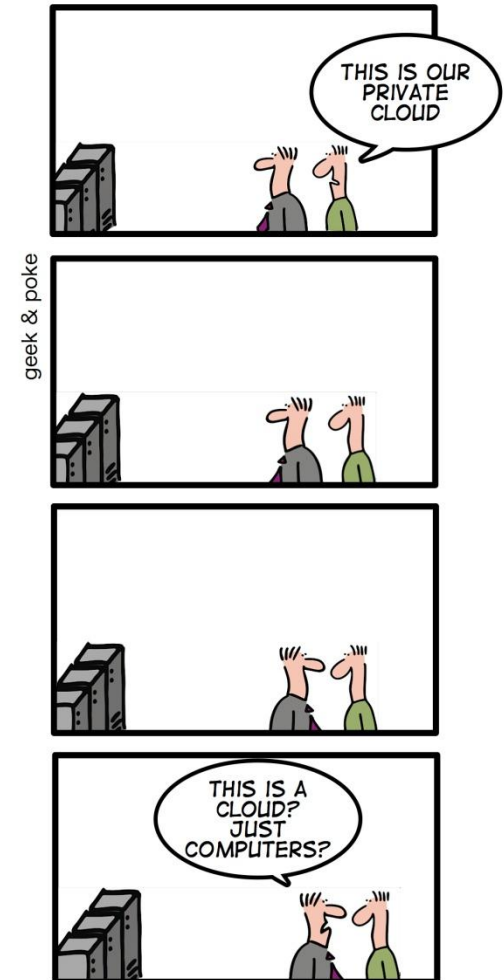
## » Public

- » shared infrastructure, public access
- » running on devices owned by a provider
- » perceived as unlimited resources
- » accessible via the Internet

## » Private

- » dedicated to an organization, company
- » dedicated ownership of devices
- » flexible, but limited resources
- » not necessarily connected to the Internet

### HOW TO DISILLUSION YOUR BOSS







# Vendors and Providers

Cloud Marketplace	
Cloud Broker Platform	
Cloud Management	
SaaS	
PaaS	
IaaS	
Cloud Platform	
Virtualization Software/Mgmt	
Hardware	

Source: Gravitant, Inc from Cloud Technology Spectrum, 2012



# Bursting

- » Cloudbursting
  - » if the private resources are exhausted, outsources the workload to the public cloud
  - » the critical tasks remain in the private cloud
- » Bursting in the cloud
  - » automated data center
  - » on-demand control and management of devices
  - » coordination



# Standardization Organizations

- » National Institute of Standards and Technology (NIST)
- » Cloud Standards Customer Council
- » Distributed Management Task Force (DMTF)
- » Global Inter-Cloud Technology Forum (GICTF)
- » Open Grid Forum (OGF)
  - » Open Cloud Computing Interface (OCCI) Working Group
- » Open Cloud Consortium (OCC)
- » The European Telecommunications Standards Institute (ETSI)
  - » TC CLOUD
- » International Telecommunication Union (ITU)

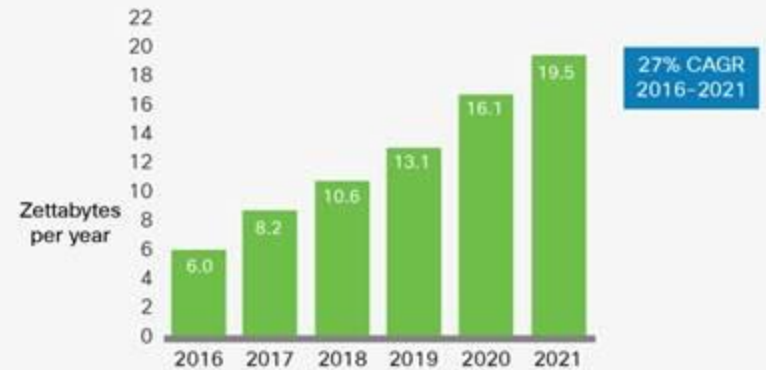
Source: <http://cloud-standards.org/wiki/>



# Forecasts

- » Cisco Global Cloud Index: Forecast and Methodology, 2016–2021 White Paper

## Cloud Data Center Traffic Growth exa: $10^{18}$ , zetta: $10^{21}$



Source: Cisco Global Cloud Index, 2016–2021.



Source: Cisco Global Cloud Index, 2016–2021.

## Global Data Center Traffic by Destination



# Forecasts

## Public vs. Private Cloud Growth



Source: Cisco Global Cloud Index, 2016-2021.

## SaaS / IaaS / PaaS trends



Source: Cisco Global Cloud Index, 2016-2021.



# Inter-cloud

- » Cloud of clouds
- » Global Inter-Cloud Technology Forum (GICTF)
  - » 2009 Japan
  - » „...standardization of network protocols and the interfaces through which cloud systems interwork with each other...”
- » Cisco Intercloud (Fabric)
  - » globally connected (hybrid) cloud platform
  - » using OpenStack (avoiding lock-in)
  - » March 2014: commitment to invest in the next two years \$1 billion into cloud area
  - » 2015: 60 partners more, than 350 data center in 50 countries
  - » April 2017: End-of-Life, recommended alternative: Cisco CloudCenter



# Future of Cloud?

- » *“...combination of cloud based software products and on premises compute to create a hybrid IT solution that balances the scalability and flexibility associated with cloud and the security and control of a private data center.”* Michael Corrado, World Wide Marketing Manager with Hewlett Packard Enterprise
- » multi-cloud
- » serverless, Function as a Service
- » Cloud to the Edge



# Our Focus in this Course

- » IaaS
  - » OpenStack
- » Network
  - » no cloud without network