INTRODUCTION TO CLOUD COMPUTING

CIT 3400

LECTURE 1

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LECTURER COMPUTER SCIENCE

“Computation may someday be organized as a public utility.”

- John McCarthy, 1961

CLOUD COMPUTING

- **No longer the next big thing – the current big thing**
  - Began in 2007 – IBM and Google "Blue Cloud"
  - Name cloud inspired by cloud symbol representing internet in diagrams
  - Amazon popularized idea of the cloud

QUESTIONS TO ANSWER

- What clouds have you used today (yesterday)?

- What is a cloud?

INTRODUCTION

CLOUD DEFINITION

Cloud computing is a set of service-oriented architectures, which allow users to access a number of resources in a way that is elastic, cost-efficient, and on-demand.

5

INTRODUCTION

CLOUD DEFINITION

The U.S. National Institute of Standards and Technology (NIST) defines cloud computing as:

- 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.

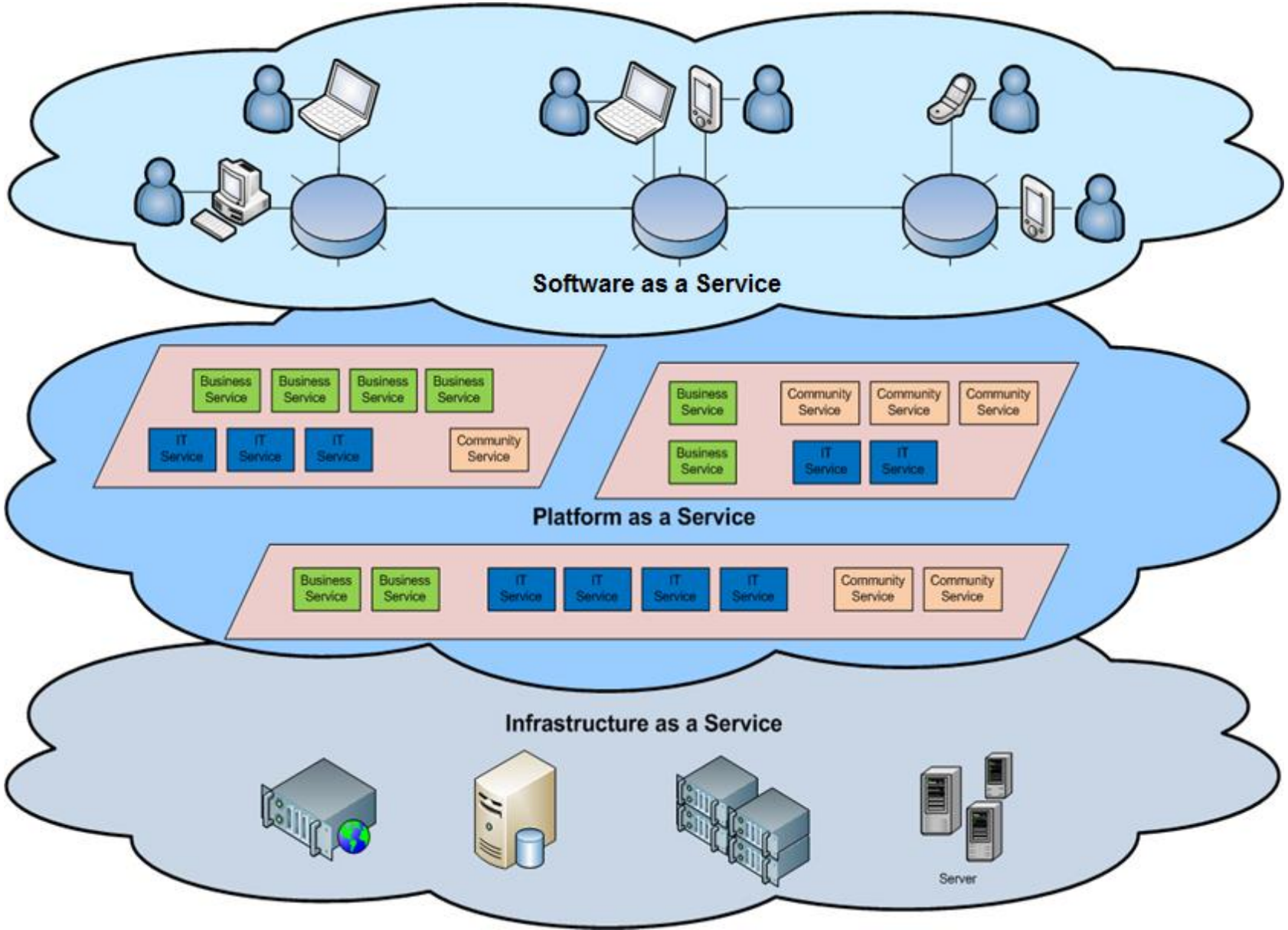
INTRODUCTION

CLOUD ARCHITECTURES

- **Scalable resource allocation**
- **Tailored services**
  - Software as a Service (SaaS)
  - Platform as a Service (PaaS)
  - Infrastructure as a Service (IaaS)

INTRODUCTION

CLOUD ARCHITECTURES



INTRODUCTION

CLOUD COMPUTING LAYERS

- **Application Service (SaaS)**
  - MS Live/Exchange, Google Docs, Salesforce.com, Quicken Online, Jupyter
- **Application Platform (PaaS)**
  - Google App Engine, Heroku, AWS
- **Server Platform (IaaS)**
  - Google Compute Engine, Amazon EC2, OpenStack, Eucalpytus

INTRODUCTION

CLOUD COMPUTING LAYERS

	Services	Description
Application Focused	Services	Services – Complete business services such as PayPal, OpenID, OAuth, Google Maps, Alexa
	Application	Application – Cloud based software that eliminates the need for local installation such as Google Apps, Microsoft Online
	Development	Development – Software development platforms used to build custom cloud based applications (PAAS & SAAS) such as SalesForce
Infrastructure Focused	Platform	Platform – Cloud based platforms, typically provided using virtualization, such as Amazon ECC, Sun Grid
	Storage	Storage – Data storage or cloud based NAS such as iCoud, Dropbox, CloudNAS
	Hosting	Hosting – Physical data centers such as those run by IBM, HP, Amazon, etc.

INTRODUCTION

CLOUD SUMMARY

- **Cloud computing is an umbrella term used to refer to Internet based development and services.**
- **Characteristics of cloud data, applications, services, and infrastructure:**
  - **Remotely hosted:** Services and data are hosted on remote resources.
  - **Ubiquitous:** Services and data are available from anywhere.
  - **Commodified:** The result is a utility computing model similar to traditional utilities such as electricity and water.
    - **You pay for what you use!**

CLOUD COMPUTING

- **Everyone has an opinion on what to use a cloud for**
  - Applications on the internet – email, tax prep
  - Storage for business, personal data
  - Web services for photos, maps, GPS
  - Rent a virtual server, load software on it, turn it on /off, clone it if sudden workload demand increases
  - Store, secure data for authorized access (really?)
  - Use a platform including OS, Apache, MySQL, Python, PHP

CLOUD COMPUTING CHARACTERISTICS

- **So what are its characteristics?**
  - Described as: On-demand computing, pay as you go, software as a service, utility computing
  - Usually costs, but cost-effective
  - Emphasizes availability
  - Virtualization
  - Scalable (expand on current hardware)
  - Elastic (dynamically add hardware as needed by application/user)
  - Distributed and highly parallel approach
  - Replication, replication, replication …

CHARACTERISTICS OF CLOUD COMPUTING

- **On-demand self service:**
  - Cloud computing resources can be provisioned on-demand by the users, without requiring interactions with the cloud service provider. The process of provisioning resources is automated.

- **Broad network access:**
  - Cloud computing resources can be accessed over the network using standard access mechanisms that provide platform-independent access through the use of heterogeneous client platforms such as workstations, laptops, tablets and smartphones.

CHARACTERISTICS OF CLOUD COMPUTING

- **Resource pooling:**
  - The computing and storage resources provided by cloud service providers are pooled to serve multiple users using multi-tenancy. Multi-tenant aspects of the cloud allow multiple users to be served by the same physical hardware.

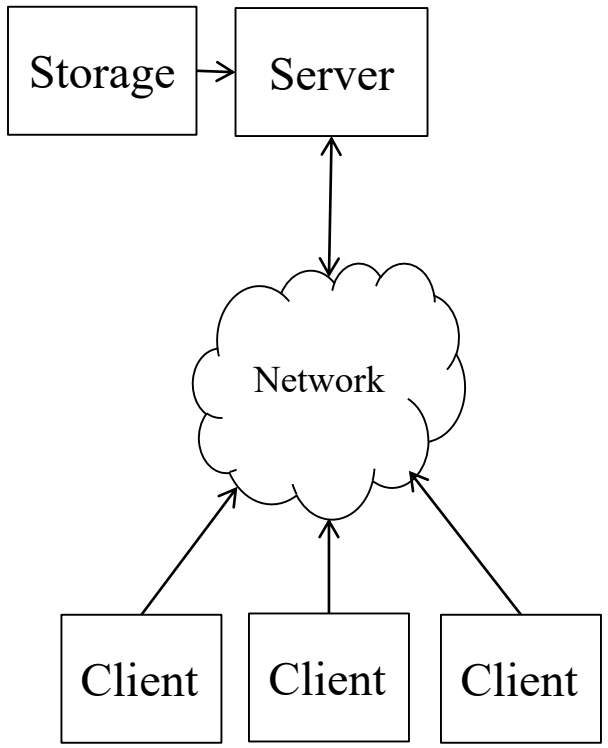
- **Rapid elasticity:**
  - Cloud computing resources can be provisioned rapidly and elastically. Cloud resources can be rapidly scaled up or down based on demand.

CHARACTERISTICS OF CLOUD COMPUTING

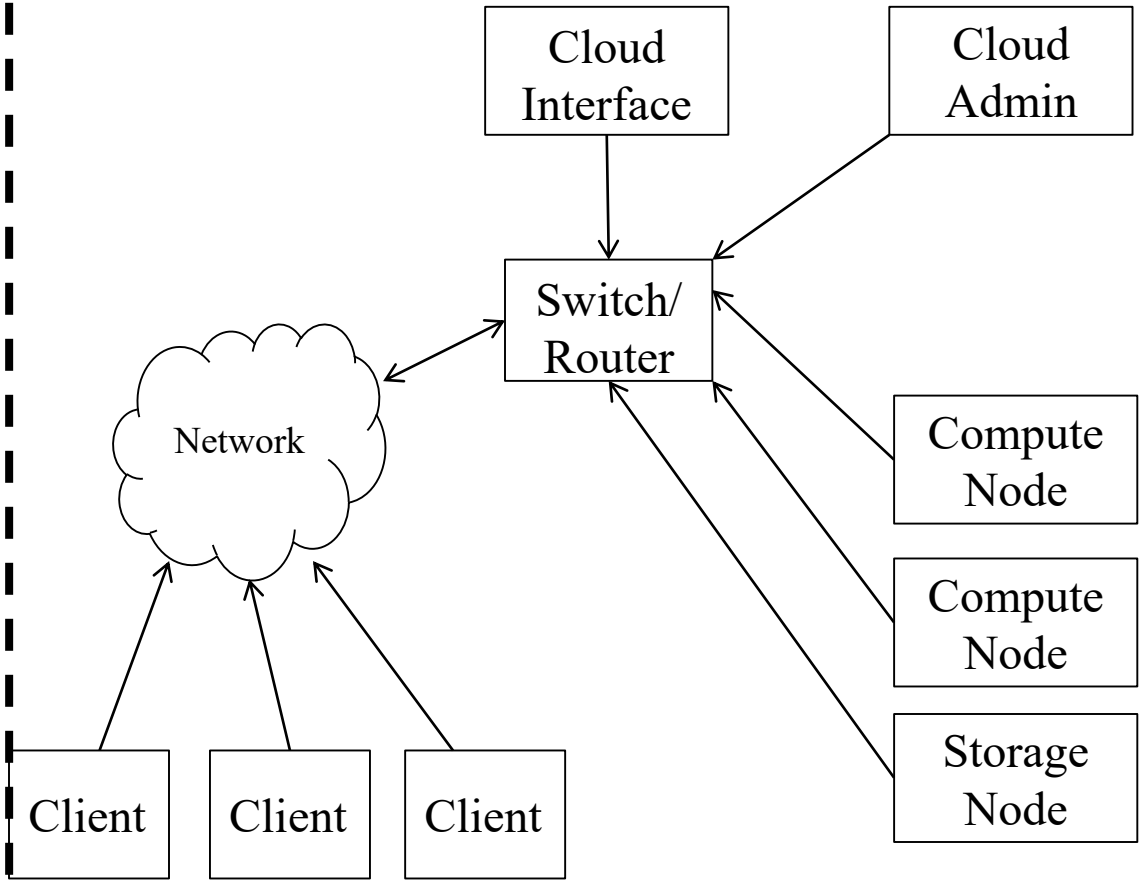
- **Reliability:**
  - Applications deployed in cloud computing environments generally have a higher reliability since the underlying IT infrastructure is professionally managed by the cloud service.

- **Multi-tenancy:**
  - The multi-tenanted approach of the cloud allows multiple users to make use of the same shared resources.
  - In virtual multi-tenancy, computing and storage resources are shared among multiple users.
  - In organic multi-tenancy every component in the system architecture is shared among multiple tenants

CLIENT/SERVER VS. CLOUD ARCHITECTURE



Client/Server Architecture



Cloud Architecture

TYPES OF CLOUDS

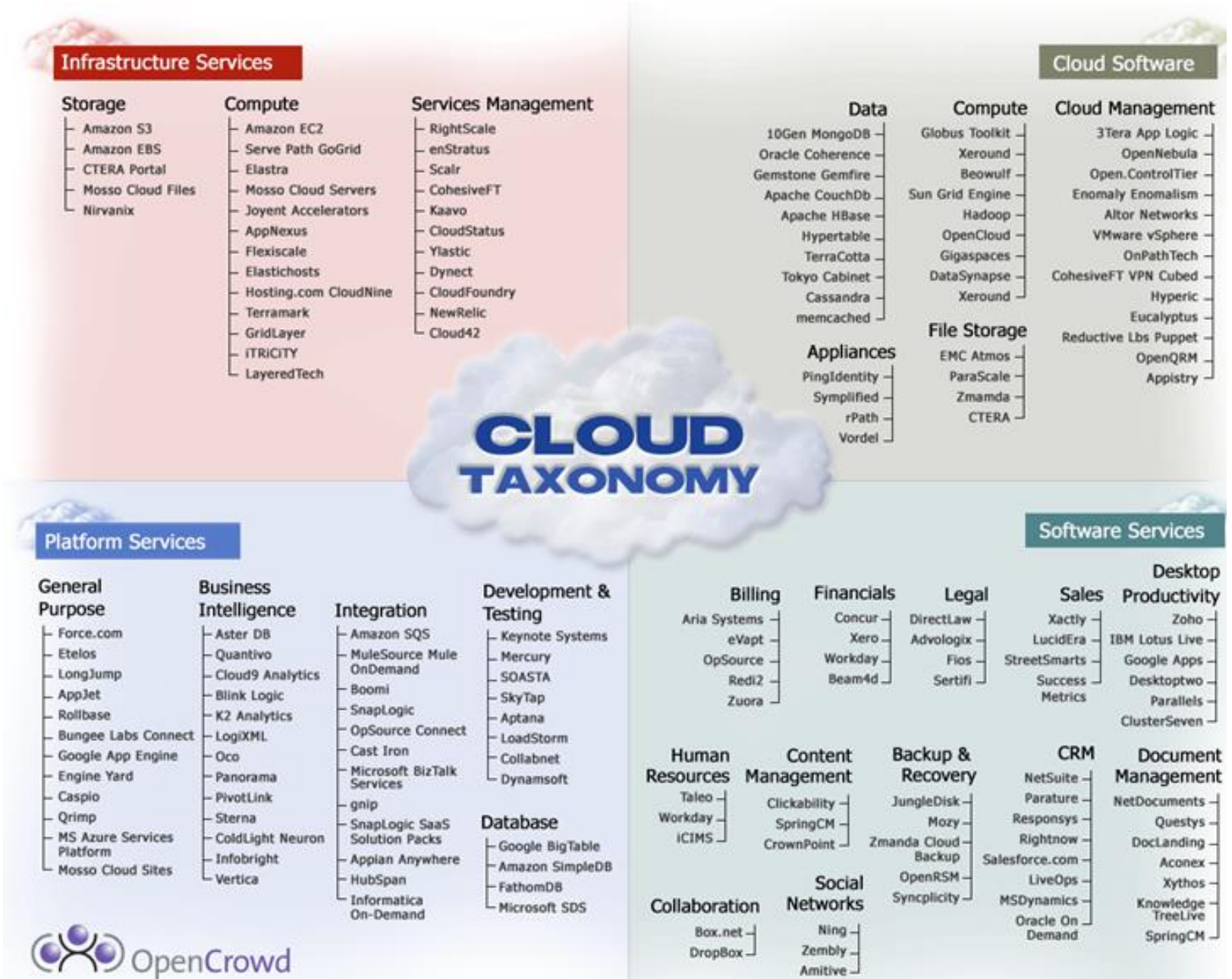
- **Public Cloud**
  - Marketed based on
    - Resources offered, availability, security, price
- **Local/Private Cloud**
  - Cloud architectures tailored to an organization's needs.
- **Hybrid Cloud**
  - Combination of public and local cloud resources.

INTRODUCTION

SUPER CLOUDS

iCloud

INTRODUCTION



WHAT MOTIVATED CLOUD COMPUTING

Initial motivation:

- Web-scale problems

Solutions:

- Large data centers

How to access:

- Highly-interactive Web applications (thin client)

INITIAL MOTIVATION: WEB-SCALE PROBLEMS

- **Characteristics:**
  - Definitely data-intensive
  - May also be processing intensive
- **Examples:**
  - Crawling, indexing, searching, mining the Web
  - "Post-genomics" life sciences research
  - Other scientific data (physics, astronomers, etc.)
  - Sensor networks
  - Web 2.0 applications
  - SmartThings/home integration

HOW MUCH DATA?

- **Google processes over 24 PB a day (24k terabytes)**
- **CERN's LHC generates 25 PB a year**
- **"all words ever spoken by human beings" ~ 5 EB (5m terabytes)**
- **Amount of data that exists in the digital universe – 3+ ZB (3b terabytes)**
- **Brain Research through Advancing Innovative Neurotechnologies (BRAIN) project – est: multiple yottabyes (trillions of terabytes)**
- **LARGE data is the next frontier**
- **How do we store this amount of data?**
  - HDD density
  - SDD density
- **How do we filter/access useful information?**

APPLICATIONS

- **What does cloud computing actually do?**
  - Consider applications you may currently be running on laptop, desktop, phone, server
  - Cloud has them also, or can potentially bring them to you
  - Brings applications, views, manipulates, shares data

CLOUDS

- **Allow access to applications other than on local computer or internet connected device**

  But

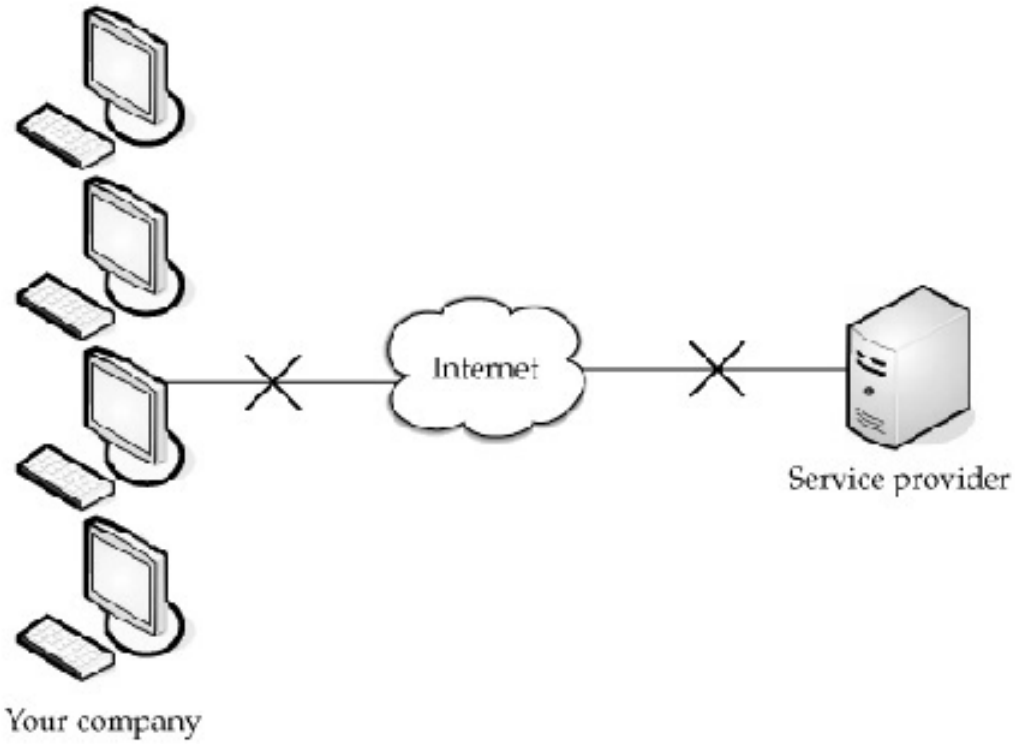
  Only as long **as have internet connection**

- **Instead, company hosts your application - Advantages?**
  - No more licenses, service packs, etc.
  - Less hardware, etc.
  - Can access anywhere

POTENTIAL PROBLEMS

- **Internet connection**
  - Completely dependent on network
- **Cloud site failure**
  - Back-end server/network failure may

    Result in inaccessible data
- **Sensitive information**
  - How much do you trust the public cloud vendor?



- **Application integration – (exchange info when local and on cloud)**

CLOUD COMPONENTS

- **3 components**
  - Clients
  - Datacenter
  - Distributed servers

CLOUD COMPONENTS

- **Clients**
  - **Mobile**
    - SmartPhones, Tablets, Service Hubs
  - **Thin**
    - no internal hard drives, lets servers do all work, displays info
  - **Thick**
    - Laptops, desktop computers
  - **Which is the best?**
    - Thin - lower costs, security, power consumption, easy to replace, less noise

DATA CENTER

- Data Center – facility used to house computer systems and associated components

DISTRIBUTED SERVERS

- **Servers host the resources needed by cloud users**
  - **Compute nodes**
    - Provides CPU, Memory, Scratch Storage, and Networking resources through virtualized interfaces.
    - Hosts guest operating systems (Virtual Machines) using one or more VM hypervisors
    - Resource interface depends on the type of cloud (horizontal/vertical cloud)
  - **Storage nodes**
    - Compute nodes only provide temporary storage space for users/applications
    - Storage nodes provide long term data storage solutions
    - Can be mapped to specific processes running on compute nodes, users, interface applications, etc.
  - **Administrative nodes**
    - Provides "hidden" back-end services such as resource load balancing, administrative/resource databases, security/firewalls, cloud macromanagement

IMPROVEMENTS SINCE ‘80S

- **Disk capacity**
  - From 10s MB to several TB – orders of magnitude
  - IBM built 120PB storage array
- **Bandwidth**
  - 1-10Mbps to 100s of Gbps

IMPROVEMENTS SINCE '80S

- CPU Improvements:
  - Transistor shrink, increased clock rate, advanced instruction pipeline, cache memory, multicores, faster bus interconnections, lower energy consumption…
- https://www.top500.org/lists/ - lists the top 500 highest (known) performance super clusters
  - Current leader: Sunway TaihuLight (China)
    - 10.6 million CPU cores
    - 1.3PB RAM
    - Power consumed while fully operational:
      - 15.3mW
    - Linpack: 93PFlop/s (.093EFlop/s) or

    93,000,000,000,000,000 floating point operations per second.
      - By comparison, your laptop: ~125 Gflop/s, Smartphone: ~400 Mflop/s

SOLUTION FOR COMPUTATIONAL GROWTH: LARGE DATA CENTERS

- Web-scale problems? Throw more machines at it!
- Decades ago – computing power in mainframes in computer rooms
- Personal computers changed that
- Now, network data centers with centralized computing are back in vogue
- In the future businesses will not need to invest in a data center
- How can we easily access datacenter resources to fit our needs?