Internet of Things
Senior Design Project Course

Cloud 🔗 **IOT**

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Lets Get Started:
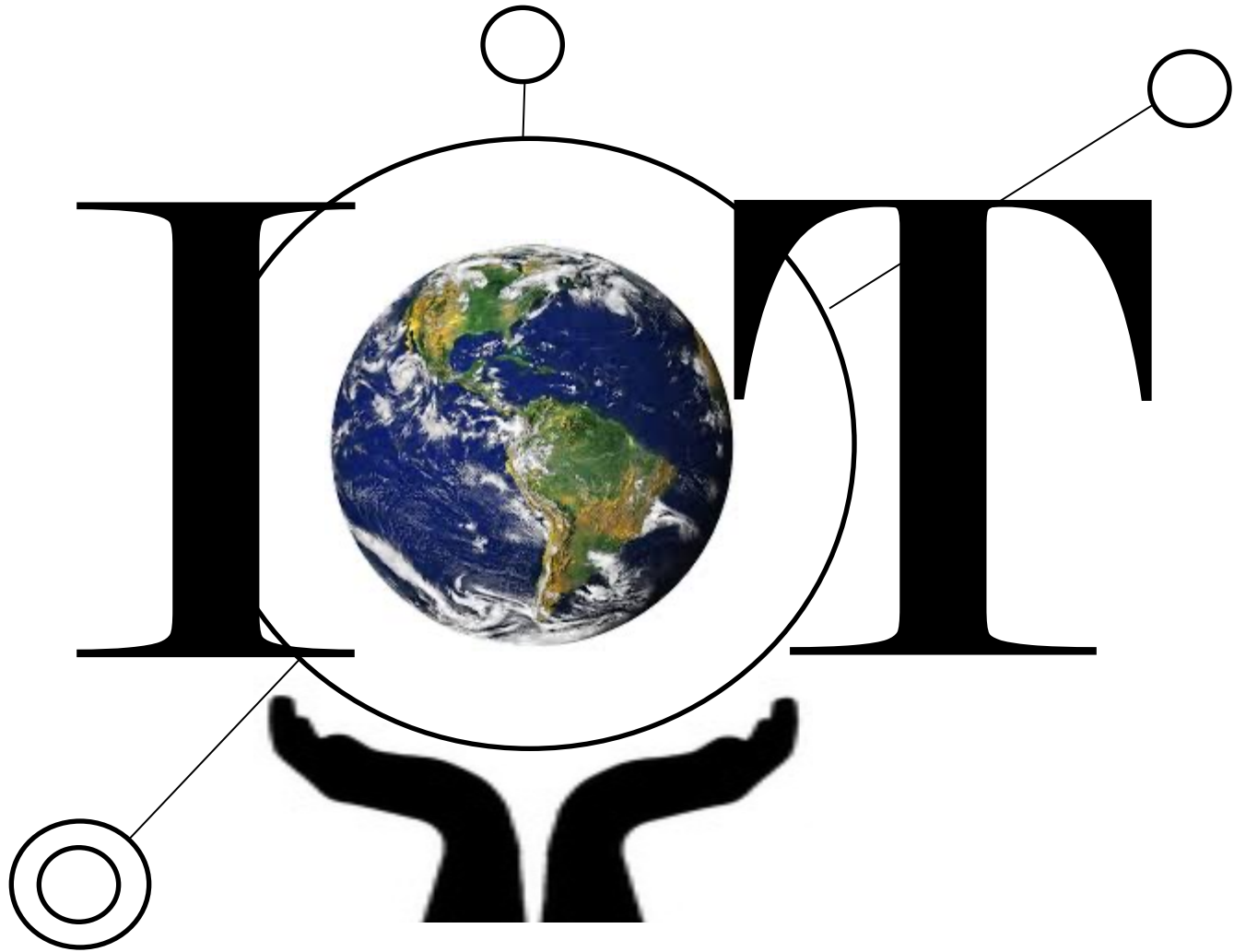
Focus of Today's Lecture: (Review)

Cloud
Today's Focus

Cloud Storage

Cloud Processing

Internet

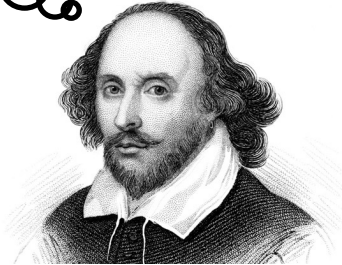Network

Local storage

Local Processing

Sensors

Image source: http://www.cchc.cl/informacion-a-la-comunidad/industria-de-la-construccion/personaje/

What is Cloud?

- **IBM definition of Cloud:**
  - the delivery of on-demand computing resources—everything from applications to data centers—over the internet on a pay-for-use basis.

Properties of Cloud:

- **Properties of Cloud (IBM definition)**
  - **Elastic resources:** Scale up or down quickly and easily to meet demand

  - **Metered service:** Only pay for what you use

  - **IT support:** All the IT resources you need with self-service access

Cloud vs Classical Computing
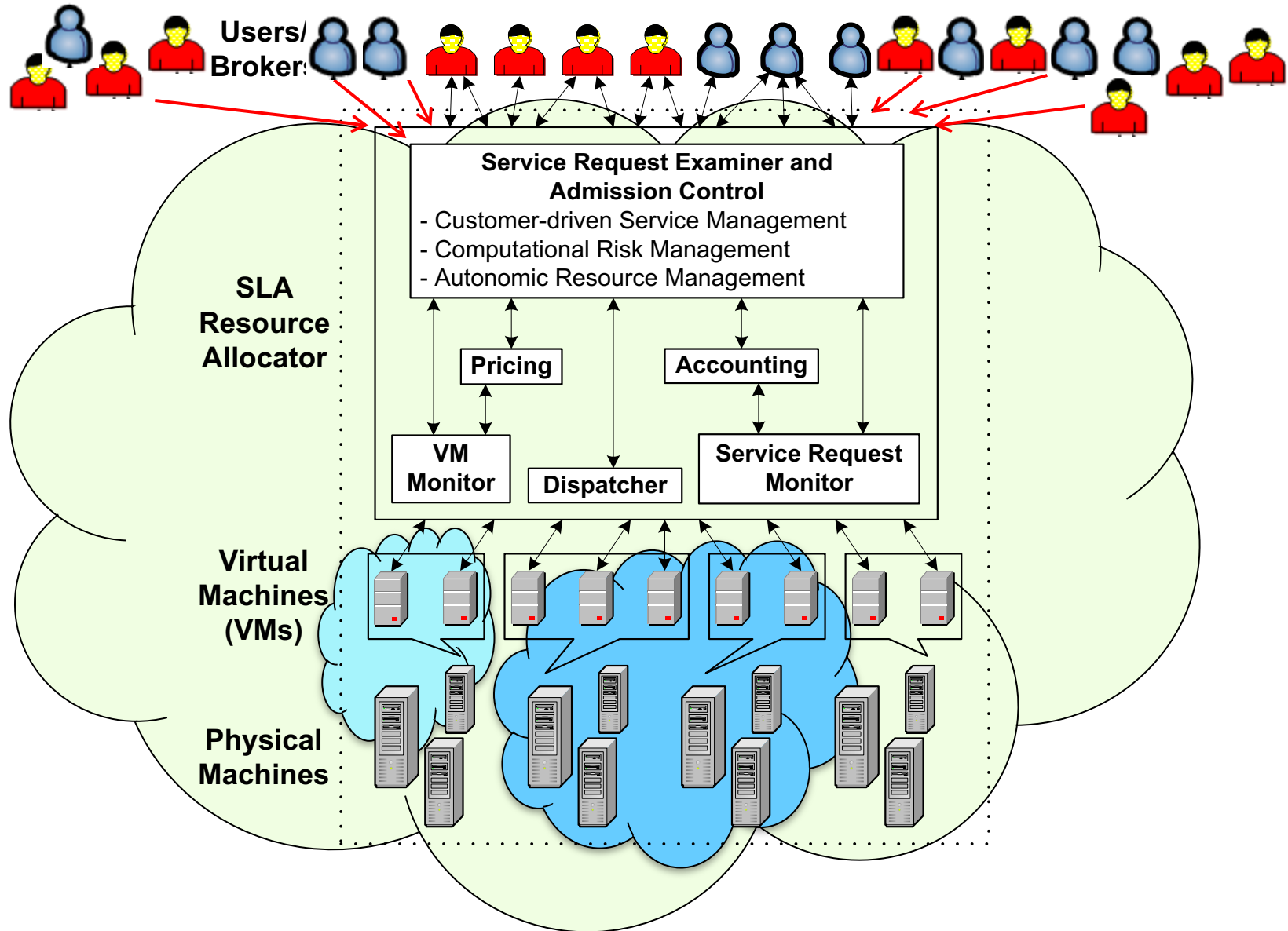
Classical Computing

- Buy & Own
  - Hardware, System Software, Applications often to meet peak needs.

- Install, Configure, Test, Verify, Evaluate

- Manage

- Finally, use it

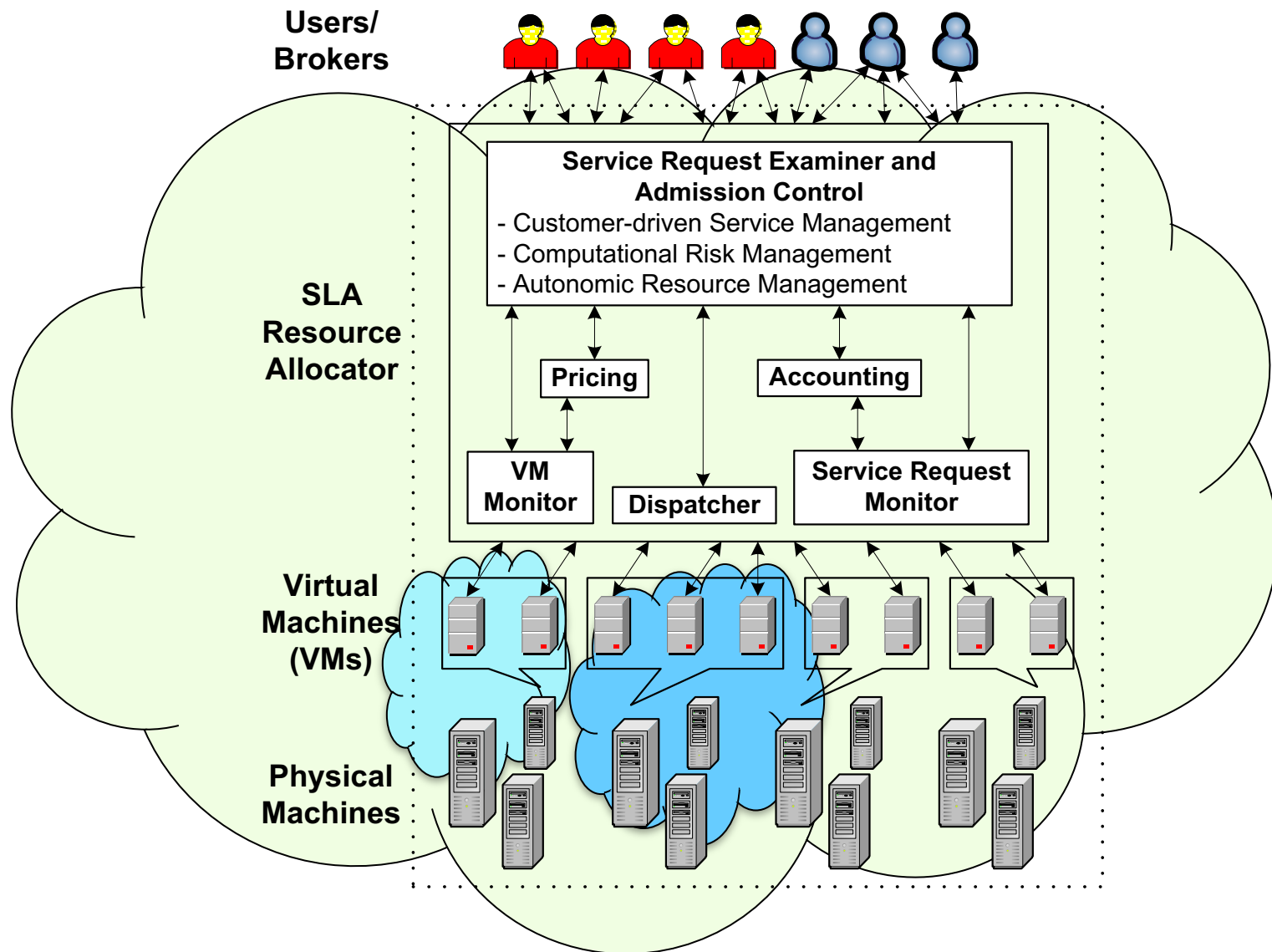- $$$$....$(High CapEx)

Every few (18) months?

Cloud Computing

- Subscribe

- Use

- Pay for what you use!

Cloud to expand (lease more resources) with increase in demand

Cloud to shrink (unlease resources) with decrease in demand

Cloud Servers

Cloud servers are powerful computers housed in big data centers or **server farms**

Cloud Services

- **SaaS** (Software as a Service)
  - Provides off-the-shelf applications offered over the internet

- **PaaS** (Platform as a Service)
  - allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure
  - makes the development, testing, and deployment of applications quick, simple, and cost-effective.

- **IaaS** (Infrastructure as a Service)
  - self-service models for accessing, monitoring, and managing remote datacenter infrastructures, such as compute (virtualized or bare metal), storage, networking, and networking services (e.g. firewalls)

Software as a Service (SaaS)

- **What is SaaS: (IBM definition)**
  - ❑ The applications/software runs on distant computers (in the cloud).
  - ❑ The distant computing resources are owned and operated by others.
  - ❑ The connection and service request is made through internet (usually by a web browser).

- **SaaS Benefits:**
  - ❑ **No Installation:** Applications are installed and ready to use (just need to signup)
  - ❑ **Access freedom:** Access the service from any computer connected to the internet.
  - ❑ **Protected Data:** data is not lost due to computer breakdown, it is always in the cloud.
  - ❑ **Scalable service:** the computing resources scale up or down based on user needs.

SaaS Examples

- **Microsoft Office 365**
  - Create, edit and share content from any PC, Mac, iOS, Android or Windows device, real-time and collaborative
- **Box**
  - Securely share large files, preview content prior to downloading, real-time notifications when edits are made.
- **Google Apps**
  - Custom professional email (eliminating email attachments), shared calendars and video meetings, document storage
- **DocuSign**
  - Electronic signature technology
- **Sharelatex**
  - Create latex document online, and work simultaniously.
- **Cisco WebEx**
- **Dropbox**

Platform as a service (PaaS)

- **What is PaaS (IBM definition)**
  - ❑ Complete environment: A cloud-based environment with everything required to support the complete lifecycle of building and delivering web-based (cloud) applications
  - ❑ Without the cost and complexity of buying and managing the underlying hardware, software, provisioning, and hosting.

- **PaaS Benefits:**
  - ❑ Develop applications and get to market faster
  - ❑ Deploy new web applications to the cloud in minutes
  - ❑ Reduce complexity with middleware as a service

PaaS Examples:

- AWS Elastic Beanstalk
- Windows Azure
- Heroku
- Force.com
- Google App Engine
- Apache Stratos
- RED HAT OPENSHIFT

Infrastructure as a service (IaaS)

- **What is IaaS (IBM definition)**
  - ❑ Provides companies with computing resources including servers, networking, storage, and data center space on a pay-per-use basis.

- **Benefits of IaaS:**
  - ❑ No need to invest in your own hardware
  - ❑ Infrastructure scales on demand to support dynamic workloads
  - ❑ Flexible, innovative services available on demand

IaaS Examples:

- Amazon Web Services (AWS)
- Cisco Metapod
- Microsoft Azure
- Google Compute Engine (GCE)
- Joyent
- Rackspace

Cloud Services

My Software Package

- My Application
- Data
- Runtime
- Middleware
- Operating Sys
- Virtualization
- Servers
- Storage
- Networking
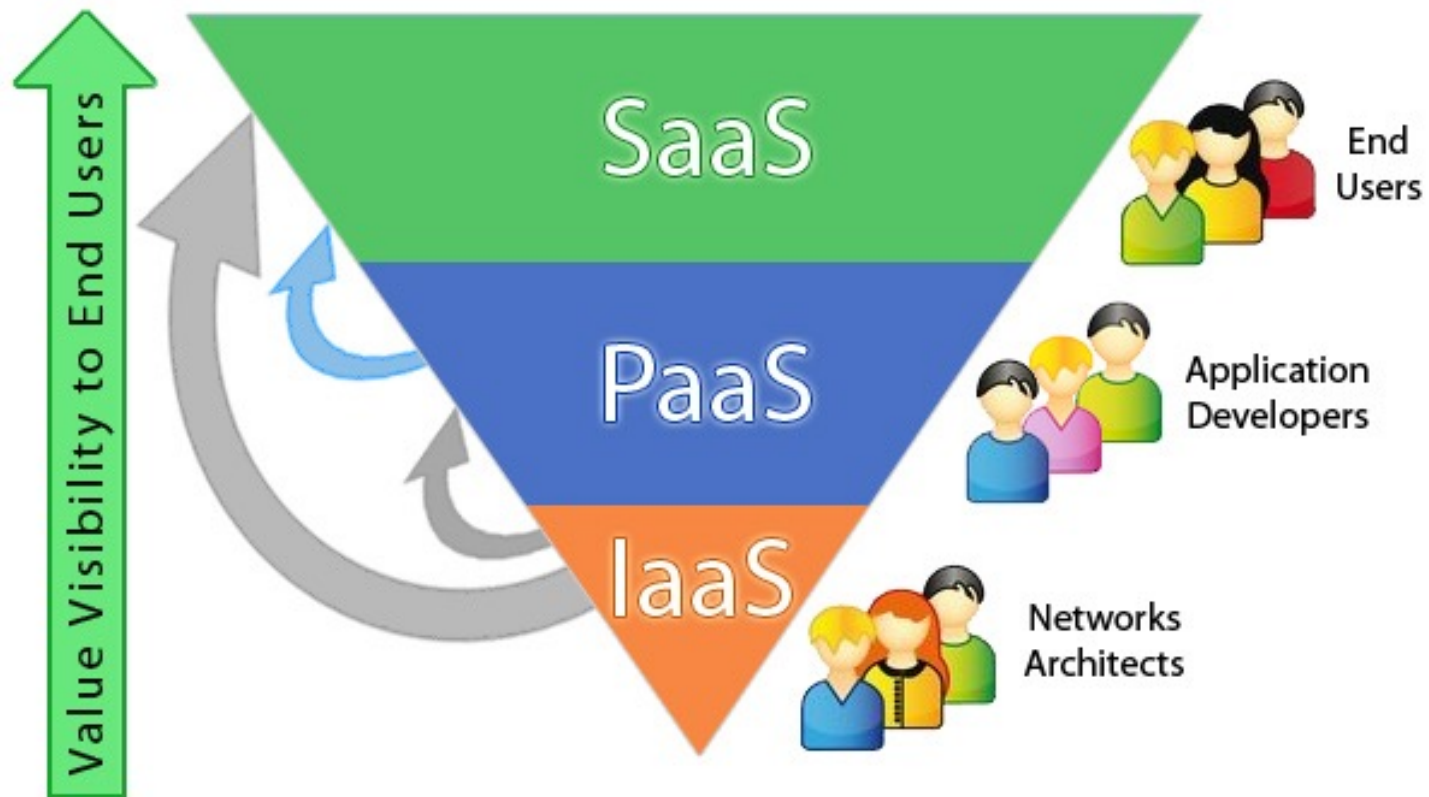
IaaS

PaaS

SaaS

Legends:

Managed by Me | Managed by the Vendor

Cloud Services

Public Cloud

- Owned and operated by companies that offer rapid access over a public network to affordable computing resources.
  - Microsoft, Amazon, Google, IBM, EMC, ….

- Users don't need to purchase hardware, software, or supporting infrastructure, which is owned and managed by providers.

- Access to SaaS, IaaS, PaaS.

Private Cloud

- Infrastructure operated solely for a **single organization**
- Could be managed internally or by a third party
- Could be hosted either internally or externally.
- Takes advantage of cloud's efficiencies, while providing more control of resources and steering clear of multi-tenancy.
- **Sophisticated security** and governance designed **for a company's specific requirements** (security and privacy are two big reasons for having private clouds).
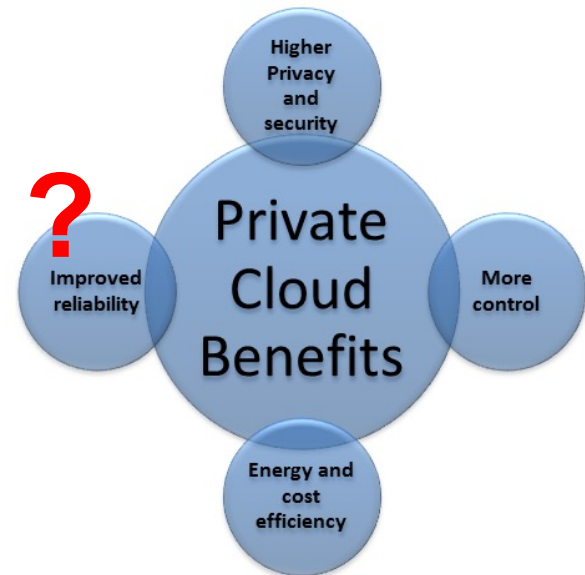
Hybrid Cloud

- Uses a private cloud foundation combined with the **strategic integration and use of public cloud services**.

- Allows companies to keep the critical applications and sensitive data in a traditional data center environment or private cloud

- Enables taking advantage of public cloud resources like SaaS, for the latest applications, and IaaS, for elastic virtual resources

- Facilitates portability of data, apps and services and more choices for deployment models
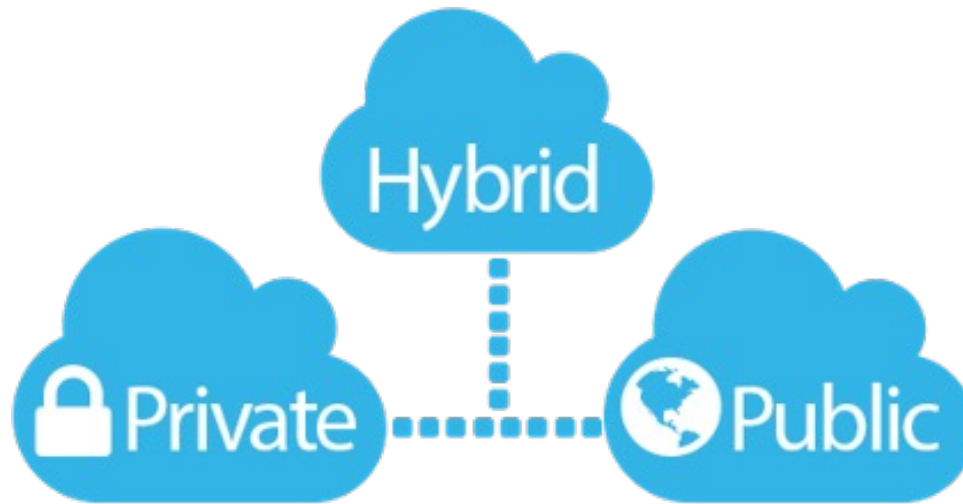
IoT Meets Cloud

- **IoT is characterized by having many edge devices with limited**
  - Storage
  - Processing capacity and Performance
  - Reliability
  - Security
  - Various privacy issues.

- **Cloud is characterized by:**
  - Large storage
  - Unlimited processing power and Performance
  - To a good extent reliable
  - (security is not yet there!)

- Most of IoT issues are at least partially solved in cloud
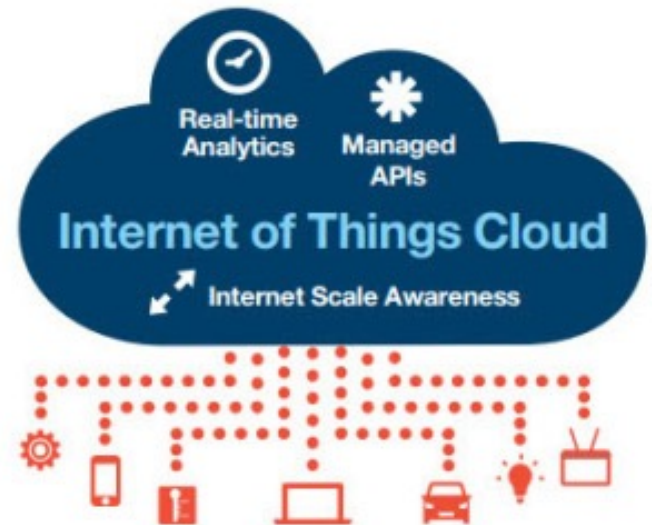
IoT Marries the Cloud!

- **Cloud can offer an effective solution to**
  - IoT service management
  - IoT service composition
  - Running applications/services that require large storage, and high performance to do
    - Predictive analysis
    - Data mining
    - …

- **IoT allows the Cloud to**
  - extending its scope to deal with real world things which are
    - distributed
    - dynamic
  - deliver new services in a large number of real life scenarios.

Cloud as a Middle Layer

- The Cloud acts as intermediate layer between the things and the applications

- It hides all the complexity and the functionalities necessary to implement the application/services.
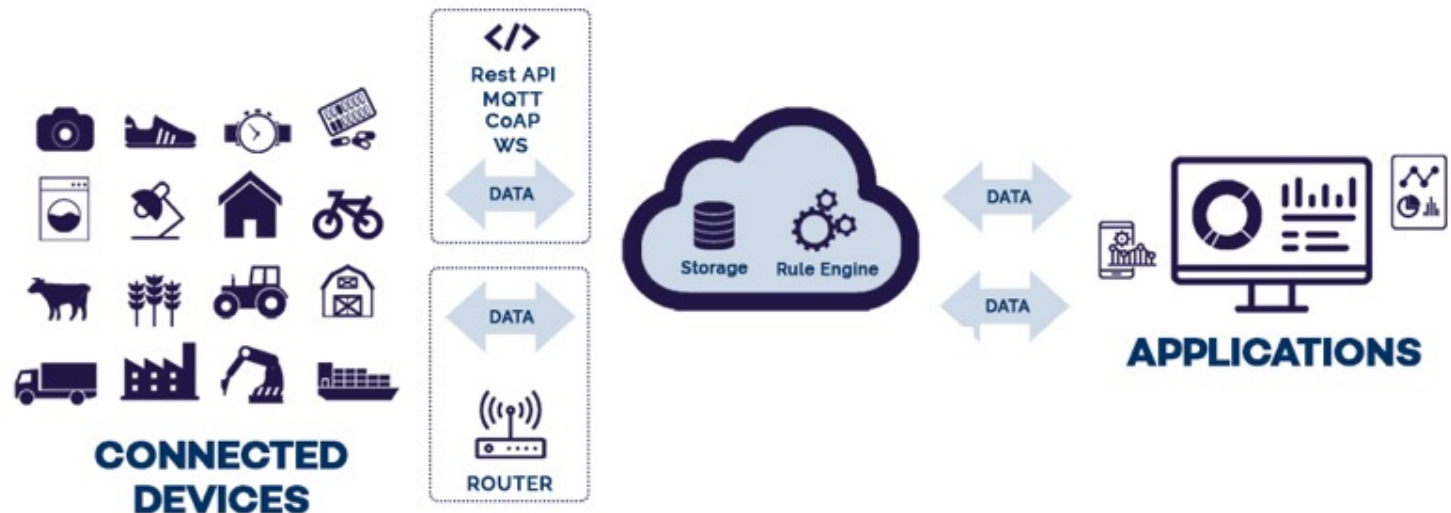
Cloud Storage

- IoT generates a huge amount of data

- Generated Data has all three characteristics
  - **Volume** (very large)
  - **Variety** (many types of data)
  - **Velocity** (rate of data generation)

- Cloud helps with needed storage services including:
  - Collecting, accessing, archiving and sharing data

- Generated data could be
  - **Unstructured**
  - **Structured**
  - **Semi Structured**
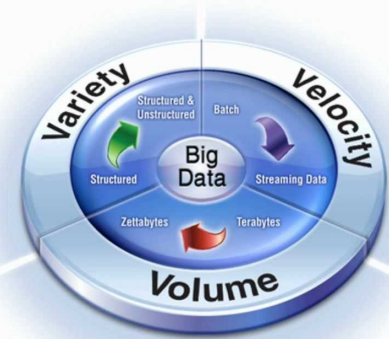
Types of Data

- **Structured Data:**
  - Data that resides in a fixed field within a record or a file.
    - Example: data contained in relational databases and spreadsheets.

- **Unstructured Data:**
  - Refers to information which does not have a pre-defined structure.
    - Example: Free text on web, audio, videos, pdf file, text document etc.

- **Semi-structured Data:**
  - A form of structured data that does not conform with the formal structure of data models associated with relational databases or other forms of data tables.
    - Example: XML

Scale Of Unstructured Data growth

About 85% is unstructured data

All Global Data in Zettabytes

1ZB = 1,126,000,000,000,000,000,000 bytes (approx)
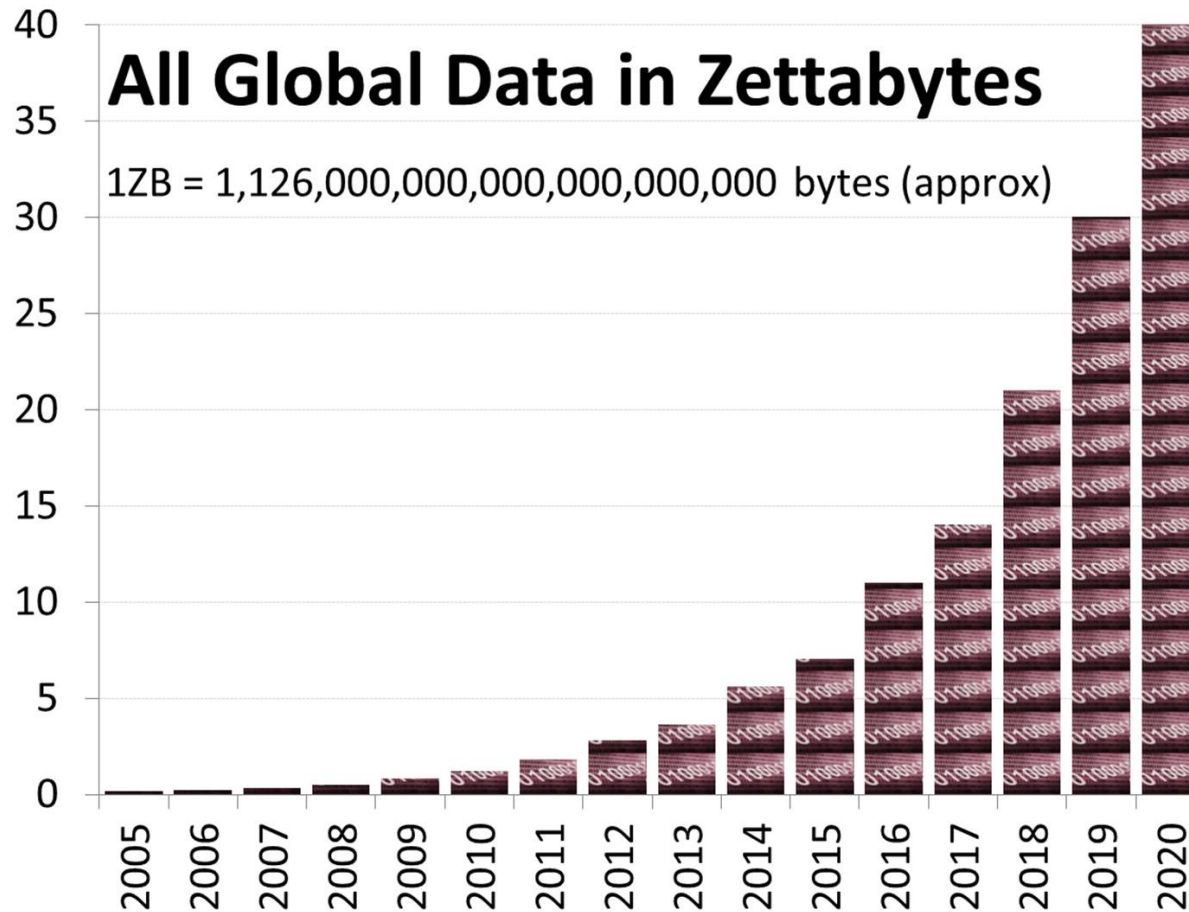
Cloud Processing

- Cloud **computational resources** are plenty.
  - Many CPUs, GPUs, TPUs, FPGAs, Custom Accelerators, Vector Processing Machines, ….

- Cloud could **help with running intensive tasks** such as:
  - Data-driven decision making
  - Prediction algorithms
  - real-time processing (on-the-fly)
  - scalable, real-time, collaborative, sensor-centric applications to manage complex events
  - Data mining
  - …

- Non of which are possible on IoT devices as
  - These services run after aggregations of data collected from many devices
  - Large scale computational resources are required.

Children of IoT and Cloud Marriage!

- The **IoT+Cloud** enables new scenarios for smart services and applications

  - **SNaaS** (Sensing as a Service):
    providing ubiquitous access to sensor data

  - **SAaaS** (Sensing and Actuation as a Service).
    enabling automatic control logics implemented in the Cloud

  - **SEaaS** (Sensor Event as a Service).
    dispatching messaging services triggered by sensor events

  - **SENaaS** (Sensor as a Service).
    enabling ubiquitous management of remote sensors

Children of IoT and Cloud Marriage!

- The **IoT+Cloud** enables new scenarios for smart services and applications (Continued ..)

  - **DaaS** (Data as a Service)
    providing ubiquitous access to any kind of data

  - **EaaS** (Ethernet as a Service)
    providing ubiquitous layer-2 connectivity to remote devices

  - **IPMaaS** (Identity and Policy Management as a Service).
    enabling ubiquitous access to policy and identity management functionalities

  - **VSaaS** (Video Surveillance as a Service).
    providing ubiquitous access to recorded video and implementing complex analyses in the Cloud.

Top 8 Cloud Companies

Companies	Major Cloud Offerings	User Groups
Amazon, Seattle 1994	Amazon Web Services, a half-dozen infrastructure as a services (IaaS) including the EC2 for computing capacity, and the S3 for on-demand storage capacity.	Over 10 thousands of businesses, and individual users, including the New York Times, Wash Post, and Eli Lilly.
Enomaly Toronto 2004	Elastic Computing Platform integrates enterprise datacenters with commercial cloud offerings, manages both internal and external resources, and VM migration among the datacenters	Customers include Business Objects, France Telecom, NBC, Deutsche Bank, Best Buy, etc.
Google, Mountain View, 1998	GAE offers a PaaS plus office productivity tools including the gmail, calendaring, docs and a web site creation tool Postini, and some security protection services.	Lots of small businesses, enterprises and colleges including Arizona State Univ. and Northwestern Univ.
GoGrid, San Francisco 2008	Offers web-based storage and deploys Windows- and Linux-based virtual servers onto the cloud, with preinstalled software from Apache, PHP, Microsoft SQL and MySQL.	Mostly start-ups, Web 2.0 and SaaS companies, plus a few big names like SAP and Novell
Microsoft, Seattle. 1975	Azure offers Windows-as-a-service platform consisting of the OS and developer services that can be used to build and enhance web-hosted applications	Epicor, S3Edge and Micro Focus are among the early customers using Azure to develop cloud applications
NetSuite, San Mateo 1998	A business software suite including e-commerce, CRM, accounting and ERP tools.	Business customers including Puck Coffee, Wrigleyville Sports and Isuzu.
Rackspace, San Antonio, 1998	Mosso cloud offers a platform for building Web sites; Cloud Files for a storage service; and Cloud Servers, an EC2-like service that provides access to virtualized server instances.	Web developers and SaaS providers such as Zapproved, which uses Mosso to deliver an online productivity tool.~~
Saleforce .com San Francisco 1999	CRM tools including salesforce automation, analytics, marketing and social networking tools. The Force.com offers a PaaS for building web apps. on Salesforce infrastructure	Half million customers in financial services, communications and media, energy, healthcare and retailing.

Cloud Vendors

- 3Leaf Systems
- 3PAR
- 3Tera
- 10Gen
- Adaptivity
- Agathon Group
- Akamai
- Amazon EC2
- Apache Hadoop
- Appirio
- Appistry
- AppNexus
- Apprenda
- Appzero
- Aptana
- Arjuna
- Asankya
- AT&T
- Bluewolf
- Boomi
- Box-Net
- Booz Allen Hamilton
- CA
- Callidus Software
- Cassatt
- Cisco
- Citrix
- Cloud9 Analytics
- CloudBerry Lab
- Cloudera
- Cloudscale
- Cloudswitch
- Cloudworks
- Coghead

- CohesiveFT
- Cordys
- Cumulux
- Dataline
- Dell
- Desktoptwo
- ElasticHosts
- Elastic Compute Cloud
- Elastra
- EMC
- Engine Yard
- ENKI
- Enomaly
- Enomalism
- Eucalyptus
- eVapt
- EyeOS
- FlexiScale
- Force.com
- Fortress ITX
- G.ho.st
- GigaSpaces
- GoGrid/ServPath
- Google
- gOS
- Grid Dynamics
- Hadoop
- Heroku
- Hosting.com
- HP
- Hyperic
- IBM
- iCloud
- IMOD

- Intel
- Interoute
- iTricity
- Joyent
- JumpBox
- Juniper Networks
- Kaavo
- Kadient
- Keynote Systems
- Layered Technologies
- LinkedIn
- LongJump
- Meeza
- Mezeo Software
- Microsoft
- Morgan Stanley
- MorphExchange
- Netsuite
- newScale
- Ning
- Nirvanix
- Novell
- OpenNebula
- OpSource
- Oracle
- OTOY
- Parallels
- ParaScale
- Penguin Computing
- Platform Computing
- Q-layer
- Qrimp
- Quantivo
- Quickbase

- Rackspace
- Red Hat
- Reservoir
- Rhomobile
- RightScale
- Rollbase
- rPath
- S3
- SalesForce.com
- Savvis
- ServePath/GoGrid
- SIMtone
- Skytap
- SLA@SOI
- SmugMug
- SOASTA
- StrikeIron IronCloud
- Sun
- Terremark
- The GridLayer
- ThinkGrid
- Unisys
- Univa UD
- vCloud
- Vertica
- Virtual Workspaces
- VMware
- WorkXpress
- Yahoo!
- Zetta
- Zimory
- Zoho
- Zuora