

IoT: Cloud Services

Introduction to Cloud Computing for IoT

Objectives

Students completing this module will be able to explain the motivation behind cloud computing, how it is used today, the development of I/O systems and the history of cyberinfrastructure.

Cloud Computing Growth

Cloud Computing Industry is growing

By 2018, 59% of the total cloud workloads will be Software-as-a-Service (SaaS) workloads, up from 41% in 2013.

Cisco is predicting that by 2018, 28% of the total cloud workloads will be Infrastructure-as-a-Service (IaaS) workloads down from 44% in 2013.

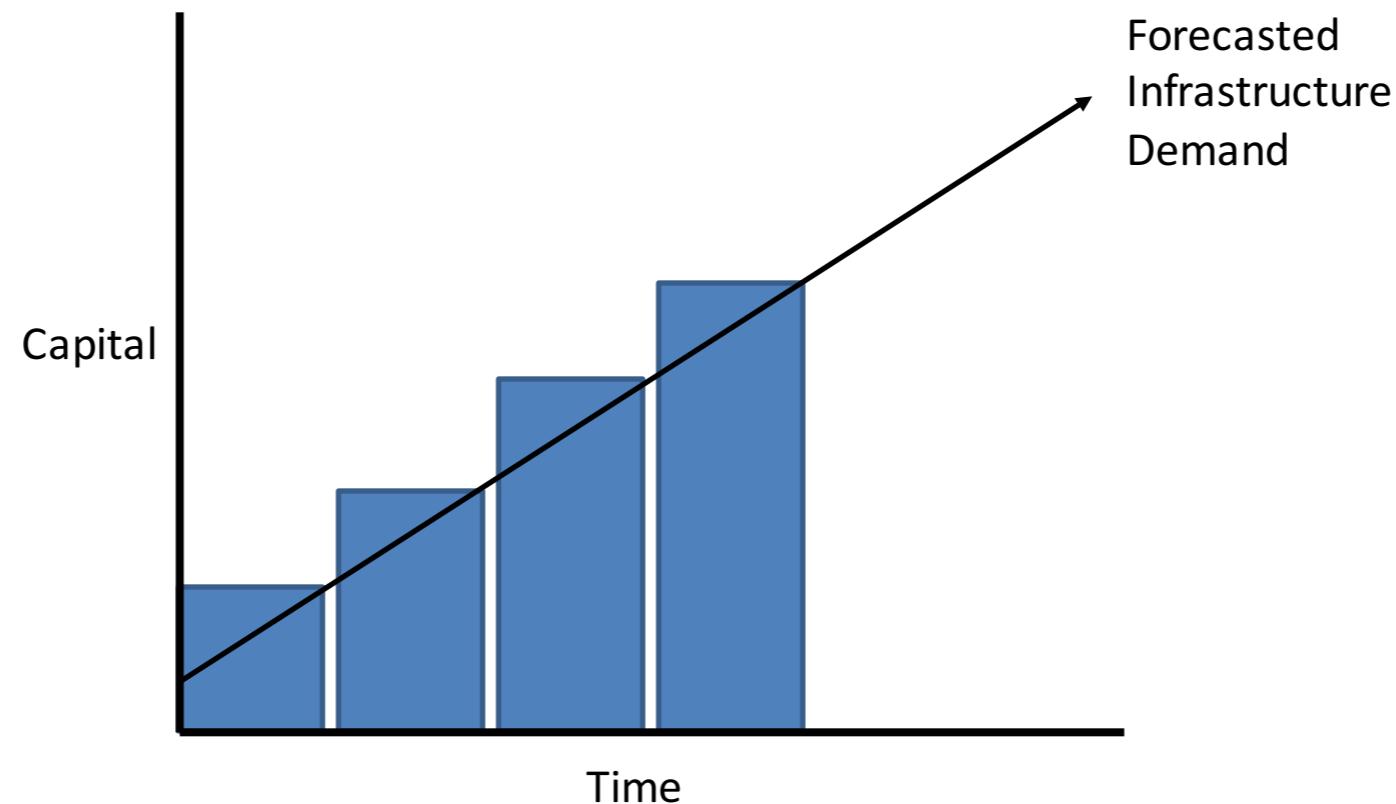
13% of the total cloud workloads will be Platform-as-a-Service (PaaS) workloads in 2018, down from 15% in 2013.

The following graphic provides a comparative analysis of IaaS, PaaS and SaaS forecasts from 2013 to 2018. Source: [Cisco Global Cloud Index: Forecast and Methodology, 2013–2018](#).

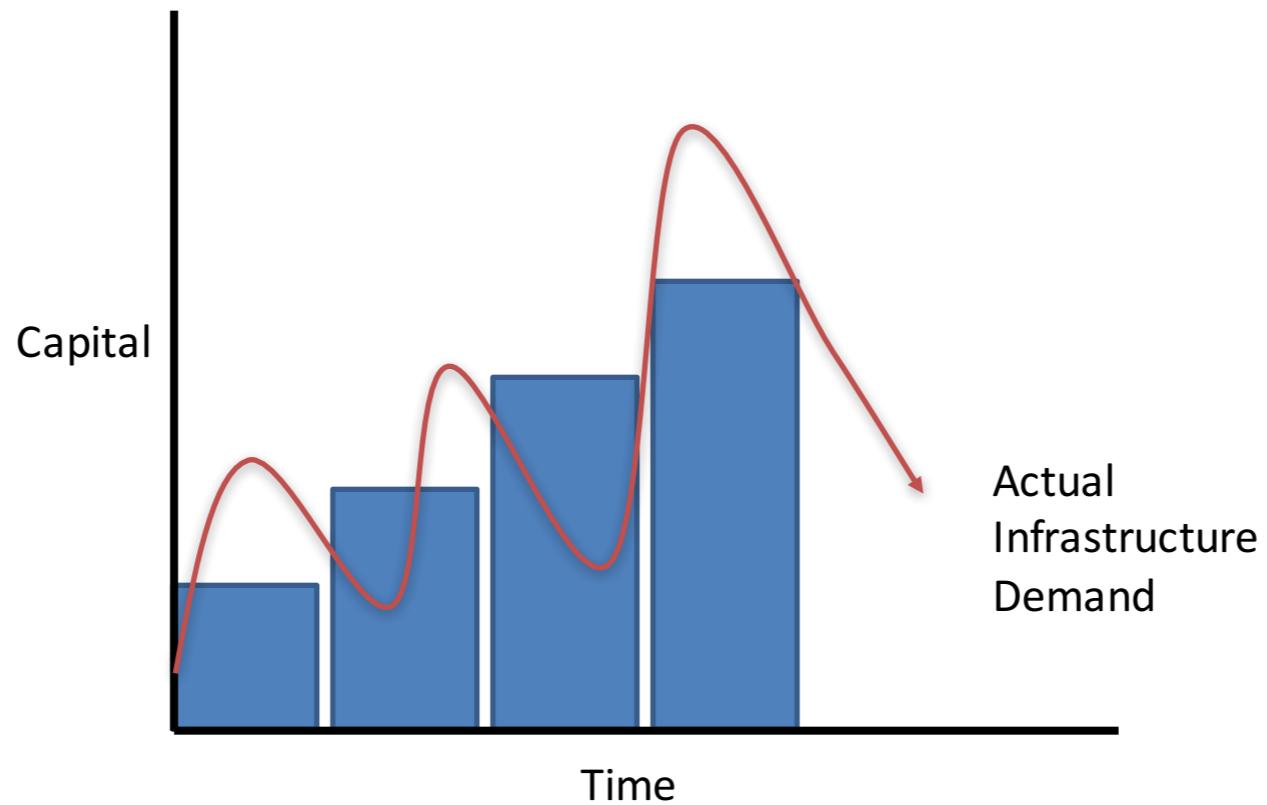
Figure 9. SaaS Most Highly Deployed Global Cloud Service by 2018



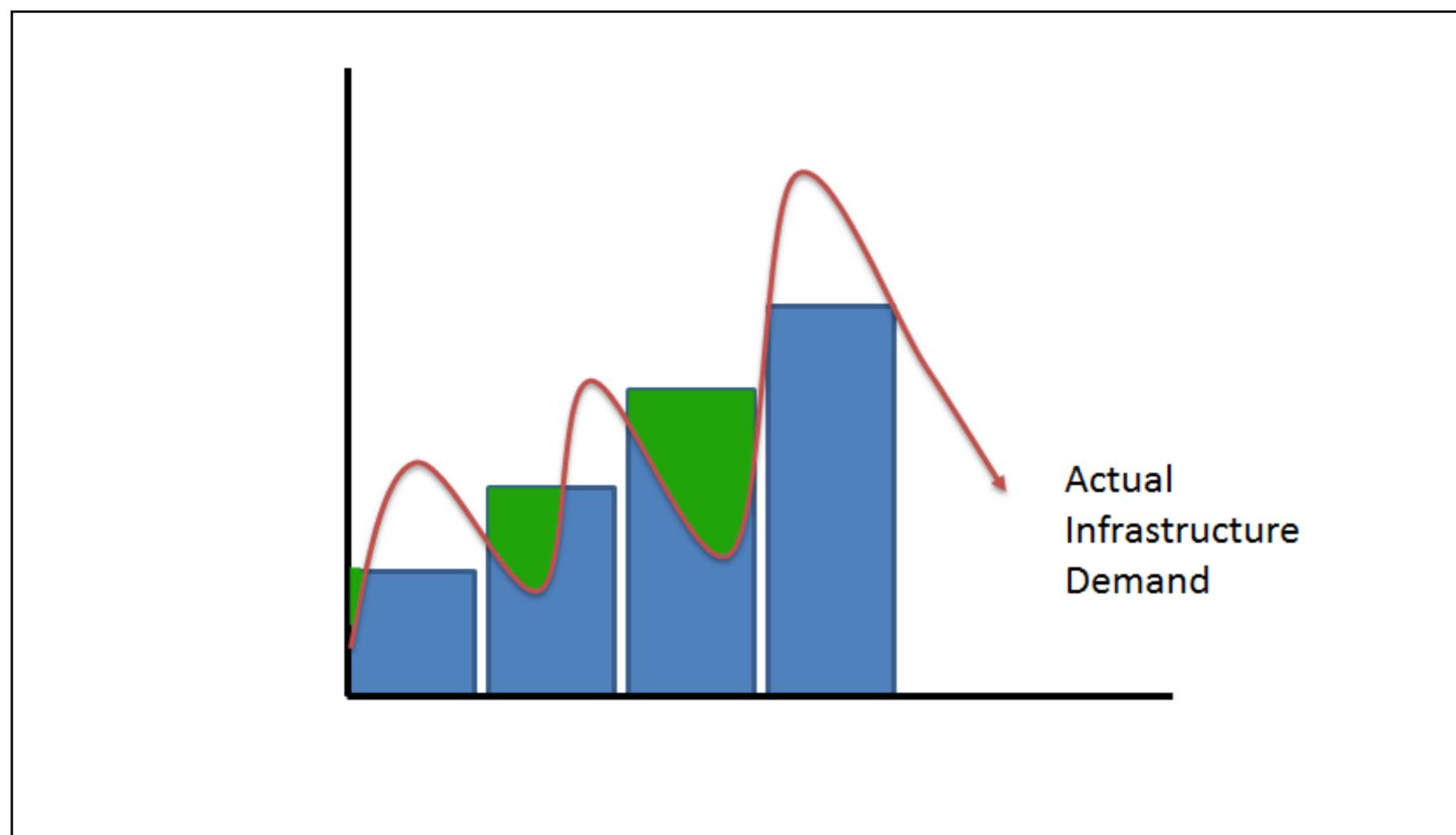
Traditional Infrastructure Model



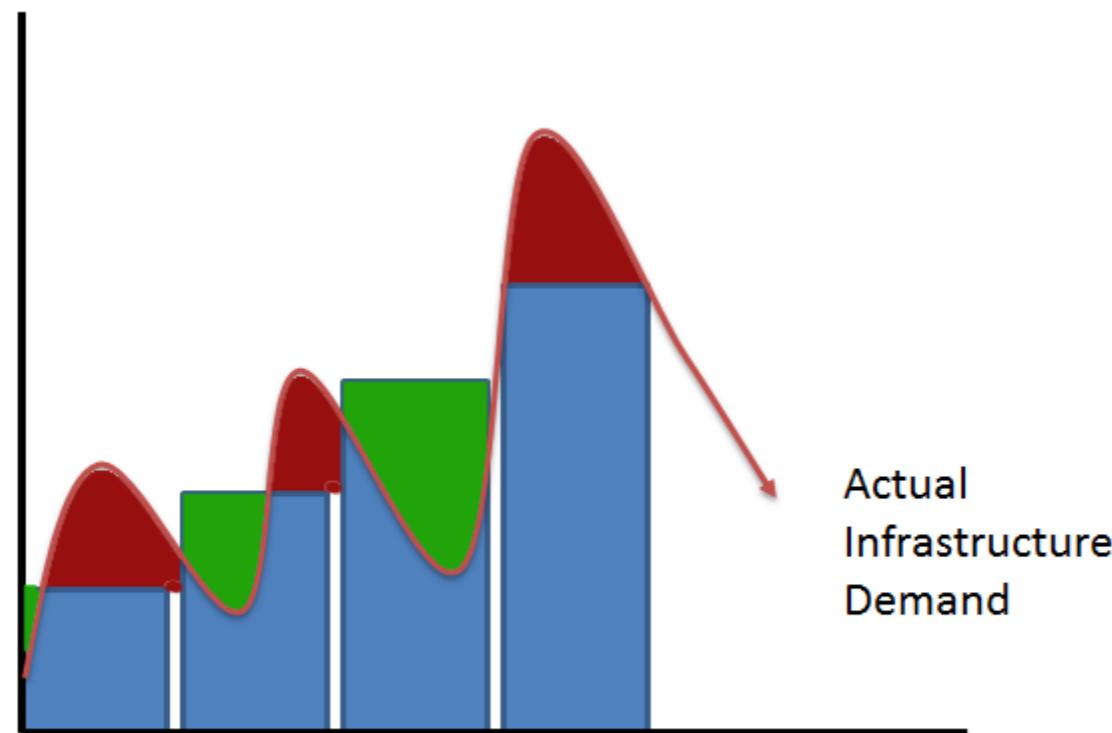
Actual Infrastructure Demand



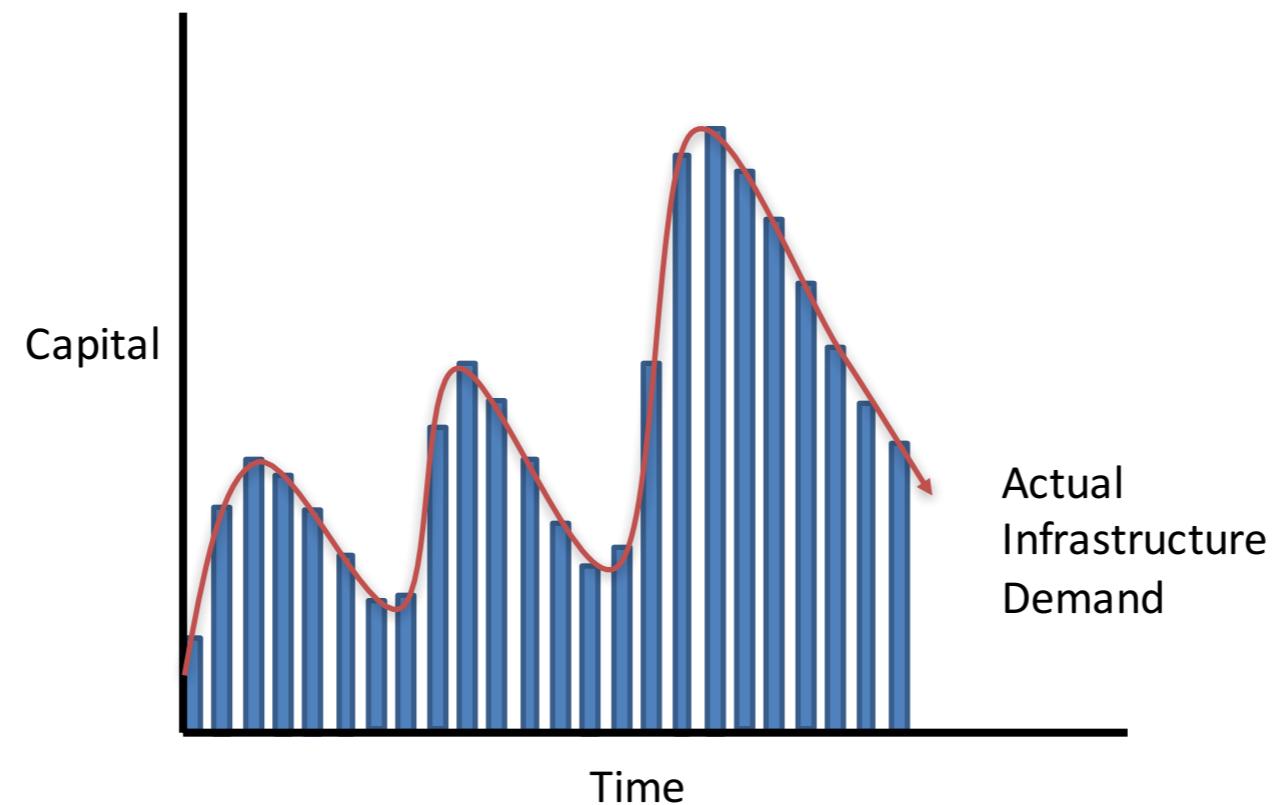
Unacceptable Surplus



Unacceptable Deficit



Utility Infrastructure Model

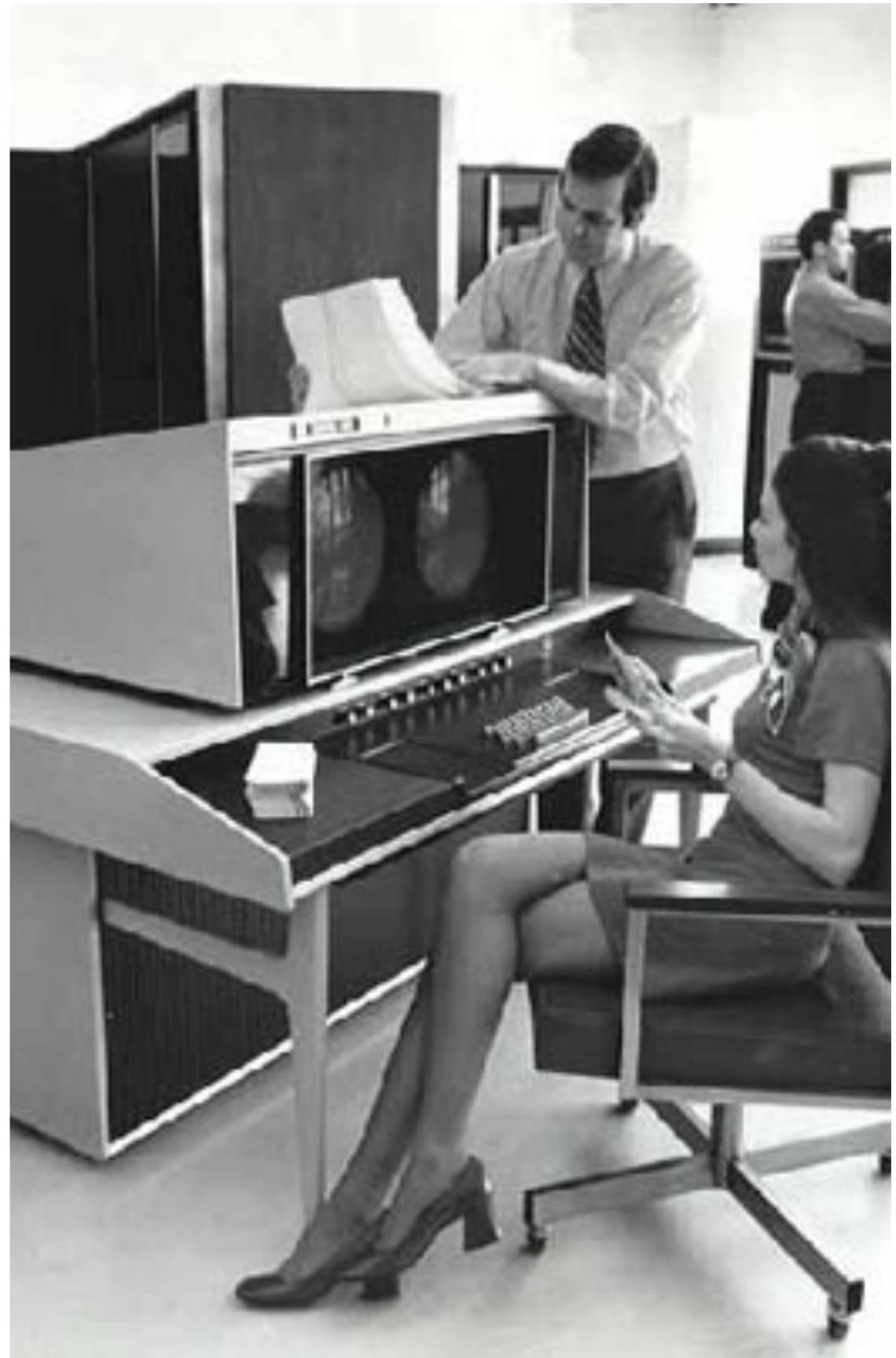


IoT: Cloud Services

History of the Cloud towards IoT

In the
beginning, it
was mainframes
and terminals

All users were connecting
through a single computer



Next came the PC

Users did individual work on
their own desktop





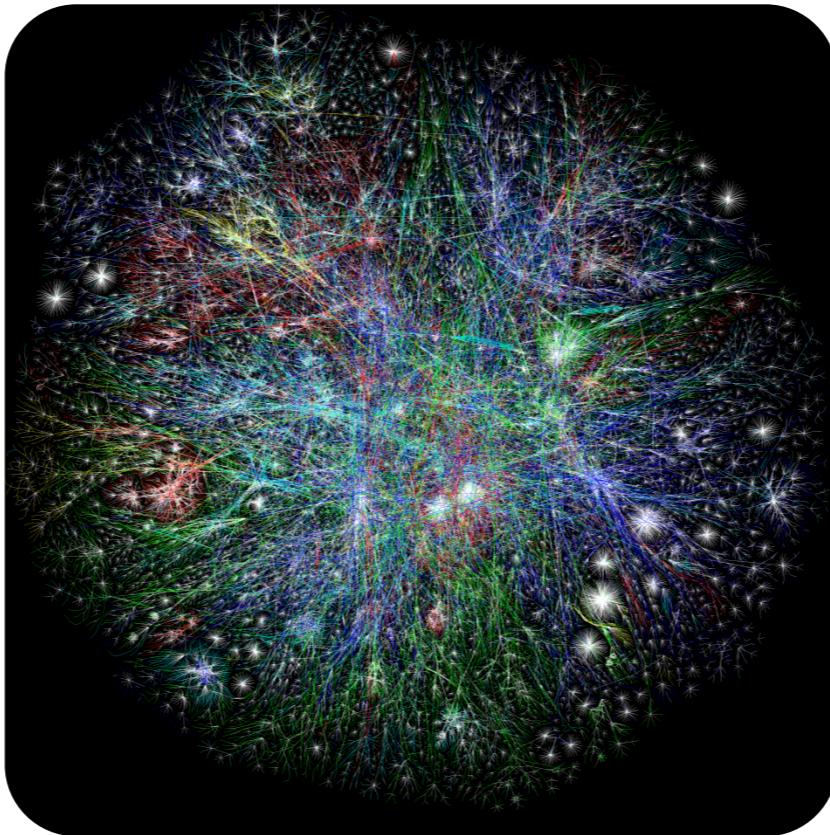
Then the PCs got connected with each other

Users could talk to each other's PC



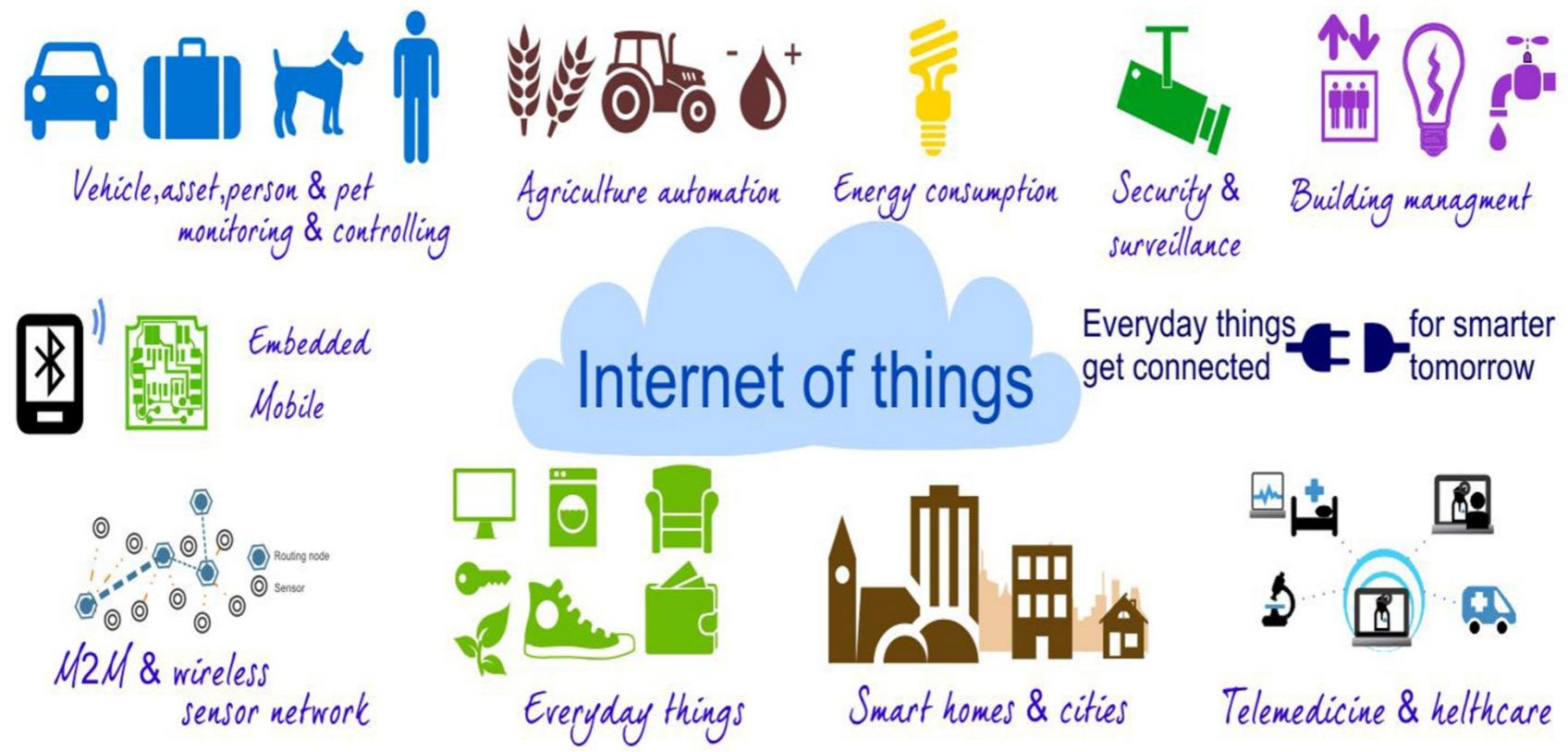
The came the Web

Users could do individual work by connecting to Web
Servers



Then the web became Big!

Server had to become cluster of PCs
Care and feeding got expensive



Then all things got connected together
The **Internet of Things** was born!

IoT: Cloud Services

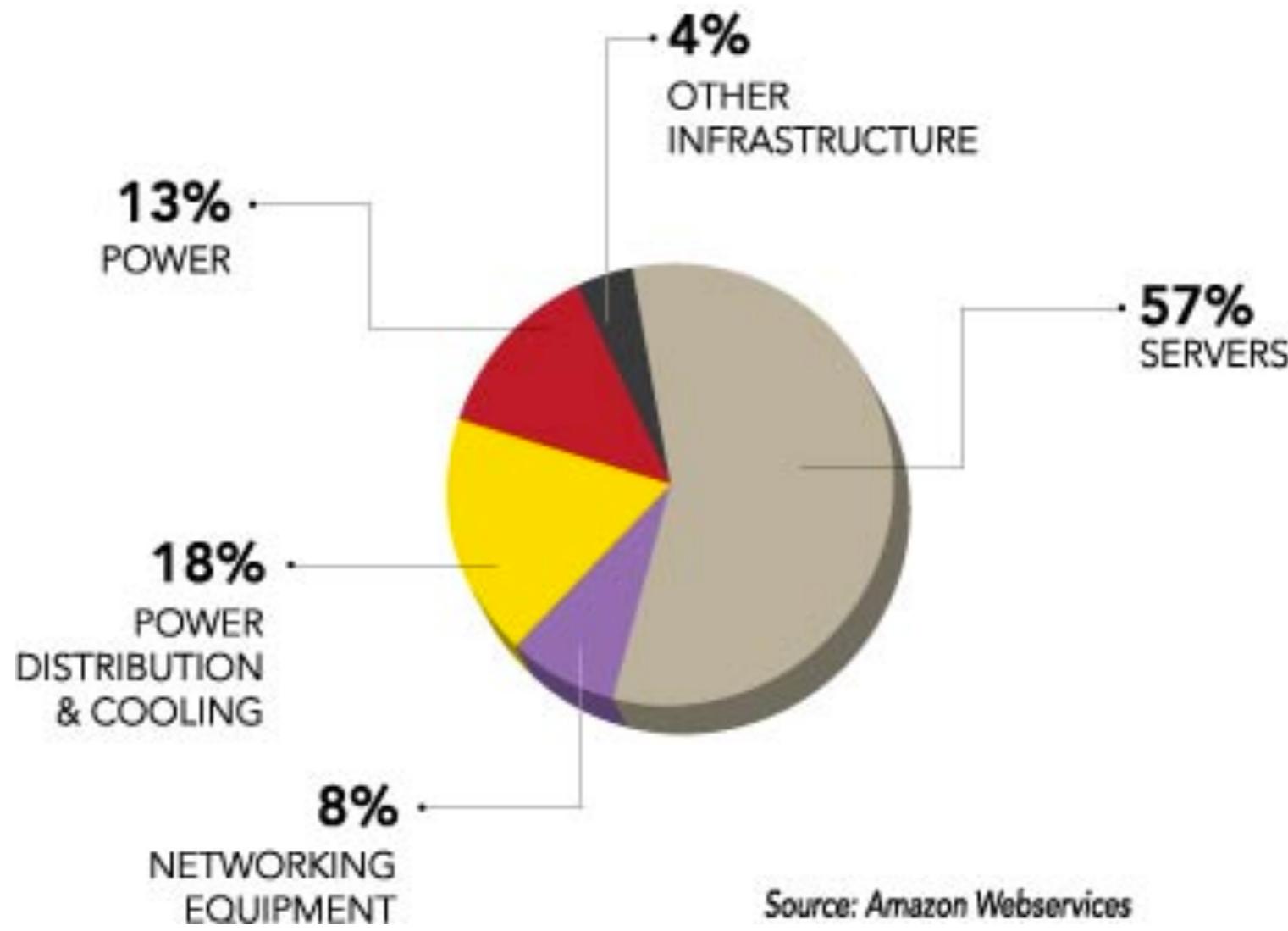
From datacenter to the Cloud



Servers are now hosted in data centers

Infrastructure = Mega datacenters





High cost of maintaining individual data centers

Data Centers

- Need lots of electric power (1.5% of all US electricity, EPA 2007)
- Long lead time to build
- Inflexible investment of capital
- Need specialized skills (security, failover, load balancing, etc.)
- Takes time away from core competencies
- Hard for all but largest companies to own/run

Solution: Outsource Data Centers

- Can reap economies of scale
- Because of scale, can afford specialized skills
- Web developers can concentrate on their core competencies that give them market advantage
- Shorter lead times
- Lower capital requirements
- Computing power becomes a commodity, as did electric power in early 20th century

Cloud Benefits

- Cloud offers low, pay-as-you-go pricing with no up-front expenses or long-term commitments.
- Cloud vendors build and manage a global infrastructure at scale.
 - They pass the cost saving benefits onto the clients in the form of lower prices.
- With the efficiencies of cloud scale and expertise, cloud vendors have been able to lower prices

Considerations of a Cloud Engineer

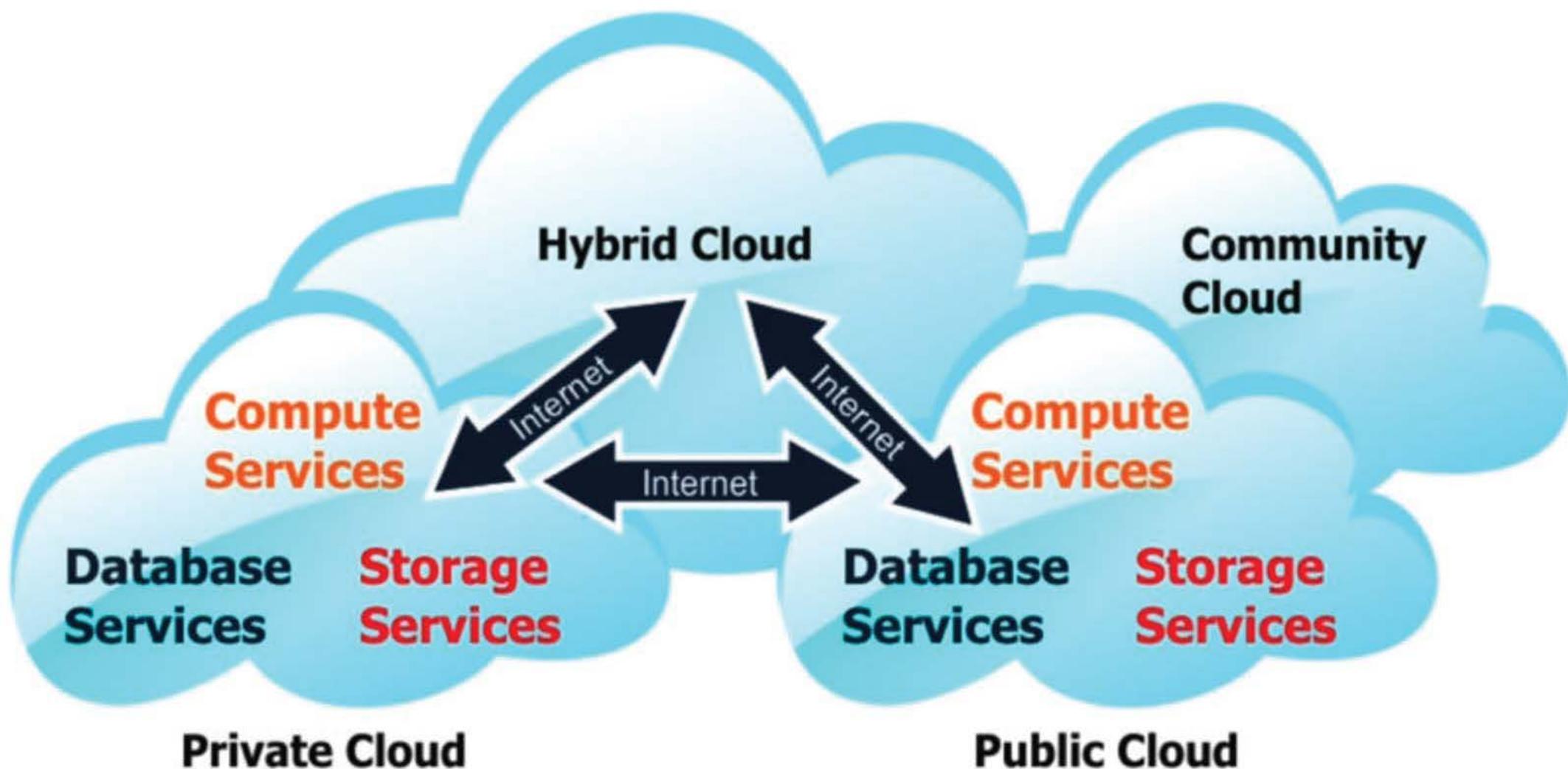
- Your instances will die
- You will share resources
- The architecture will change
- You will never see the lights...



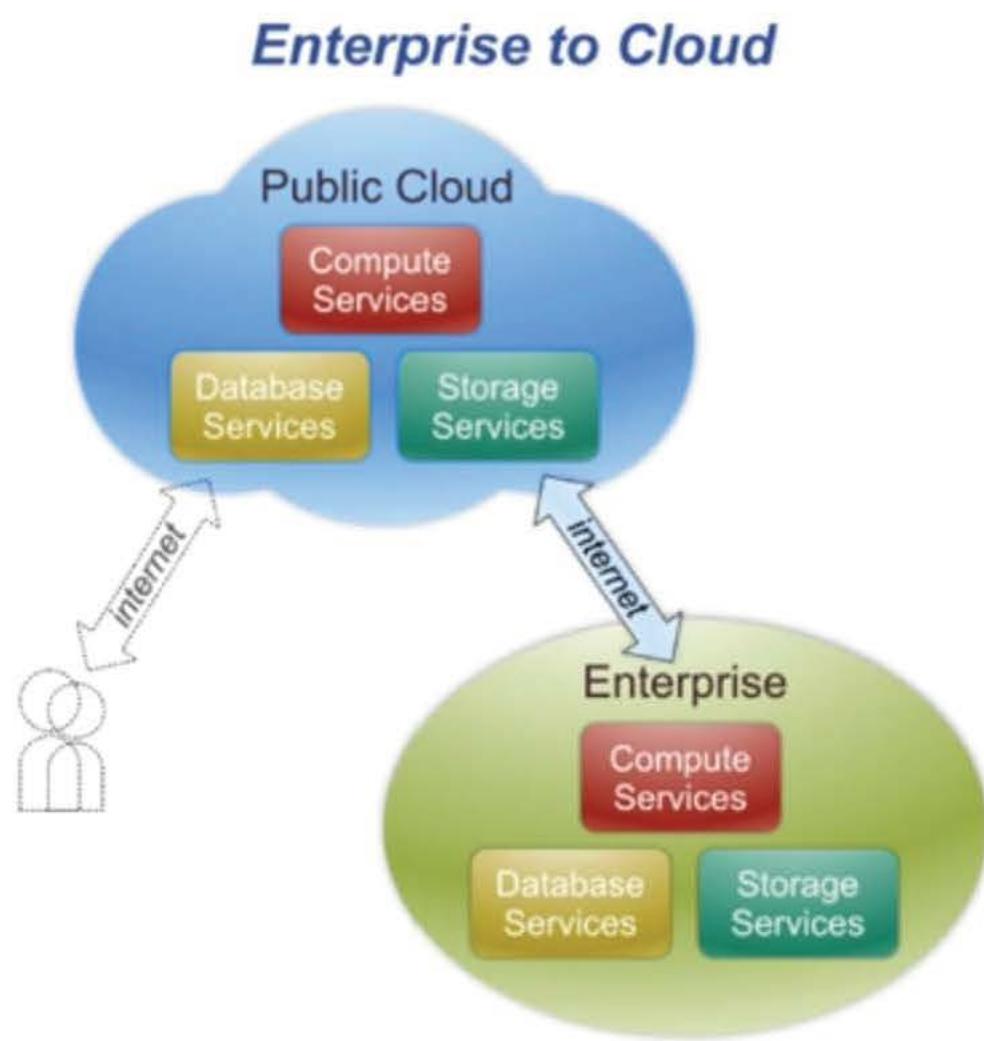
IoT: Cloud Services

Cloud Deployment Models

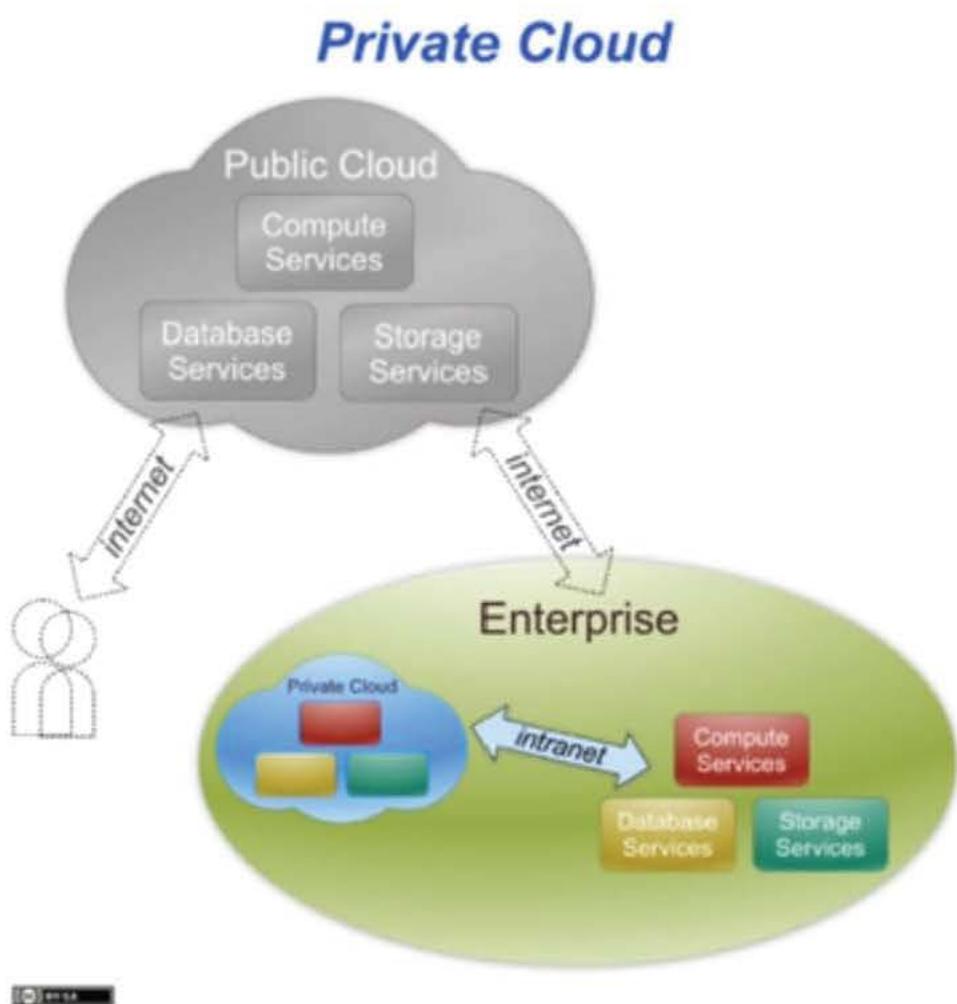
Types of Cloud Deployment Models



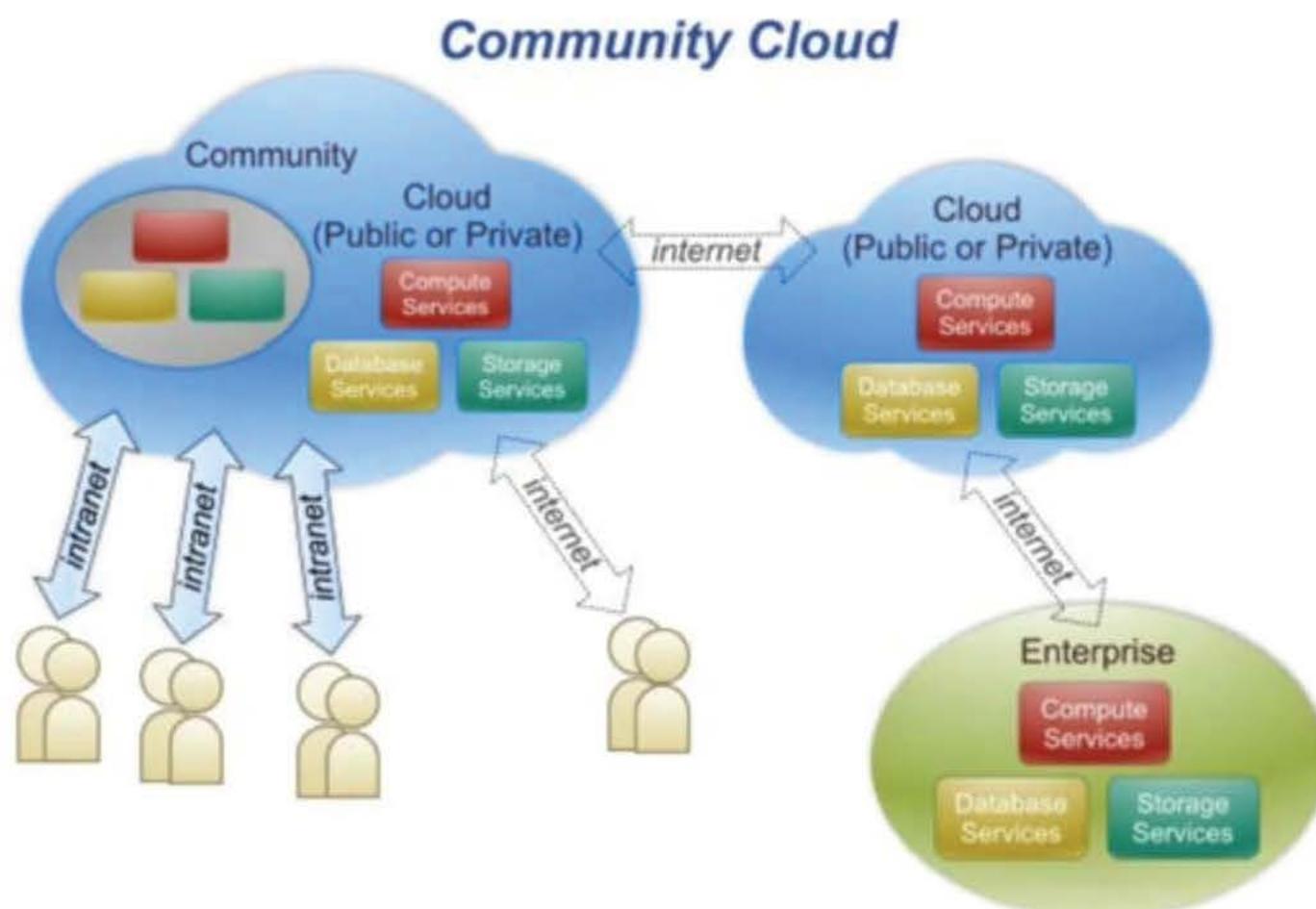
Four Deployment Models



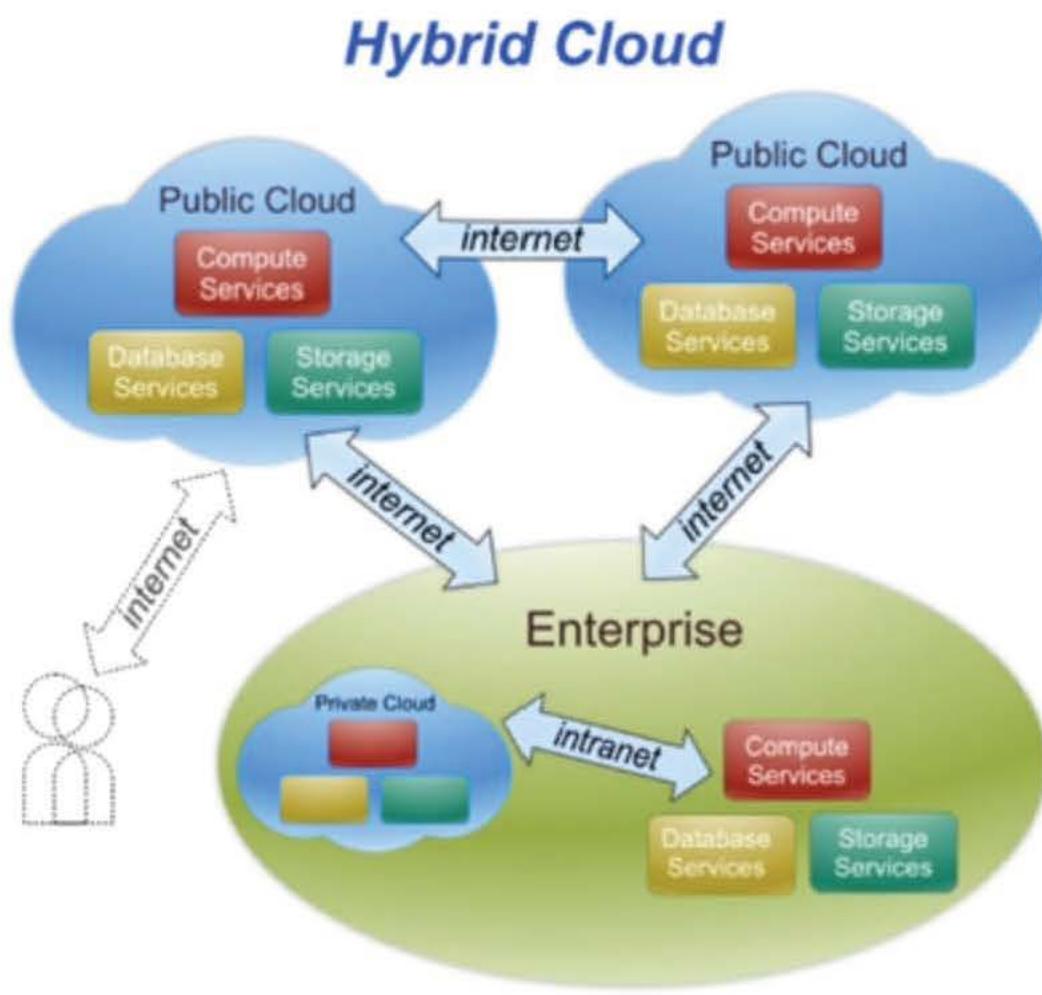
Four Deployment Models



Four Deployment Models



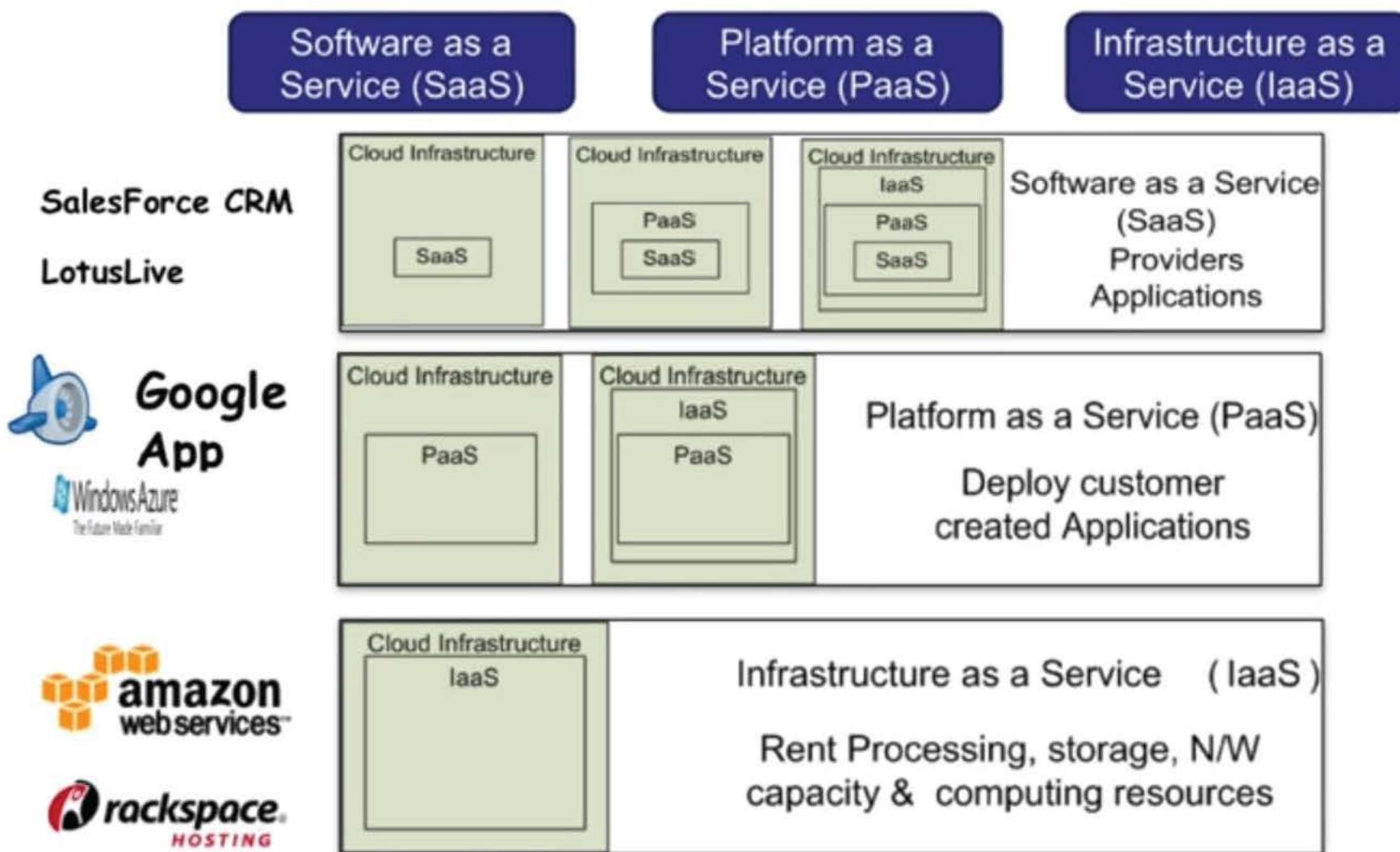
Four Deployment Models



Private vs Public Cloud

- Rationale for Private Cloud:
- Security and privacy of business data was a big concern
- Potential for vendor lock-in
- SLA's required for real-time performance and reliability
- Cost savings of the shared model achieved because of the multiple projects involving semantic technologies that the company is actively developing

Cloud Service Models



Download started. To see it, press **Esc**.



Amazon Web Services

The screenshot shows the official AWS website. At the top, there's a navigation bar with links for Menu, Products, Solutions, Pricing, Software, Support, Customers, Partners, Enterprises, Startups, and Public Sector. It also includes language (English), account information (My Account), and a 'Sign in to the Console' button.

The main banner is orange and features a call to action: 'Enterprise-grade software. Try AWS Marketplace — Get \$500 in AWS Credits'. It includes a link 'Claim your credit' and a graphic of a laptop with a shopping cart icon and a dollar sign.

To the right of the banner is a box for 'Manage Your Resources' with a 'Sign in to the Console' button. Below it is information about the 'AWS Console Mobile App' with a download link.

Below the banner, there are four cards:

- PROJECTS ON AWS**: Build a project using our step-by-step guides.
- AMAZON ELASTICSEARCH SERVICE**: Now with support for Elasticsearch 5 & Kibana 5. Faster, easier, more secure.
- ANNOUNCING AWS SNOWBALL EDGE**: Petabyte-scale data transport with on-board storage and compute.
- COMPUTE: AWS BATCH**: Fully managed batch processing at any scale.

Below these cards is a section titled 'Explore Our Products' with five categories: Compute, Storage, Database, Migration, and Networking & Content Delivery. Each category has a corresponding icon and a brief description.

Compute	Storage	Database	Migration	Networking & Content Delivery
Amazon EC2 Virtual Servers in the Cloud	Amazon EC2 Container Registry Store and Reference Docker Images	Amazon EC2 Container Service Run and Manage Docker Containers		
Amazon Lightsail Launch and Manage Virtual Private Servers	Amazon VPC Isolated Cloud Resources	AWS Batch Run Batch Jobs at Any Scale		
Amazon Elastic Beanstalk Run and Manage Web Apps	AWS Lambda Run Your Code in Response to Events	Auto Scaling Automatic Elasticity		

At the bottom, there are five more categories: Developer Tools, Management Tools, Security, Identity & Compliance, Analytics, and Artificial Intelligence, each with its own icon.

AWS Console

The screenshot shows the AWS Console homepage. At the top, there's a navigation bar with 'Services' (selected), 'Resource Groups', a search bar, and user information ('Jannis Papapanagiotou - Oregon - Support'). Below the navigation is a large search bar labeled 'Search services'. The main content area is organized into several columns:

- Compute:** EC2, EC2 Container Service, Lambda, Batch.
- Storage:** S3, EFS, Glacier, Storage Gateway.
- Database:** RDS, DynamoDB, ElastiCache, Redshift.
- Networking & Content Delivery:** VPC, CloudFront, Direct Connect, Route 53.
- Migration:** DMS, Server Migration, Snowball.
- Developer Tools:** CodeCommit, CodeBuild, CodeDeploy, CodePipeline.
- Management Tools:** CloudWatch, CloudFormation, CloudTrail, Config, OpenMetrics, Service Catalog, Trusted Advisor, Managed Services, Application Discovery Service.
- Security, Identity & Compliance:** IAM, Inspector, Certificate Manager, Directory Service, WAF & Shield, Compliance Reports.
- Analytics:** Athena, EMR, CloudSearch, Elasticsearch Service, Kinesis, Data Pipeline, QuickSight.
- Application Services:** Step Functions, SWF, API Gateway, Elastic Transcoder.
- Artificial Intelligence:** Lex, Polly, Rekognition, Machine Learning.
- Internet Of Things:** AWS IoT.
- Business Productivity:** WorkDocs, WorkMail.
- Game Development:** GameLift.
- Mobile Services:** Mobile Hub, Cognito, Device Farm, Mobile Analytics, Pinpoint.
- Messaging:** SQS, SNS, SES.
- Desktop & App Streaming:** WorkSpaces, AppStream 2.0.

On the right side, there are three vertical panels with promotional text:

- 'Optimize your cost and performance.' (with links to Step Functions, SWF, API Gateway, and Elastic Transcoder)
- 'Ingest data faster.' (with links to CloudWatch, CloudFormation, CloudTrail, Config, OpenMetrics, Service Catalog, Trusted Advisor, Managed Services, Application Discovery Service, and AWS IoT)
- 'Run your apps faster with the AWS Lambda service.' (with links to WorkDocs, WorkMail, GameLift, and AppStream 2.0)

AWS History



- Officially Launched in 2006
- Amazon Web Services (AWS) began offering IT infrastructure services to businesses in the form of web services.
- Amazon Web Services has datacenters in U.S., Europe, Brazil, Singapore, Japan, and Australia
- AWS provides a highly reliable, scalable, low-cost infrastructure platform in the cloud that powers hundreds of thousands of businesses in 190 countries around the world.

Amazon Web Services

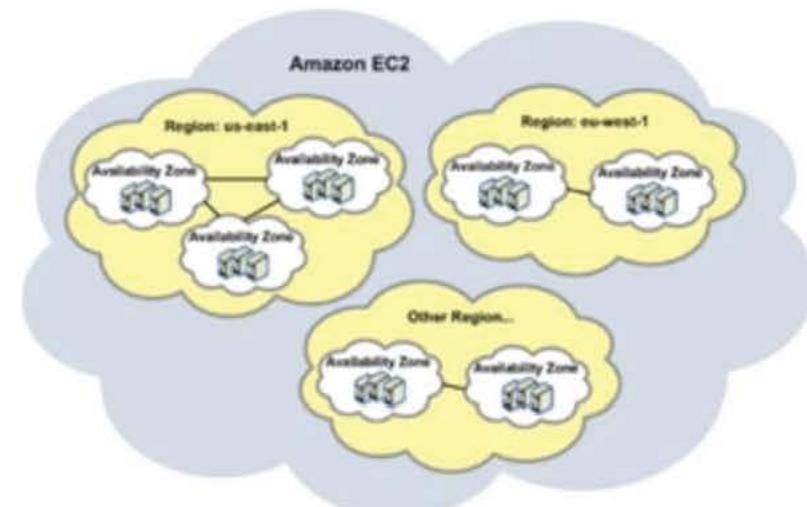
- AWS is a collection of remote computing services that together make up a cloud computing platform
- Compute
 - Elastic Compute (EC2) = virtual private servers
 - Elastic MapReduce (EMR) = Hadoop framework running on EC2
- Storage
 - Simple Storage Service (S3) = storage
 - Glacier = low-cost and long-term storage (high redundancy, low access time)
 - Elastic Block Storage (EBS) = persistent block-level storage
- Database
 - DynamoDB = NoSQL backed by SSD
 - ElasticCache= in-memory cache based Memcached
 - Relational Database Service (RDS) = scalable database MySQL, Informix, Oracle, SQL server etc
- ...

Amazon Web Services

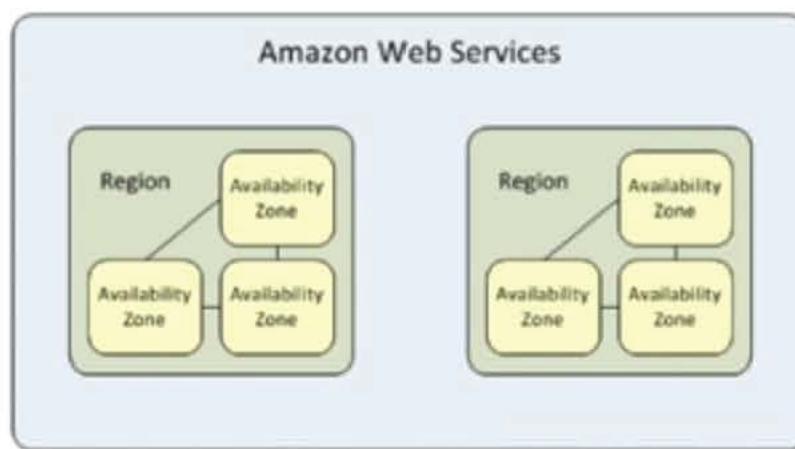
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AWS Global Infrastructure

- AWS is hosted in multiple locations world-wide. These locations are composed of **Regions**.
 - Each **region** is a separate geographic area.
 - Each **region** has multiple, isolated locations known as *Availability Zones*.
 - 11 Regions



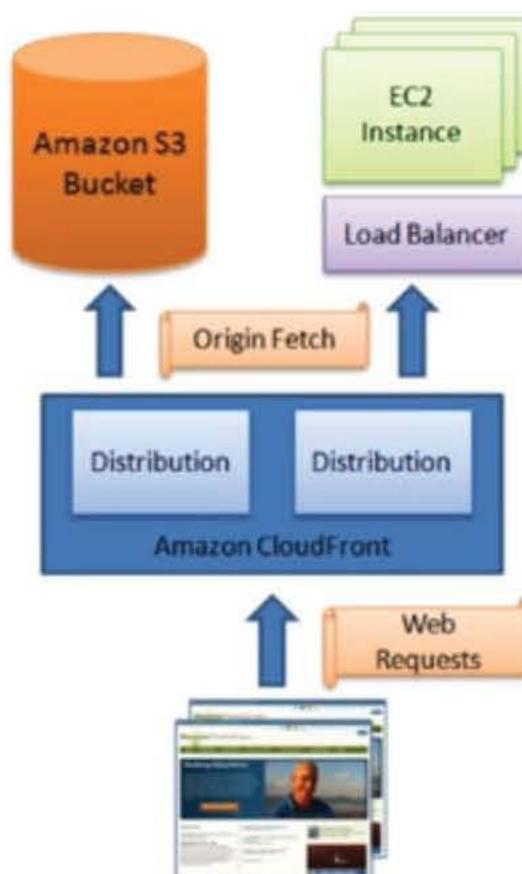
Availability Zones



- Each Region has 2 or more "Availability Zones", which are distinct data centers providing AWS services.
- Each Amazon EC2 region is designed to be completely isolated from the other Amazon EC2 regions. This achieves the greatest possible fault tolerance and stability.
 - Several services operate across Availability Zones (e.g., S3, DynamoDB) while others can be configured to replicate across Zones to spread demand and avoid downtime from failures.

Edge Locations

- 52 Edge Locations
- Edge Locations are CDN edge points
 - There are many more Edge Locations than Regions.
- Used to cache data closed to the user so that the latency is reduced.





AWS Global Infrastructure

IoT: Cloud Services

Common Cloud providers: AWS Architecture

Networking (DNS)

Router 53: a highly available and scalable cloud Domain Name System (DNS) web service.



Virtual Private Cloud (VPC)

- Amazon VPC lets you provision a logically isolated section of the AWS Cloud where you can launch AWS resources in a virtual network that you define.
- For example, you can create a public-facing subnet for your webservers that has access to the Internet, and place your backend systems such as databases or application servers in a private-facing subnet with no Internet access.

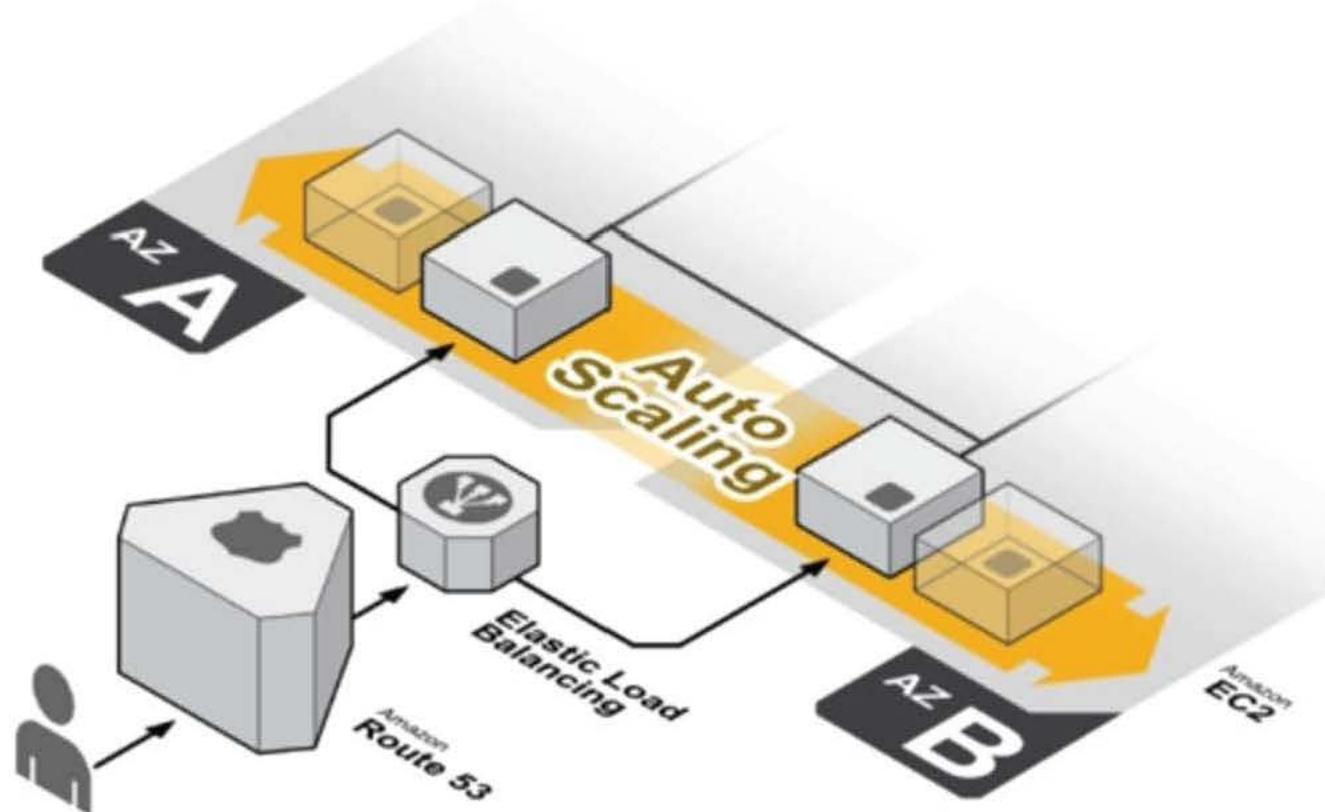


Compute



- Amazon Elastic Cloud Compute (EC2) is a simple web service interface allows you to obtain and configure capacity with minimal friction.
- EC2 allows to provision virtual instances.
 - These instances can be CentOS, Ubuntu, Amazon's linux, Windows 2008/2012 etc.
 - Amazon also provides a marketplace where you can pre-configured instances.
- EC2 uses Xen virtualization.

Autoscaling

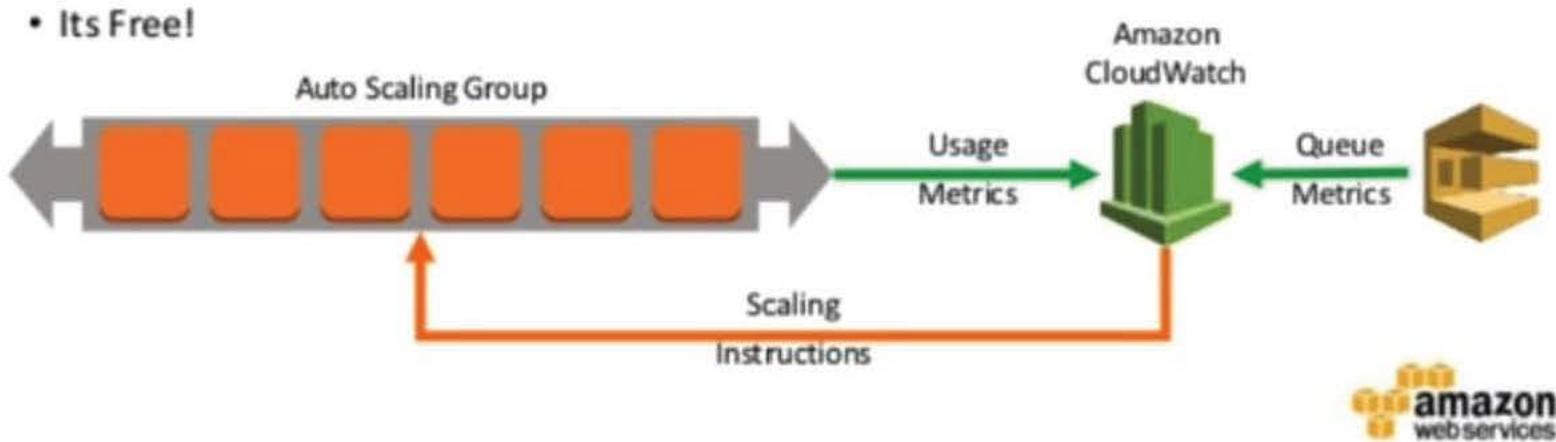


Autoscaling

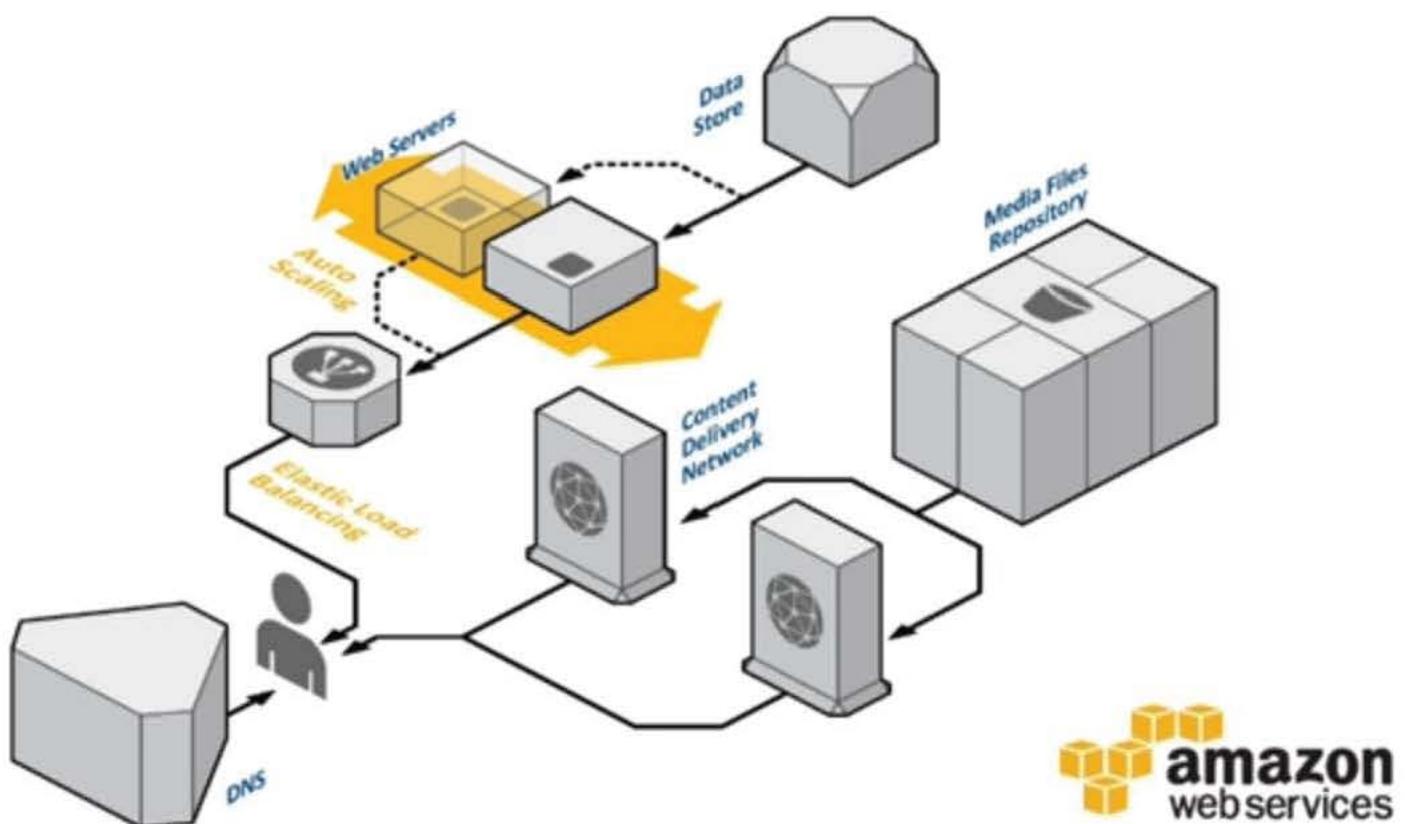
Auto Scaling



- Automatic resizing of compute clusters based on demand
- Define minimum and maximum number of instances
- Define when scaling out and in occurs
- Use metrics collected in Amazon CloudWatch to drive scaling
- Run Auto Scaling for On-Demand and Spot instance types
- It's Free!

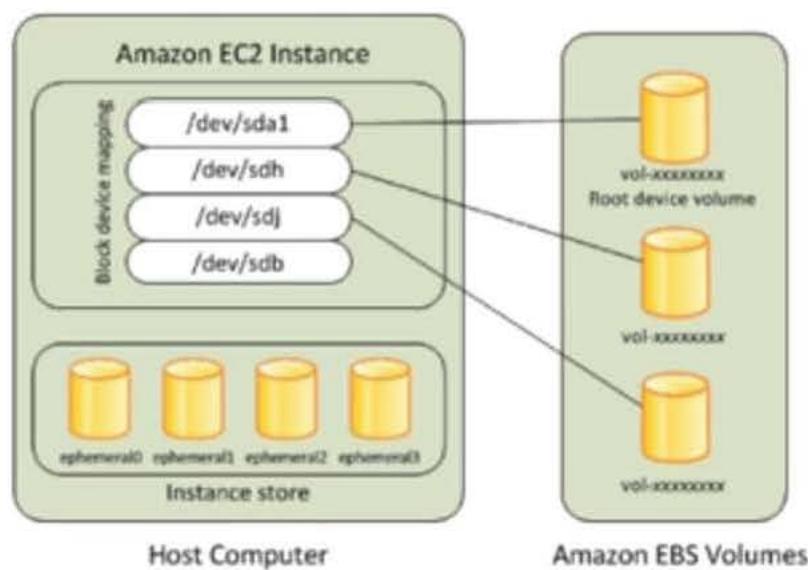


Elastic Load Balancing



Amazon EBS

- Amazon Elastic Block Storage (EBS) provides raw block devices that can be attached with EC2 instances.
 - EBS supports a number of advanced storage features, including snapshotting and cloning.
 - EBS volumes can be up to 1TB in size.
 - EBS volumes are built on replicated storage, so that the failure of a single component will not cause data loss.



IoT: Cloud Services

Common Cloud Providers: Google Cloud and Microsoft Azure



Google App Engine

- PaaS for developing web apps in Google-managed data centers
 - deployment Java , Go, PHP and Python.
- Google offers the same reliability, availability and scalability at par with Google's own applications
 - High-Replication Datastore App Engine applications have a 99.95% uptime SLA.
 - App Engine is designed to sustain multiple datacenter outages without any downtime. This resilience to downtime is shown by the statistic that the High Replication Datastore saw 0% downtime over a period of a year
- Compared to Amazon EC2,
 - App Engine provides more infrastructure to make it easy to write scalable applications, but can only run a limited range of applications designed for that infrastructure.
 - Runs application instances as needed. Hence removes the overhead from the developer to monitor requests per second etc
- Per-day and per-minute quotas restrict bandwidth and CPU use, number of requests served, number of concurrent requests, and calls to the various APIs.

Google Cloud Platform

The screenshot shows the 'SOLUTIONS' section of the Google Cloud Platform website. At the top, there's a dark header bar with the Google Cloud logo, navigation links like 'Why Google', 'Products', 'Solutions', etc., and a search bar. Below the header is a large dark banner with the word 'SOLUTIONS' in white. Underneath it, a sub-header reads 'Tutorials, architecture guides and additional resources to help you build on Cloud Platform'. There are two buttons: 'TRY IT FREE' and 'CONTACT SALES'. The main content area is divided into three columns:

- Media**: Features icons for video and audio processing. Description: 'Power mission-critical workloads on our infrastructure including rendering, media archival, and transcoding.'
- Mobile Applications**: Features an icon of a smartphone. Description: 'Build your app for Android, iOS, and the mobile web on services that will reliably scale as your app grows.'
- Big Data**: Features icons of databases and clouds. Description: 'An integrated, serverless Big Data platform for data-driven analytics.'



Media

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Mobile Applications

Build your app for Android, iOS, and the mobile web on services that will reliably scale as your app grows.



Big Data

An integrated, serverless Big Data platform for data-driven analytics.



Financial Services

Scale to massive transactional volume on a cloud platform designed for security and reliability.



Gaming

Engage a global player base with dynamic, shared gaming experiences on our global fiber network.



Retail & Commerce

Serve a global customer base with industry-leading scale and analytics to personalize your experience.

Microsoft Azure

Released February 2010

Provides both IaaS and PaaS

Supports many programming languages but mainly MSFT specific ones

Azure runs on multiple Windows PCs in a data center. It is the layer that provides system services to the application. From the app's point of view, this is the operating system.

full PaaS.

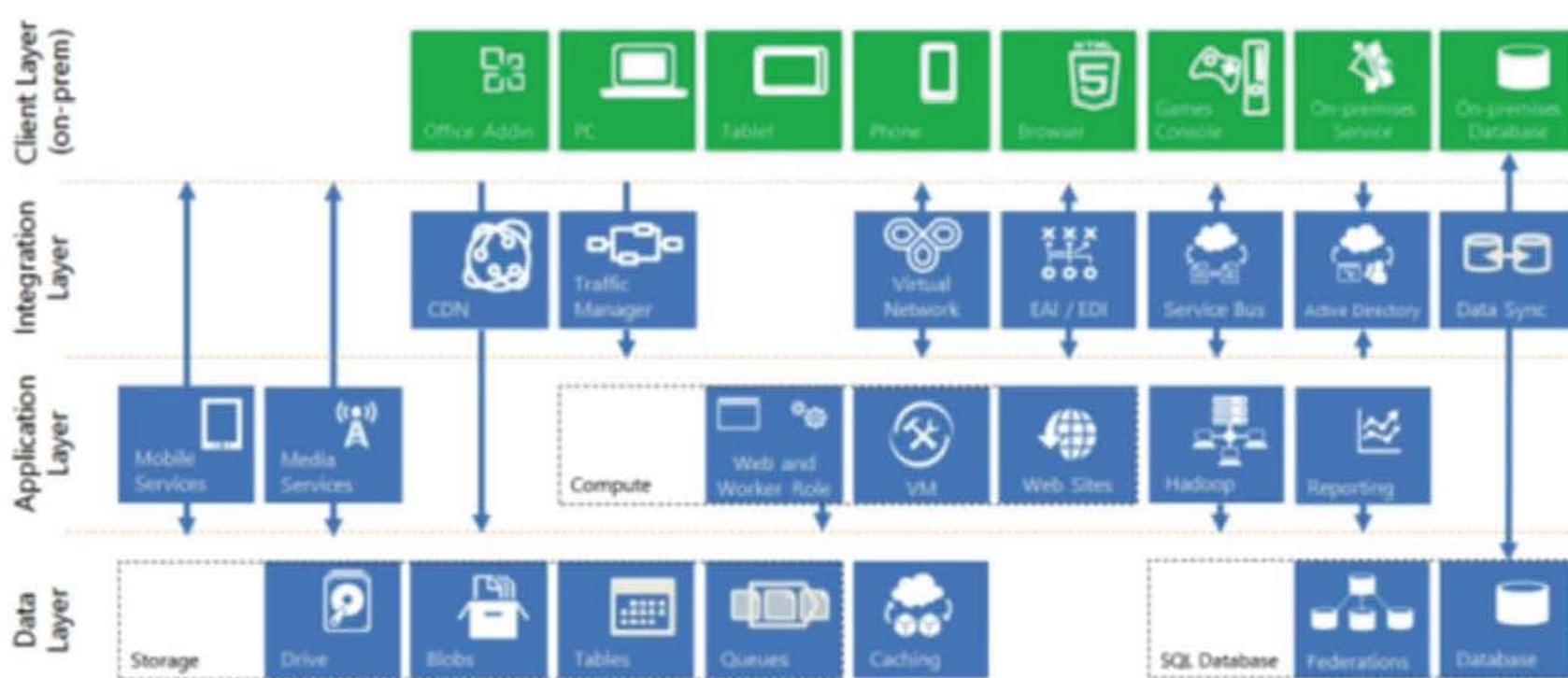
Note: Azure also contains the ability for the programmer to supply a complete VM, as does Amazon (IaaS).

Customers have complete control, to run the Microsoft Data Center.

Mainly Windows Server 2008/2012 and a few Linux distros

Windows Azure

Windows Azure



IoT: Cloud Services

Why (not) move IoT services to the Cloud?

IoT Requirements	Cloud Challenges
Highly dynamic resource demands	Support for application elasticity
Real-time needs	Quality of service assurance
Expected exponential growth of demand	Cloud infrastructure scalability
Availability of applications	Cloud reliability
Data protection and user privacy	Cloud privacy and security
Efficient power consumption of applications	Efficient energy resource management
Execution of the applications near to end users	Cloud federation
Access to an open , interoperable cloud ecosystem	Cloud interoperability and portability

Challenges in Cloud Computing to Enable IoT

What are the benefits of moving IoT apps to the Cloud?

- Cloud computing enables IoT applications, which are system infrastructure dependent, to be infrastructure-less.
- By using the Cloud infrastructure on “pay as used and on demand”, we can save in capital and operational investment!
- IoT devices can:
 - Put their data on the platform instead of on their own servers.
 - Push some of the computation to the Cloud by having the apps run on the cloud
 - Data manipulation and app can exist in the same environment simplifying the communication (intra-cloud)

Leveraging Public Cloud providers

- The use of the cloud provides a number of opportunities:
 - It enables services to be used without any understanding of their infrastructure.
 - Cloud just provides an API
 - Cloud computing works using economies of scale:
 - It potentially lowers the outlay expense for start up companies, as they would no longer need to buy their own software or servers.
 - Cost would be by on-demand pricing.
 - Vendors and Service providers claim costs by establishing an ongoing revenue stream.
 - Data and services are stored remotely but accessible from “anywhere”.

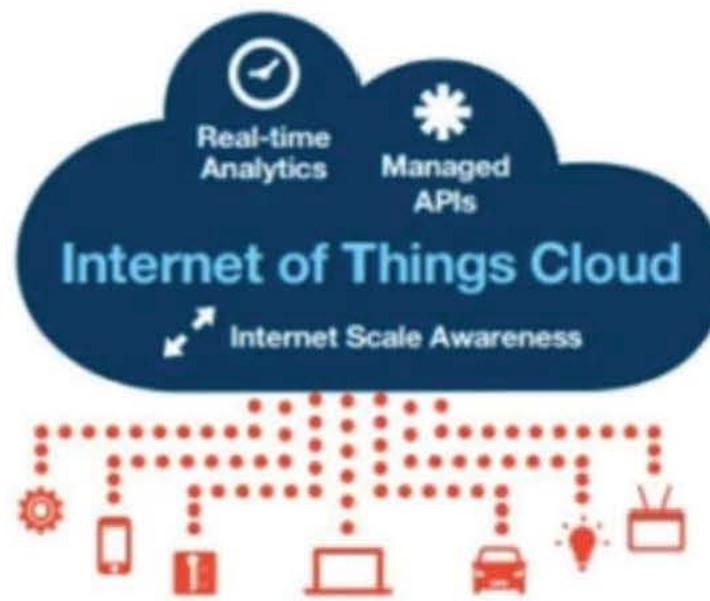
Lowering Cost

- You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
- Since applications run in the cloud, not on the a local server, your server does not need the processing power or hard disk space demanded by traditional desktop software.
- When you are using web-based applications, your server can be less expensive, with a smaller hard disk, less memory, more efficient processor...
- In fact, your server does not need software programs to be loaded and no document files need to be saved.

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Improved Performance



- With few large programs hogging your computer's memory, you will see better performance from your servers.
 - You may actually not need servers at all :)
- Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory...

Reduced Software Costs

- Instead of purchasing expensive software applications, you can get most of what you need for free-ish!
 - most cloud computing applications today, such as the Google Docs suite.
- better than paying for similar commercial software
 - which alone may be justification for switching to cloud applications.

Instant Software Updates

- Instant software updates:
 - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
 - When the application is web-based, updates happen automatically
 - available the next time you log into the cloud.
 - When you access a web-based application, you get the latest version
 - without needing to pay for or download an upgrade.

IoT Interoperability



- Device independence.
 - You are no longer tethered to a single computer or network.
 - Changes to computers, applications and documents follow you through the cloud.
 - Move to a portable device, and your applications and documents are still available.