Welcome to the Cloud!

Tribal Data Workshop
April 10 – 11, 2018
CRITFC
Portland, OR

Goals of this Tutorial

- Examine the impact cloud computing is having across industries and geographies
- Introduce the concept and utility of a *virtual machine*
- Explain how virtual machines are the enabling technology for cloud computing
- Demonstrate the technological and economic advantages of cloud computing
- Demonstrate how cloud computing enables fully fault tolerant systems
- Recommend cloud computing usage models for the tribes and ITMD project
- Demonstrate the economics advantages of having a cloud data center

Agenda

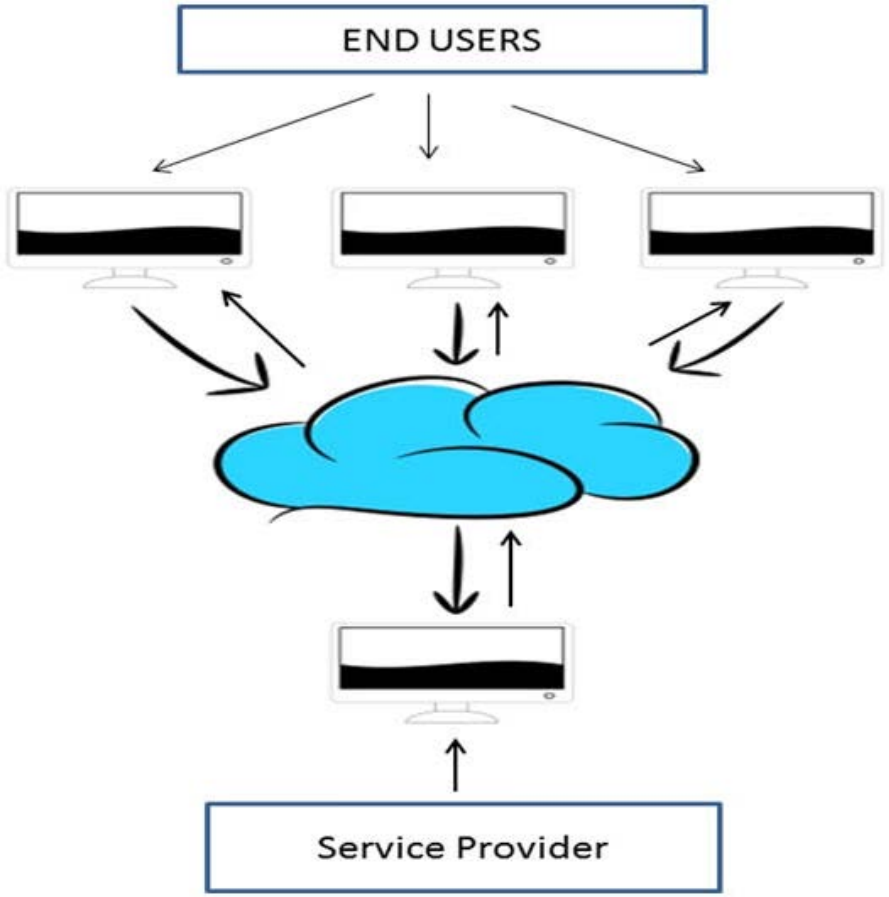
- Basic facts about the cloud
- Structure of the cloud
- VMs, hypervisors, and virtualization, oh my!
- Fault tolerance
- Advantages of cloud computing
- How can ITMD and the tribes use the cloud?
- How to learn more

Official Definition

According to the official **NIST definition**, "**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 ... Oct 25, 2011

Final Version of NIST Cloud Computing Definition Published
www.**nist**.gov/itl/csd/**cloud**-102511.cfm

Why is it called “cloud computing”?



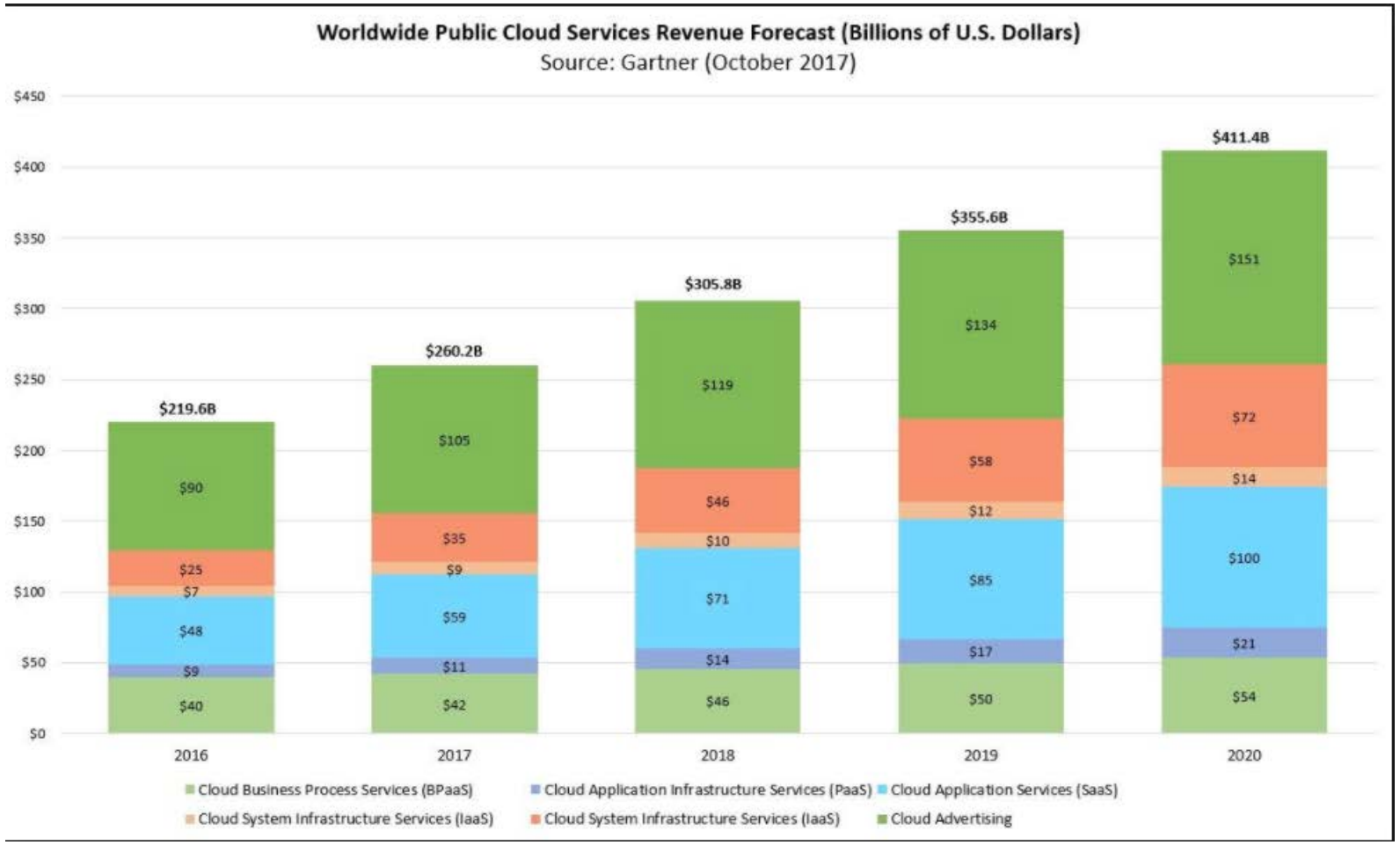
Some Examples of the Impact of the Cloud

- Educational institutions leverage cloud technology for its ability to:
  - let students access data anywhere, anytime
  - enroll in online classes
  - participate in group activities
- It benefits developing countries since:
  - they no longer have the burden of investing in costly infrastructures
  - because they can tap into data and applications available in the cloud
- The healthcare industry is embracing this technology:
  - managing non-siloed patient data to provide better access to medical records
  - sharing data among different parties such as medical professionals or patients checking their own status
  - cloud data can be accessed through common devices such as mobile phones or tablets

Some Examples of the Impact of the Cloud

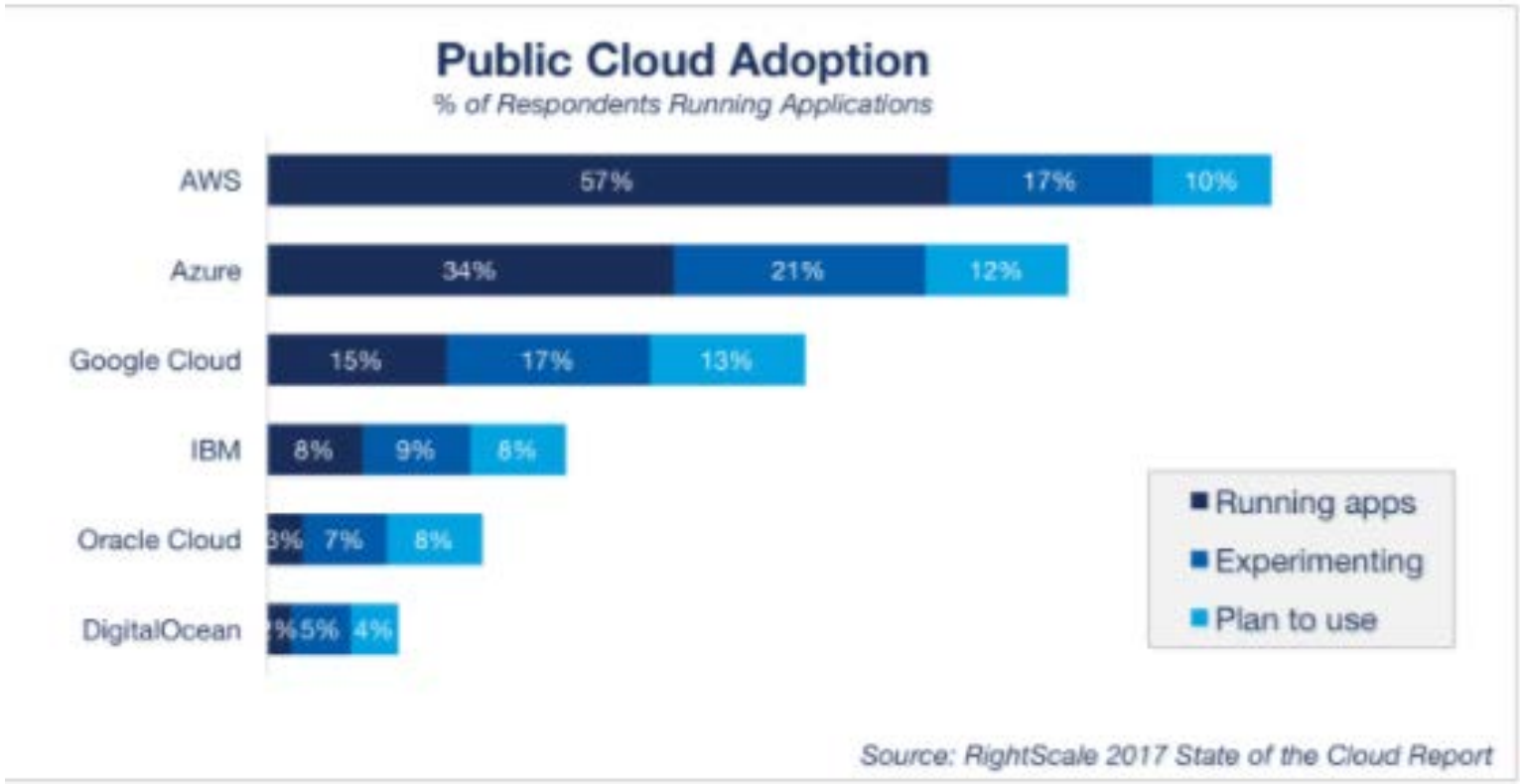
- Corporate CTOs are using the cloud to:
  - minimize risk of internal outages
  - mitigate the complexity of housing network and computing devices in-house
  - both of which lower the cost of IT organizations
- Major cloud technology companies invest billions of dollars per year in cloud R&D, e.g., in 2011 Microsoft committed 90 percent of its $9.6 billion R&D budget to its cloud

Cloud Computing is Growing Exponentially Fast



Cloud revenues are growing at about 17% per year.

Adoption of the Cloud



From Forbes Magazine

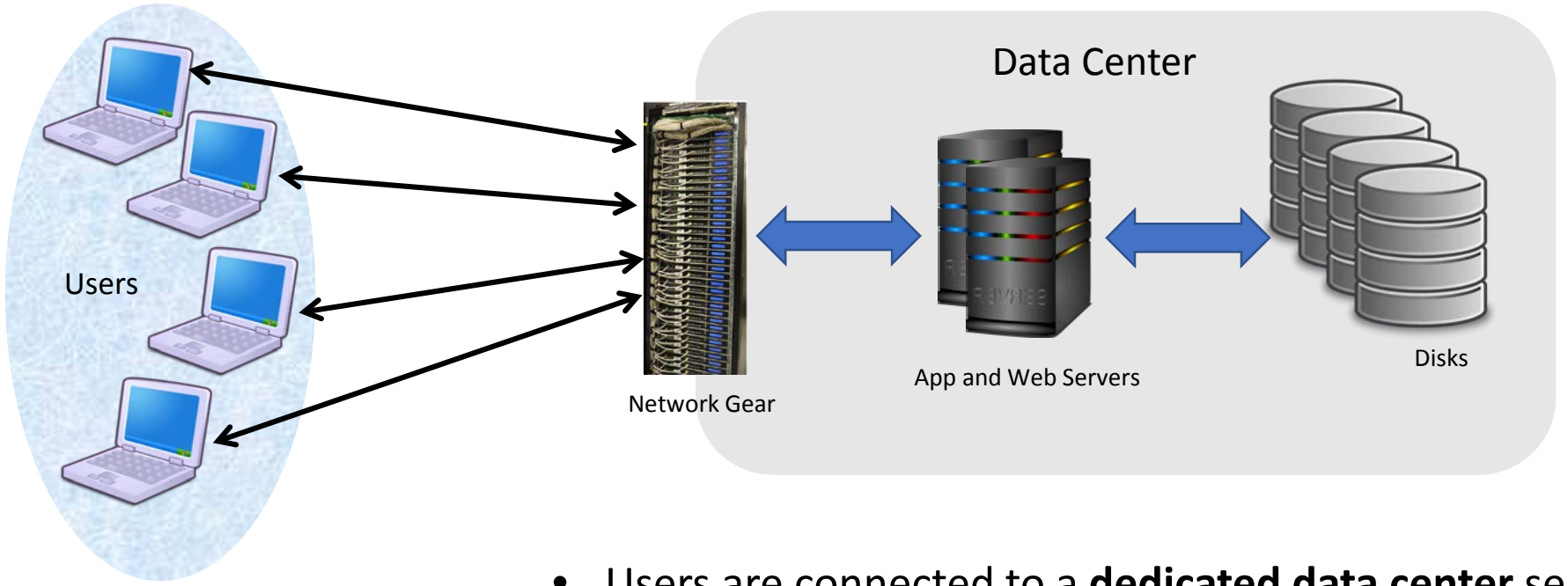
2017 State Of Cloud Adoption And Security

Louis Columbus, CONTRIBUTOR
FULL BIO

Opinions expressed by Forbes Contributors are their own.

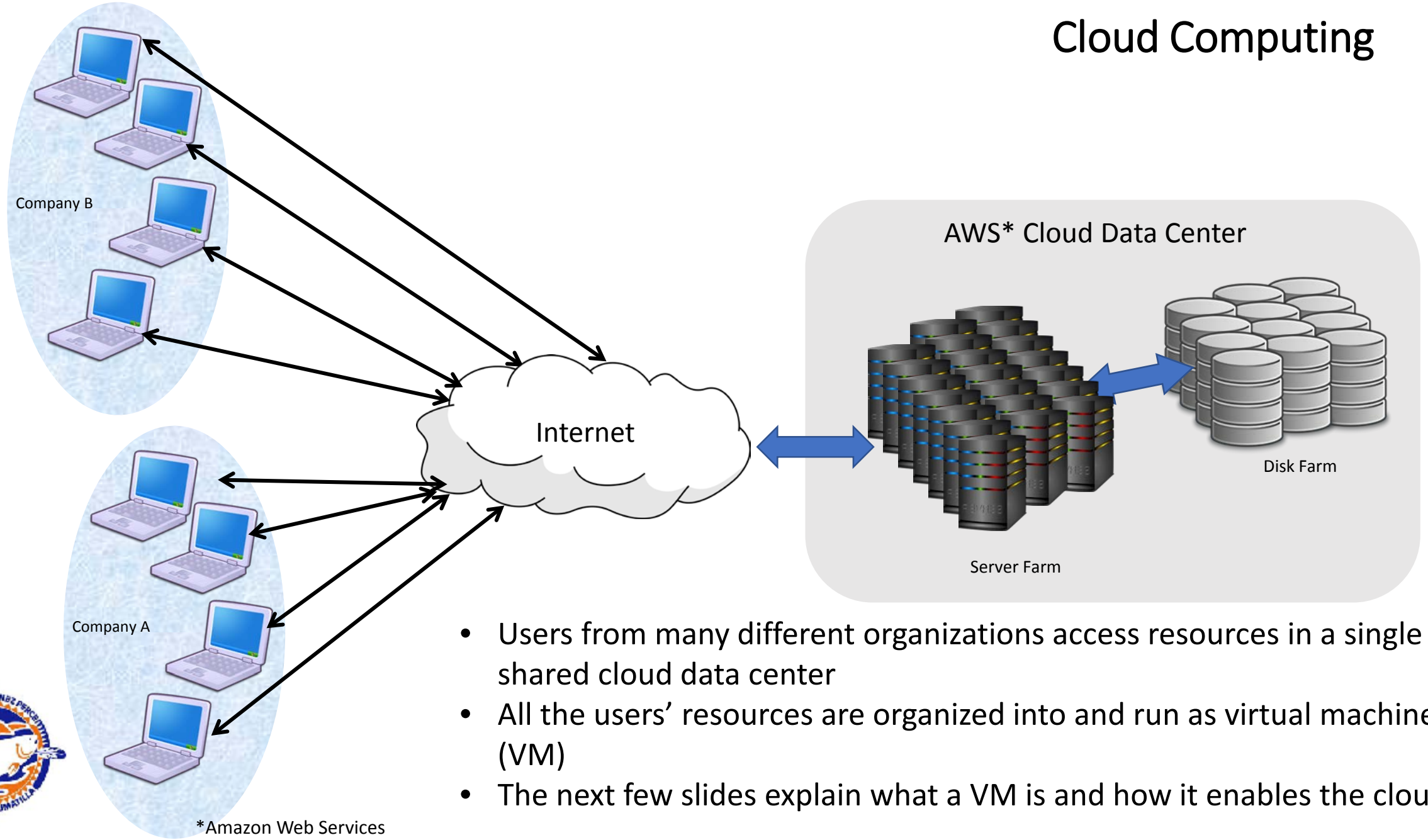
- Hybrid cloud adoption grew 3X in the last year, increasing from 19% to 57% of organizations surveyed.
- In 15 months, 80% of all IT budgets will be committed to cloud solutions.
- 73% of companies are planning to move to a fully software-defined data center within 2 years.
- 49% of businesses are delaying cloud deployment due to a cybersecurity skills gap.

Conventional Computing



- Users are connected to a **dedicated data center** serving *only* one business and its partners
- An example: FedEx runs a worldwide data center in Memphis (including its own air traffic control center) to manage its shipping network

Cloud Computing

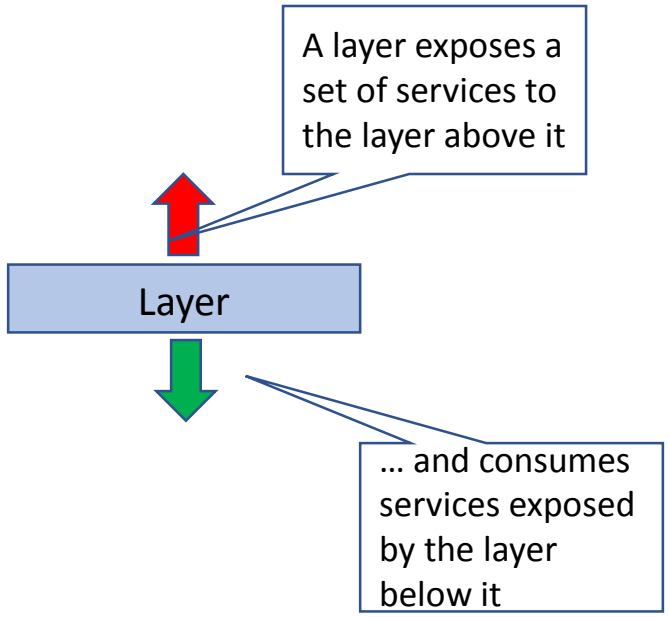


- Users from many different organizations access resources in a single shared cloud data center
- All the users' resources are organized into and run as virtual machines (VM)
- The next few slides explain what a VM is and how it enables the cloud

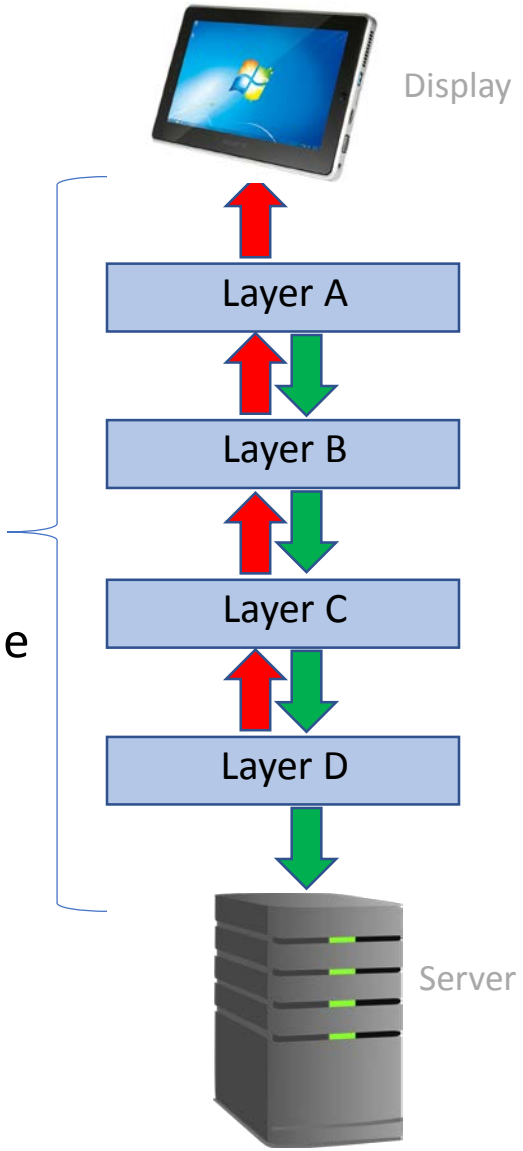
*Amazon Web Services

How Software is Built … in 30 seconds

Software is built in layers

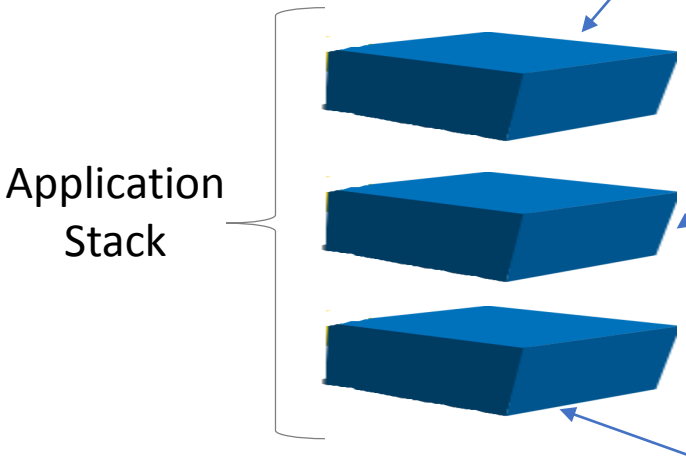


Layers are stacked on each other to create applications
(often referred to as “the application stack”)



Basic Application Architecture

Here is a simplified view of how an application is built



Application Software (app)

- Excel
- Powerpoint

Adds application knowledge that consumes the services of the OS to solve domain problems, i.e., calculating a trip route

Operating System (OS)

- Windows
- Unix
- IOS

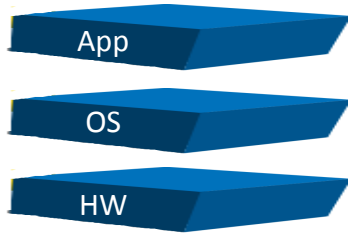
Provides logical services to the application – paints screens, prints files, searches disks, etc. so it manages the physical resources and provides the services to exploit them

Hardware (HW)

- Dell
- IBM
- Apple

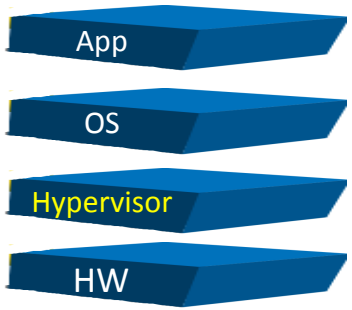
Controls raw computational power, provides physical interfaces to devices and networks, and manages memory

Architecture of a Virtualized Application



There is a problem with the ordinary stack:

- If you want to move an application from one physical location to another:
  - The OS could be different (or simply at a different release level)
  - The HW could be different
- Changes to either could require *major* adjustments to the code and/or configuration data (this is known as “redeployment”)
- Redeployment can take many months of work by many people
- Using the traditional stack makes it hard to move applications around physically



Virtualization solves this by adding one more layer to the stack: the “*hypervisor*”

- The hypervisor sits between the OS layer and the HW
- The hypervisor provides a “virtual machine” i.e., a simulation of actual hardware to the OS layer

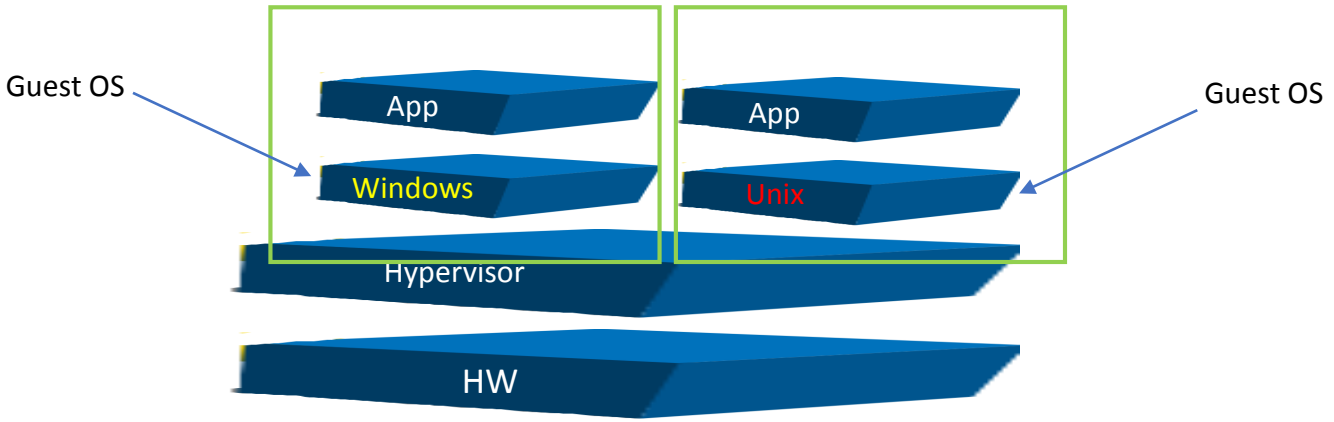
What is the *hypervisor*?

"A *hypervisor* is a hardware virtualization technique that **allows multiple guest operating systems (OS) to run on a single host system at the same time.** The guest OS shares the hardware of the host computer, such that each OS appears to have its own processor, memory and other hardware resources."

Techopedia

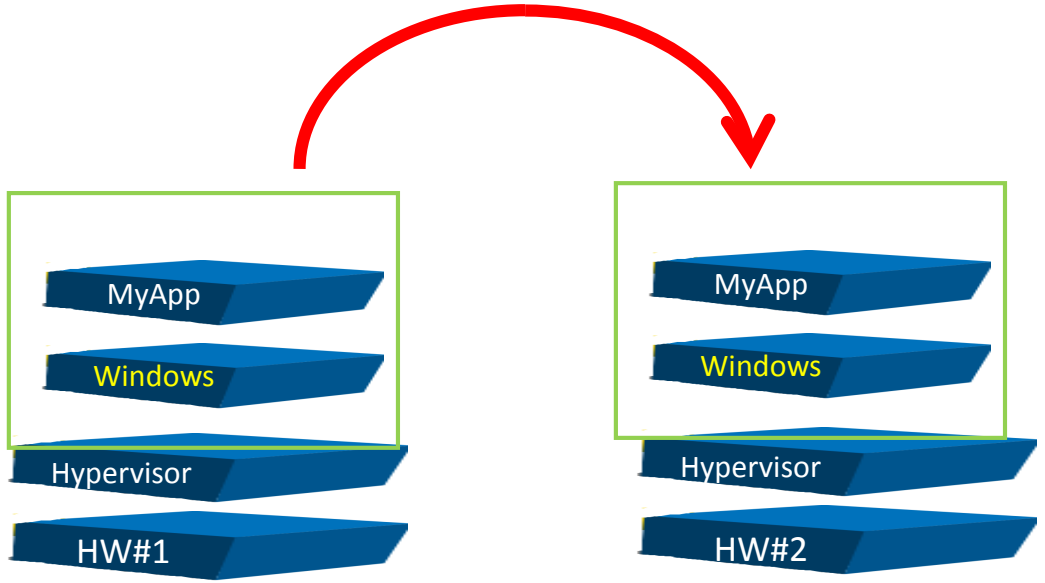
(explained on next slide)

Mixing Guest OSs on a Single HW Server



- Conceptually, the ☐ represents a VM
- VMs physically exist as files
- VMs depending on different OSs can reside and run on the same physical machine sharing the actual physical resources

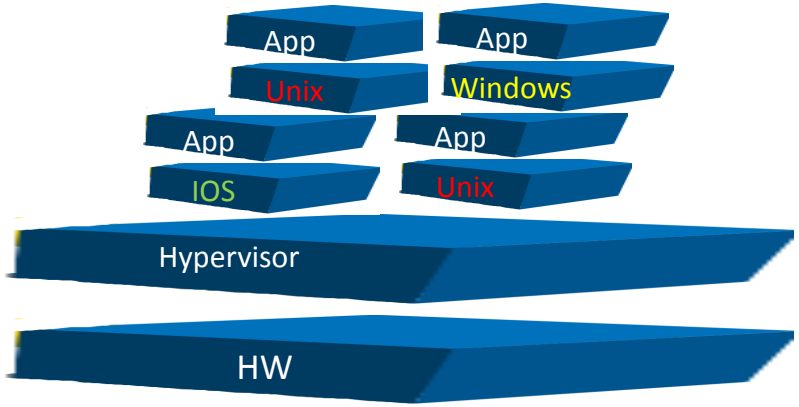
What VMs Do Better



- VMs make it possible to move an application from one hardware platform to another without code or configuration changes
- The ability to use VM's like this is the basis of cloud computing

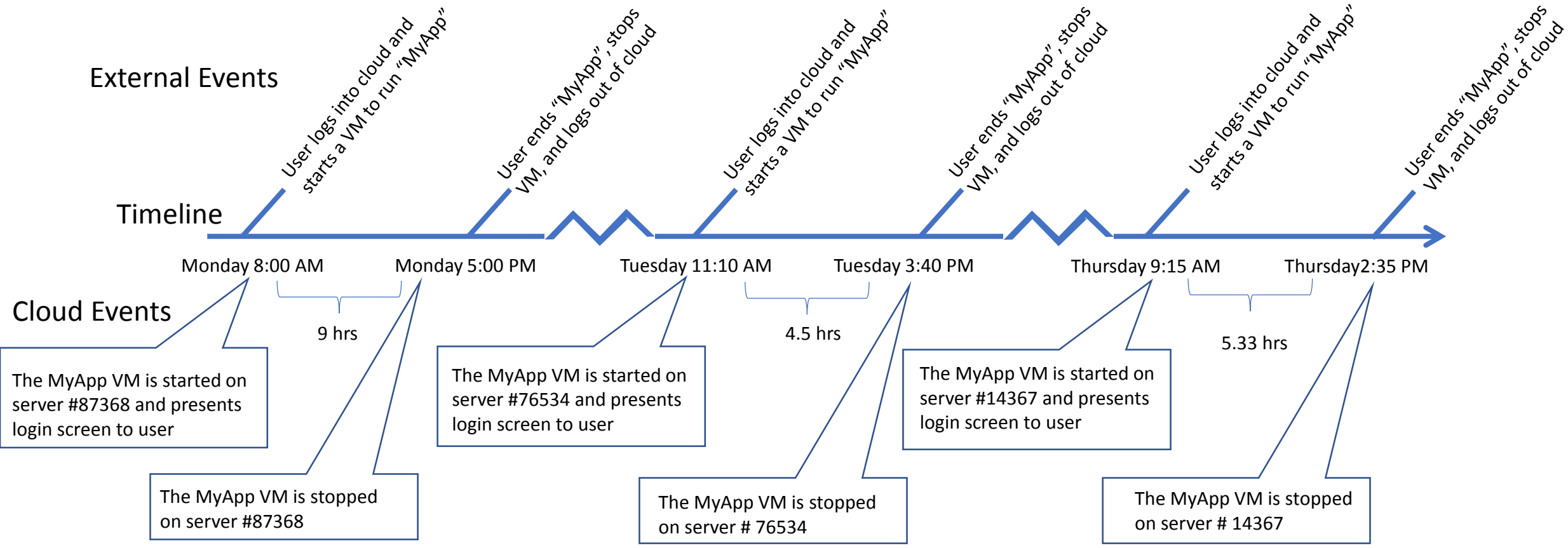
What VMs Do Better

In a cloud data center, many VMs can share the same physical hardware



- A hypervisor can simultaneously run many VMs
- The HW processor may be better utilized by multiple VMs rather than a single application
- Cloud data centers (CDC) assign a VM to a server based on availability at the time the VM is loaded
- CDC load balance demand across their entire server cluster

Economies of the Cloud



- Total elapsed time: 78 hrs 35 min but in the cloud you only pay for actual usage: 18 hrs 20 min
- Each time app was started on a different available physical server – potentially in different data centers and/or countries and this is done automatically by the cloud (or not)
- Contrast with running your own data center and having dedicated machines running 24 hours a day
- And, you may be sharing the server with many other peoples' VMs which makes it even more economical

VM versus Physical Machine: Technology

Physical Machine

- Relocation difficult - downtime to make moves
- Upgrading software also requires downtime and lots of prep time
- Machines require physical maintenance which is downtime typically
- Hardware failures cause unanticipated user downtime
- Disasters can completely cripple a data center and therefore an enterprise which depends on it
    - Fire
    - Earthquake
    - ???

VM versus Physical Machine: Technology

Virtual Machine

- VMs are files, easy to relocate or duplicate remotely
- VMs do not have hardware dependencies
- VMs are insulated from:
  - Other VMs
  - Hardware changes
- VMs running on different OSs can reside on the same physical machine:
  - Allows consolidation of servers
  - Cloud data centers can be fault tolerant (more on this later)

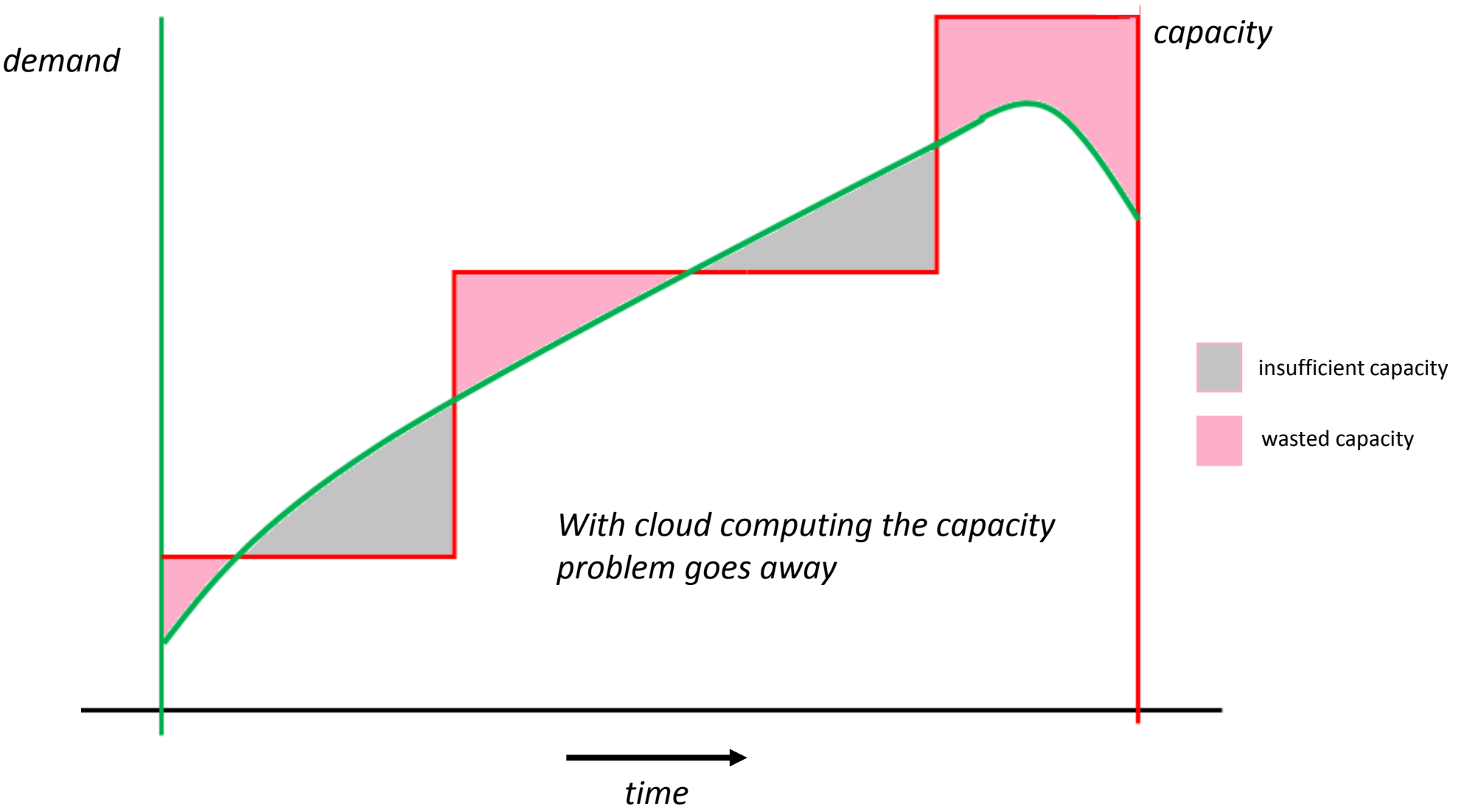
VM versus Physical Machine: Economics

- Physical Machine
  - Machines must be replaced every few years
  - Machines must reside in a data center with AC, “clean” power, fire suppression equipment, … and must be staffed
  - Software requires significant expense to pay for support and upgrades
  - Backups have to be carefully managed
  - Achieving fault tolerance is very difficult and expensive requiring duplication of hardware -- a complete duplicate data center may even be required
  - Redeployments are time consuming and costly
  - Data centers cost money 24 hours a day every day and typically have unused “growth factors” baked in

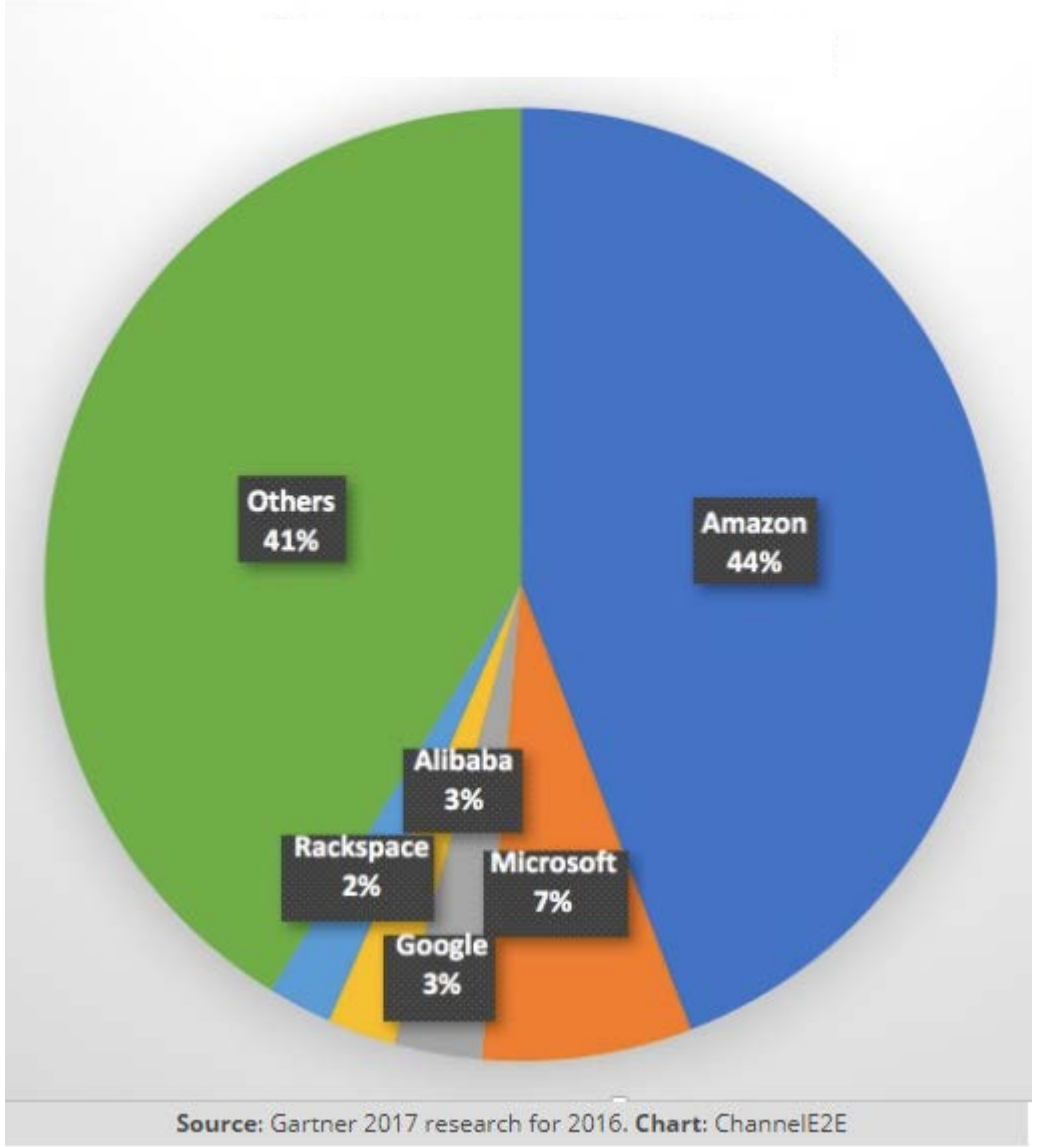
VM versus Physical Machine: Economics

- Virtual Machine
  - No hardware required
  - No software maintenance costs
  - No on-site data center required
  - Software upgrades can be instant
  - Fault tolerance is baked into the cloud
  - Backup tools exist to create appropriate backup schemes easily
  - Redeployments are extremely easy
  - Fewer technical skills need to be hired
  - You *only* pay for the actual time you use – no guessing the capacity needed

The Capacity Problem



Cloud Computing Market Share



- Since Amazon is the world leader in cloud services, we'll talk about AWS (Amazon Web Services) in this presentation
- Other major players include:
  - Microsoft's Azure
  - Google Web Services

AWS Products

Explore Our Products

Compute | Storage | Database | Migration | Networking & Content Delivery

Amazon EC2
Virtual Servers in the Cloud

Amazon EC2 Auto Scaling
Scale Compute Capacity to Meet Demand

Amazon Elastic Container Service
Run and Manage Docker Containers

Amazon Elastic Container Service for Kubernetes
Run Managed Kubernetes on AWS

Amazon Elastic Container Registry
Store and Retrieve Docker Images

Amazon Lightsail
Launch and Manage Virtual Private Servers

AWS Batch
Run Batch Jobs at Any Scale

AWS Elastic Beanstalk
Run and Manage Web Apps

AWS Fargate
Run Containers without Managing Servers or Clusters

AWS Lambda
Run your Code in Response to Events

AWS Serverless Application Repository
Discover, Deploy, and Publish Serverless Applications

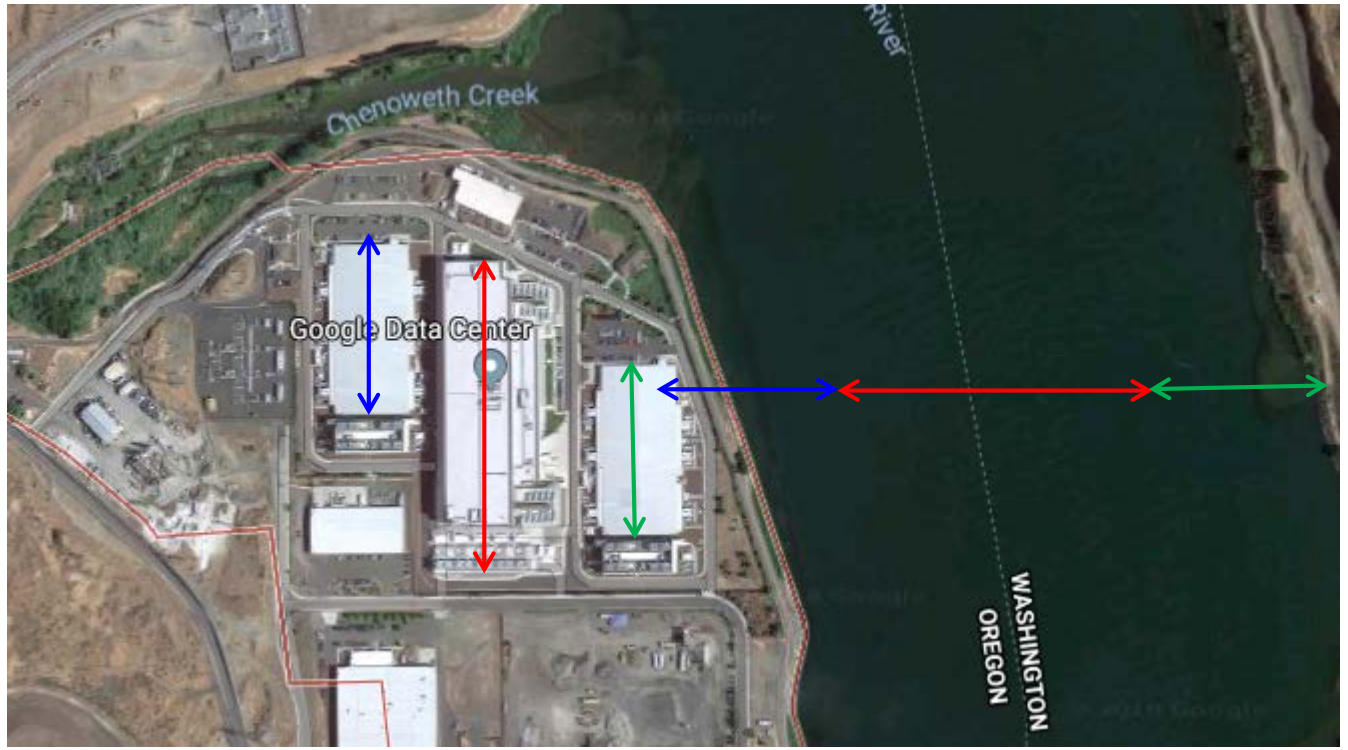
VMware Cloud on AWS
Build a Hybrid Cloud without Custom Hardware

Developer Tools | Management Tools | Media Services | Security, Identity & Compliance | Analytics

Machine Learning | Mobile Services | AR & VR | Application Integration | Customer Engagement

Business Productivity | Desktop & App Streaming | Internet of Things | Game Development

Cloud Data Centers: big, big, big



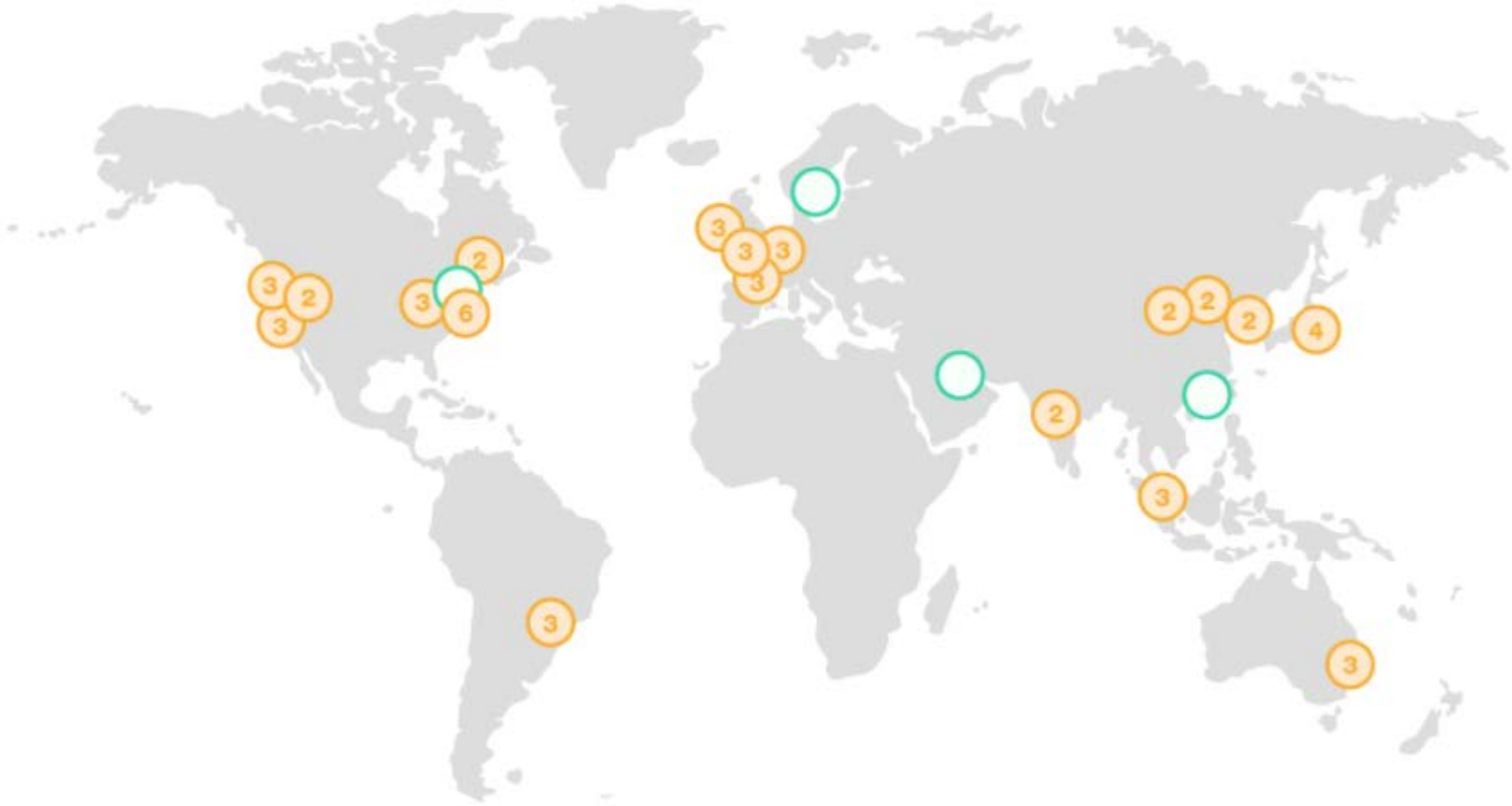
Crtl+click for tour of Amazon Data Center infrastructure layer

Crtl+click for tour of Amazon Data Center data layer

Google Cloud Data Center, The Dalles, OR

Colored lines compare combined length of buildings to the width of the river to give a sense of scale

AWS Global Infrastructure



Region & Number of Availability Zones

New Region (coming soon)

AWS Likes Oregon

COMPANIES > AMAZON

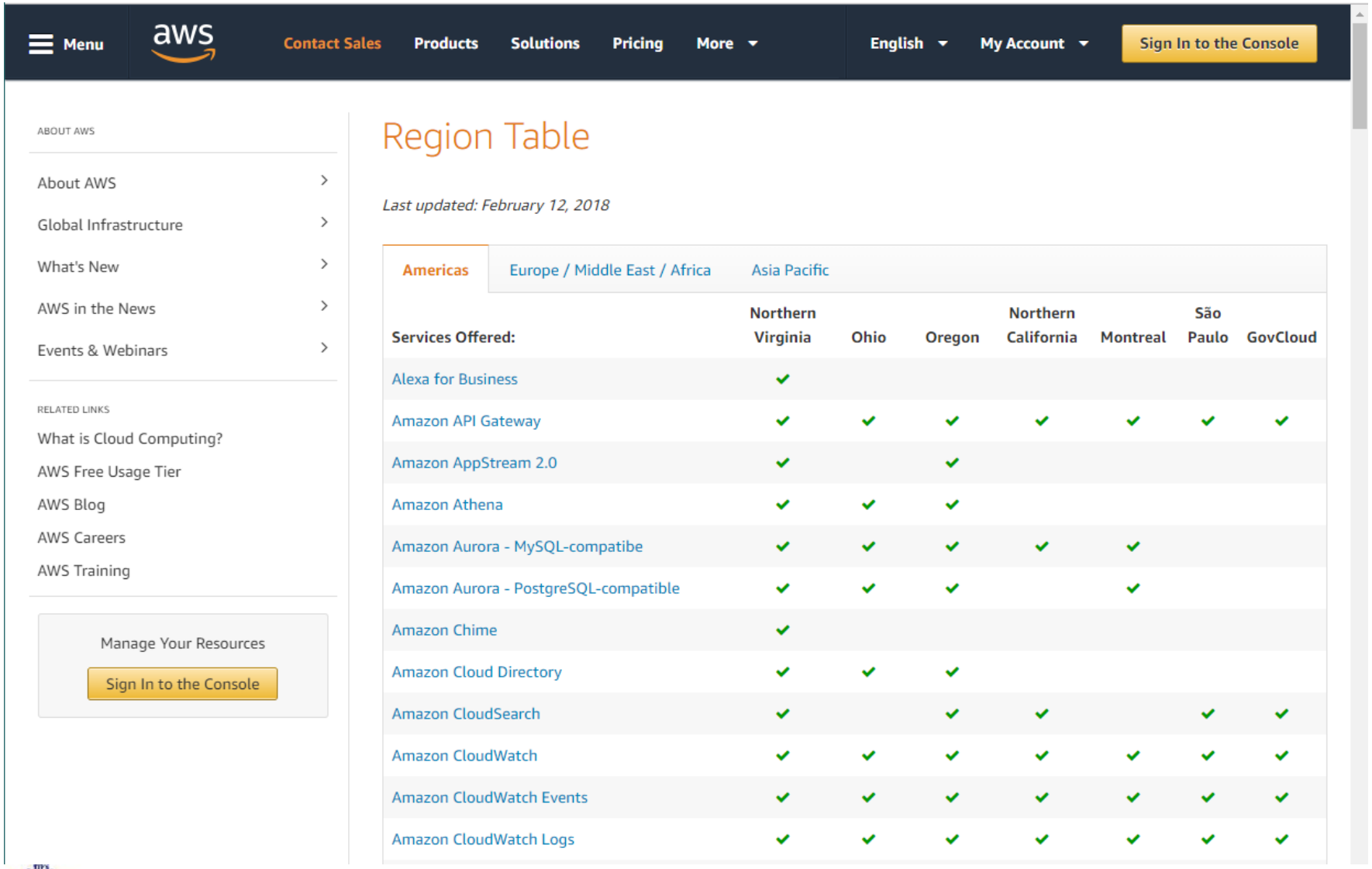
Amazon Looks to Build Ninth Oregon Data Center

Company has plans to build 120-acre data center park in Umatilla County

Karen Riccio | Mar 21, 2017

The cloud pavilion of Amazon Web Services at the 2016 CeBIT tech fair in Hanover, Germany (Photo by Sean Gallup/Getty Images)

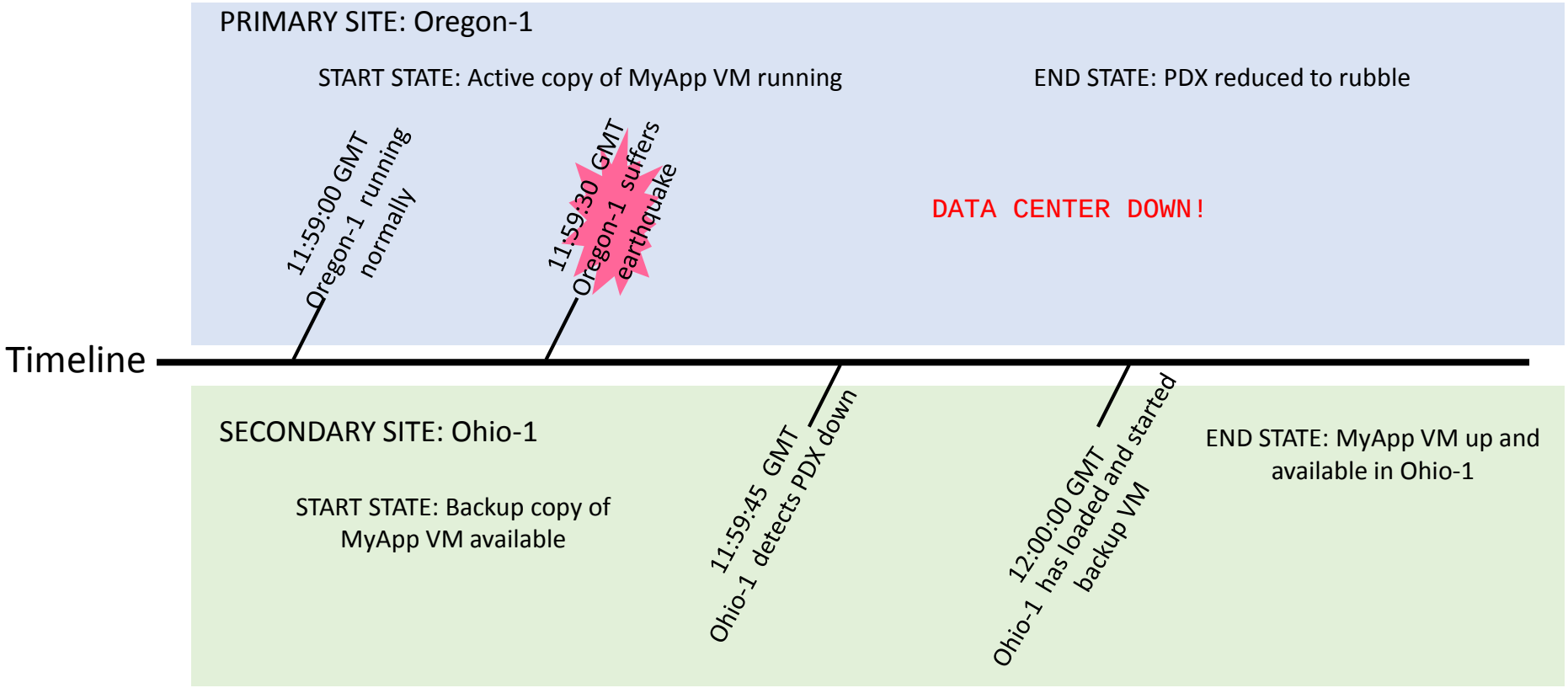
AWS Regions



Services Offered:	Northern Virginia	Ohio	Oregon	Northern California	Montreal	São Paulo	GovCloud
Alexa for Business	✔						
Amazon API Gateway	✔	✔	✔	✔	✔	✔	✔
Amazon AppStream 2.0	✔		✔				
Amazon Athena	✔	✔	✔				
Amazon Aurora - MySQL-compatibe	✔	✔	✔	✔	✔		
Amazon Aurora - PostgreSQL-compatible	✔	✔	✔		✔		
Amazon Chime	✔						
Amazon Cloud Directory	✔	✔	✔				
Amazon CloudSearch	✔		✔	✔		✔	✔
Amazon CloudWatch	✔	✔	✔	✔	✔	✔	✔
Amazon CloudWatch Events	✔	✔	✔	✔	✔	✔	✔
Amazon CloudWatch Logs	✔	✔	✔	✔	✔	✔	✔

This is slightly out of date

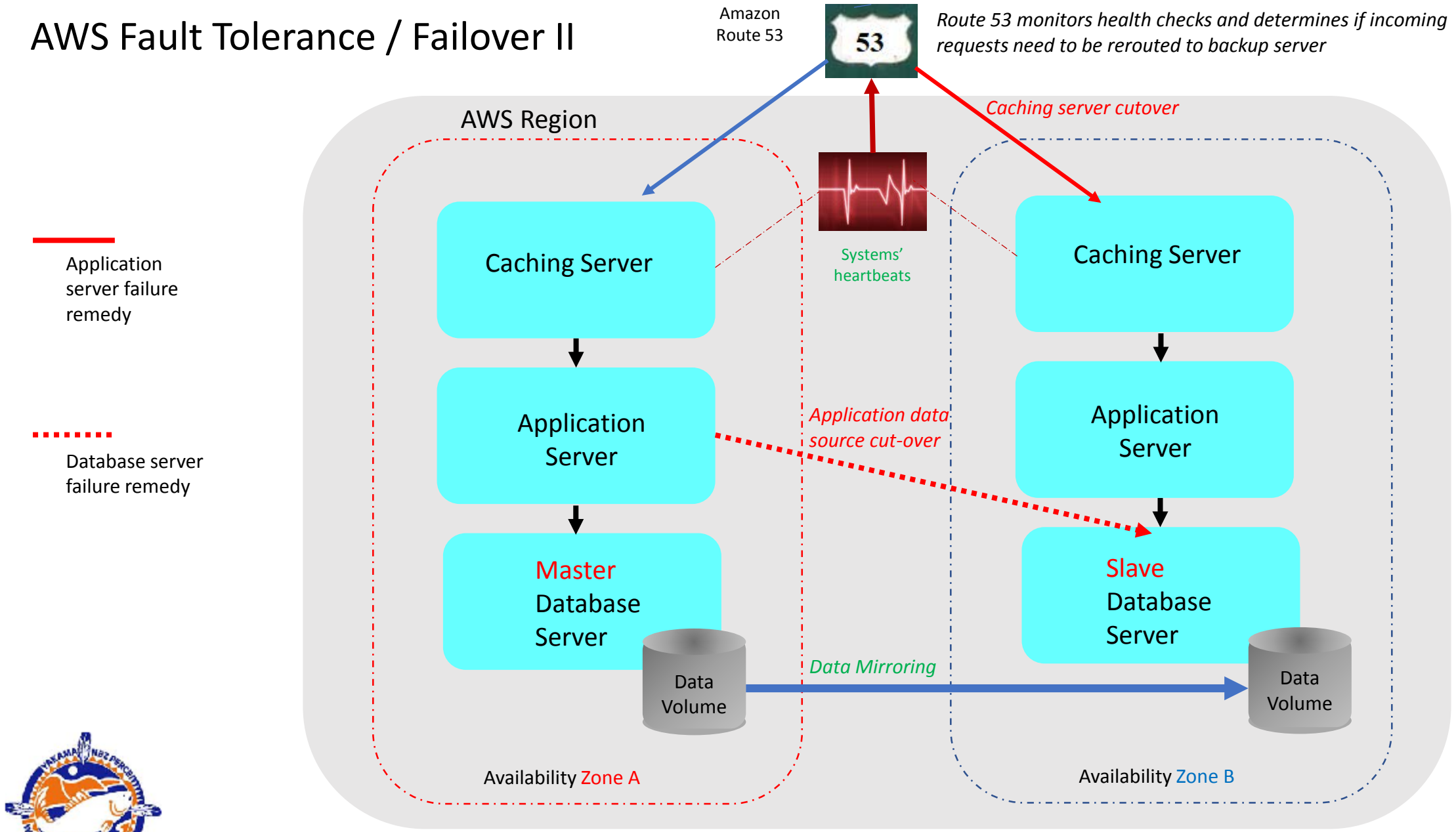
Fault Tolerance / Failover



BTW:

- Setting up fault tolerance is a very, very difficult problem in traditional data centers so most companies don't do it
- And, it is very expensive to do since it involves buying or leasing duplicate hardware and software -- which may never actually be used!

AWS Fault Tolerance / Failover II



Security and the AWS Cloud

- All of the guest OS/database security features are present and active
- Additionally, the AWS hypervisor/products implement many security features of their own. Here is a small sampling:
  - An application cannot access raw disk blocks
  - Every block of storage freed by an app is wiped clean before being recycled
  - When an app release some memory, the memory is wiped before being reassigned elsewhere
  - System admins must login with multi-factor authentication (e.g., password and emailed key)
  - Use of secure shell (SSH) or remote desktop requires public key/private key authentication
  - Firewalls are mandatory and customer must specifically open ports to inbound traffic
  - Data stored in Amazon EBS volumes is redundantly stored in multiple physical locations as part of normal operation
  - AWS provides ability to encrypt entire storage volumes with AES-256
  - SQL Server Enterprise Edition is available on AWS VMs and it supports encryption of entire databases

… and there many other security features

Six Advantages and Benefits of Cloud Computing

Trade capital expense for variable expense

Instead of having to invest heavily in data centers and servers before you know how you're going to use them, you can only pay when you consume computing resources, and only pay for how much you consume.

Benefit from massive economies of scale

By using cloud computing, you can achieve a lower variable cost than you can get on your own. Because usage from hundreds of thousands of customers are aggregated in the cloud, providers such as Amazon Web Services can achieve higher economies of scale which translates into lower pay as you go prices.

Stop guessing capacity

Eliminate guessing on your infrastructure capacity needs. When you make a capacity decision prior to deploying an application, you often either end up sitting on expensive idle resources or dealing with limited capacity. With cloud computing, these problems go away. You can access as much or as little as you need, and scale up and down as required with only a few minutes notice.

Increase speed and agility

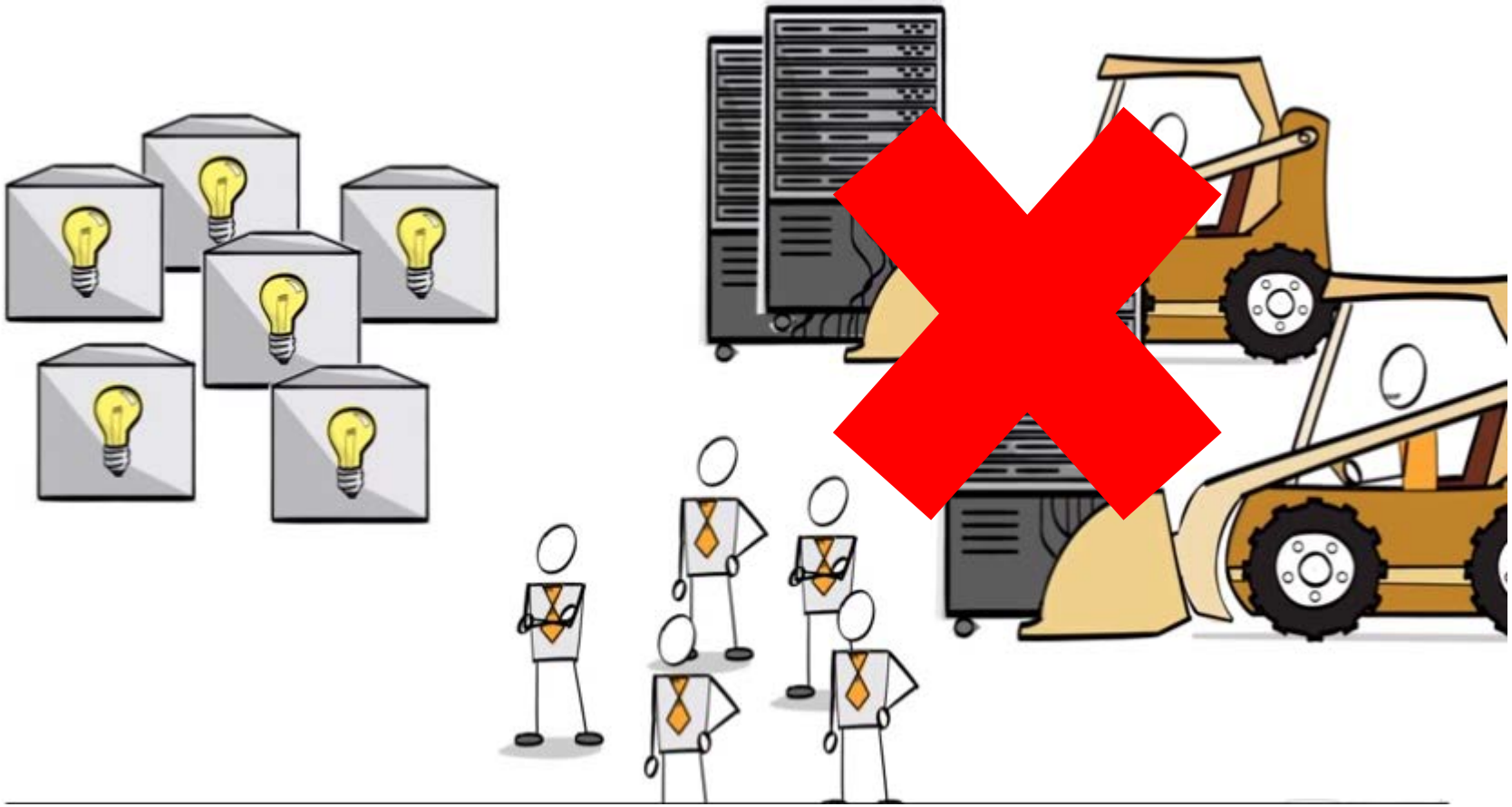
In a cloud computing environment, new IT resources are only ever a click away, which means you reduce the time it takes to make those resources available to your developers from weeks to just minutes. This results in a dramatic increase in agility for the organization, since the cost and time it takes to experiment and develop is significantly lower.

Stop spending money on running and maintaining data centers

Focus on projects that differentiate your business, not the infrastructure. Cloud computing lets you focus on your own customers, rather than on the heavy lifting of racking, stacking and powering servers.

Source: AWS web page

Another way to look at it



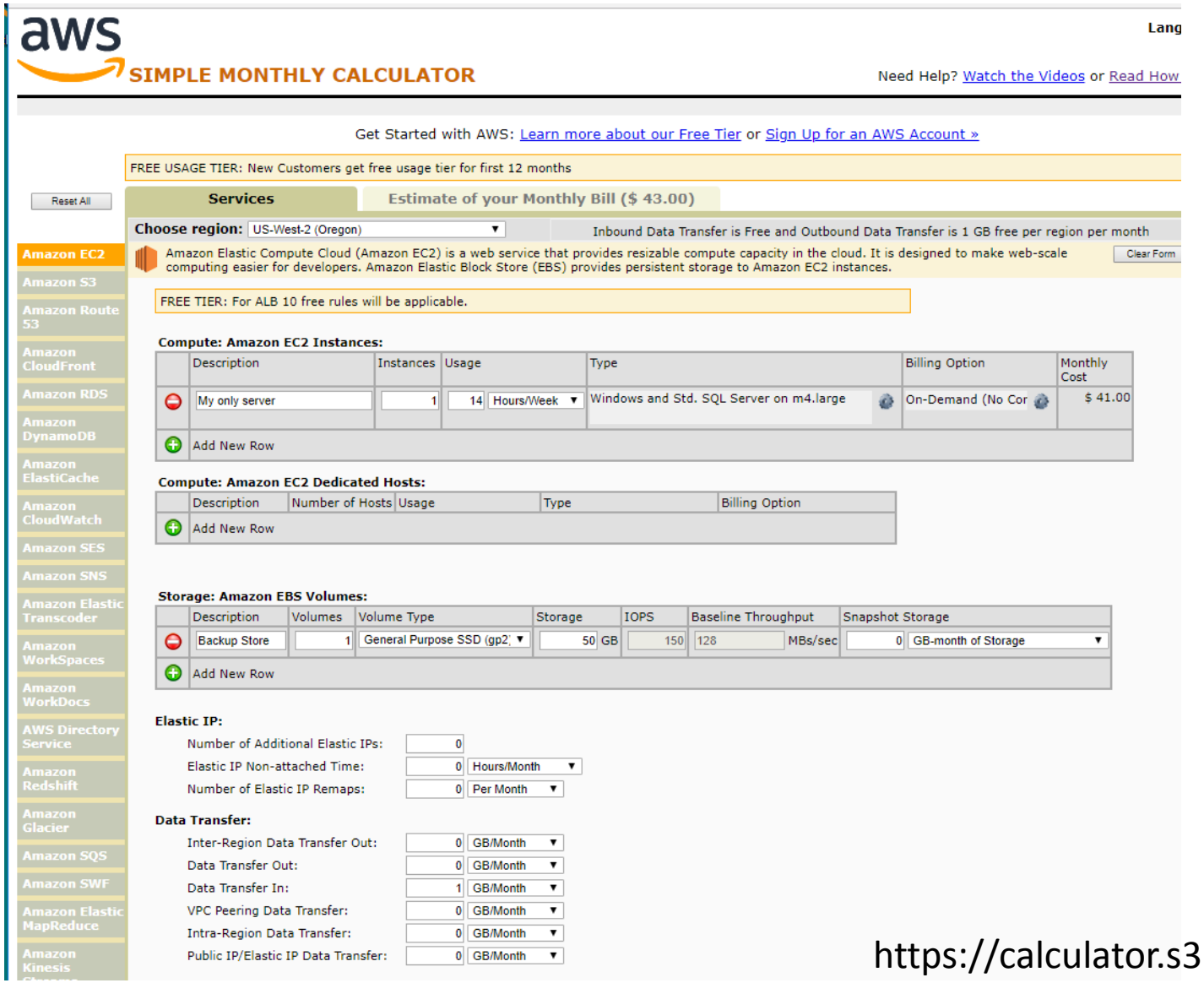
- The cloud eliminates costs associated with building and deploying new assets
- Assets are available on demand and disappear when your release them
- Costs are reduced by economy of scale and sharing of assets

Source: AWS graphic

ITMD and Cloud Computing

- How could CRITFC and the tribes benefit from the cloud?
  - Back data up in the cloud
  - Create an entire backup data center in the cloud
    - Could be used in times of disaster
    - Remember: only pay for what you actually use
    - Forest fire? Earthquake?
  - Or, just move entire data center into the cloud
    - Much cheaper than maintaining physical data center
    - Better security
    - Can’t run out of capacity
    - Don’t have to deal with maintenance issues (except for on site PC’s)
    - Don’t have to have down time due to equipment failure
    - Need fewer technical skills, AWS has that expertise

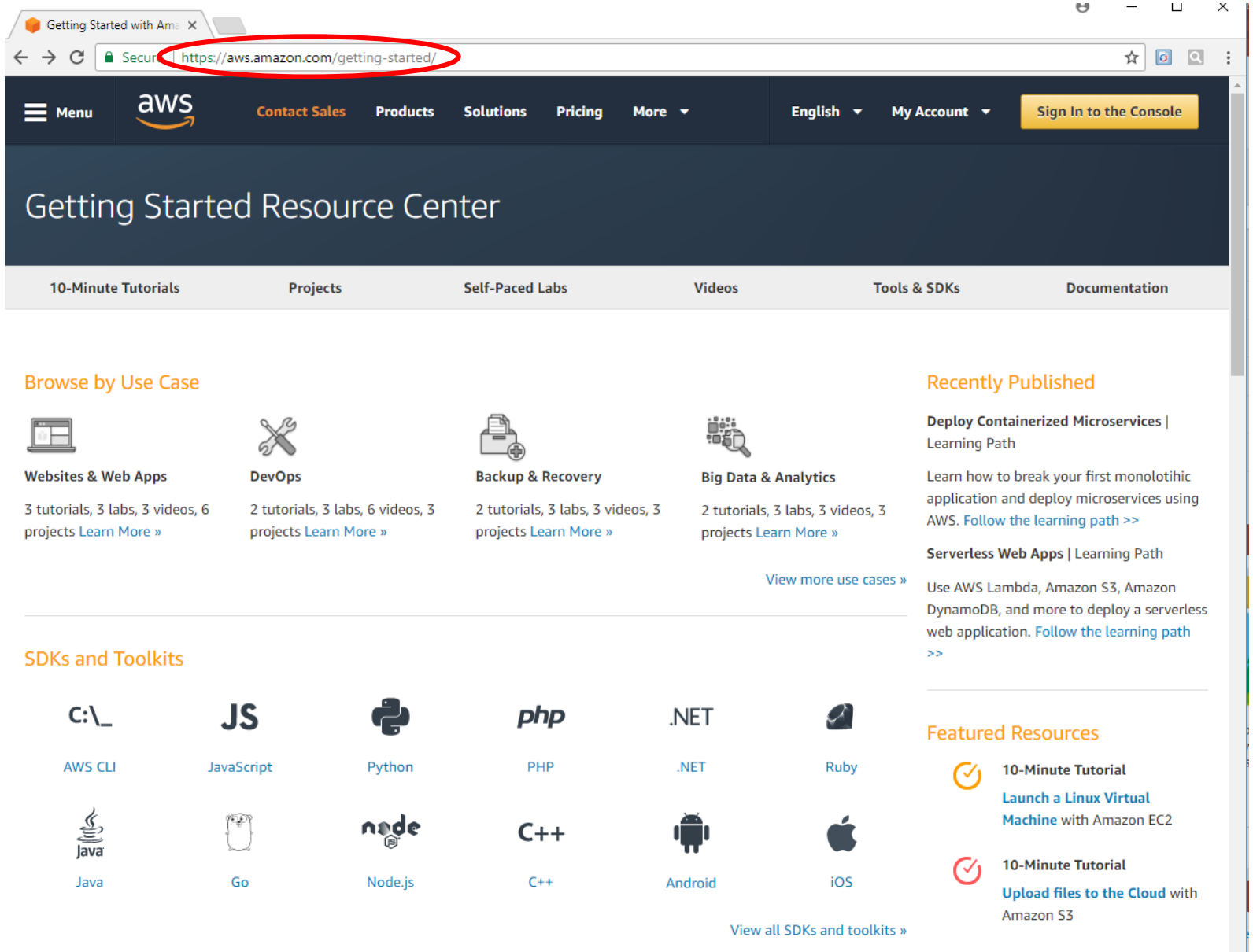
What Does It Cost?



https://calculator.s3.amazonaws.com/index.html

To Learn More

BTW Amazon will give you a free account for one year to help you learn AWS!



Questions, please…