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EE4221: CLOUD COMPUTING

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THE FUNDAMENTAL IDEA OF THE CLOUD

**Why do it yourself if you can
find someone to do it for you?**

OUTLINE

- Cloud Computing Characteristics
- Cloud Deployment Models – Private, Public, Hybrid and Community Cloud
- Cloud Services – IaaS, PaaS, and SaaS
- Cloud Computing Economics
- Opportunities and Challenges

WHAT IS THE “CLOUD”?

Examples:

- CityU Email (Microsoft Outlook Web App) is in the cloud
- Gmail is in the cloud
- iPhone's backup is in the cloud
- Dropbox's data is in the cloud
- Amazon (AWS) EC2 and S3 are the cloud
- Google App Engine is the cloud
- Windows Azure is the cloud

WHAT IS CLOUD COMPUTING?

From Wikipedia:

- Cloud computing, or something being in the cloud, is an expression used to describe a variety of different types of computing concepts that involve **a large number of computers connected through a real-time communication network such as the Internet.**
- In science, cloud computing is a synonym for **distributed computing over a network** and means the ability to **run a program on many connected computers at the same time.**
- The phrase is also more commonly used to refer to **network-based services** which appear to be provided by real server hardware, which in fact are served up by **virtual hardware**, simulated by software running on one or more real machines.
- Such **virtual servers** do not physically exist and can therefore be moved around and scaled up (or down) on the fly without affecting the end user—arguably, rather **like a cloud.**

CHARACTERISTICS (GENERAL)

- “Pay as you use”, like utility service (water/electricity/gas)
- Pay operating expense not capital expense
- “Infinite” capacity
- Scale up or down on demand
- Share resources and costs across a large pool of users (reduce cost)
- Adding or removing computer resources do not affect users

MORE ON CHARACTERISTICS (CONT'D)

- *On-demand self-service*

A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

- *Broad network access*

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

MORE ON CHARACTERISTICS (CONT'D)

○ *Resource pooling*

- The provider's computing resources are pooled to serve multiple consumers
- Resources can be dynamically assigned and reassigned according to customer demand
- Customer generally may not care where the resources are physically located but should be aware of risks if they are located offshore

MORE ON CHARACTERISTICS (CONT'D)

○ *Rapid elasticity*

- Capabilities can be expanded or released automatically (i.e., more CPU power, or ability to handle additional users)
- To the customer this appears seamless, limitless, and responsive to their changing requirements

○ *Measured service*

- Customers are charged for the services they use and the amounts
- There is a metering concept where customer resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service

CLOUD DEPLOYMENT MODELS

- Private cloud
- Public cloud
- Community cloud
- Hybrid cloud

PRIVATE CLOUD

- Private cloud is cloud infrastructure operated solely for a single organization, whether managed internally or by a third-party and hosted internally or externally.
- Undertaking a private cloud project requires a significant level and degree of engagement to virtualize the business environment, and requires the organization to re-evaluate decisions about existing resources.
- When done right, it can improve business, but every step in the project raises **security** issues that must be addressed to prevent serious vulnerabilities. They have attracted criticism because users "still have to buy, build, and manage them" and thus do not benefit from less hands-on management". (Is it worth doing?)

Source: Wikipedia

PUBLIC CLOUD

- A cloud is called a 'Public cloud' when the services are rendered over a network that is open for public use.
- Technically there may be little or no difference between public and private cloud architecture, however, **security** consideration may be substantially different for services (applications, storage, and other resources) that are made available by a service provider for a public audience and when communication is effected over a non-trusted network.
- Generally, public cloud service providers like Amazon Web Services , Microsoft and Google own and operate the infrastructure and offer access only via Internet (direct connectivity is not offered).

Source: Wikipedia

COMMUNITY CLOUD

- Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party and hosted internally or externally.
- The costs are spread over fewer users than a public cloud (but more than a private cloud), so only some of the cost savings potential of cloud computing are realized.

Source: Wikipedia

HYBRID CLOUD

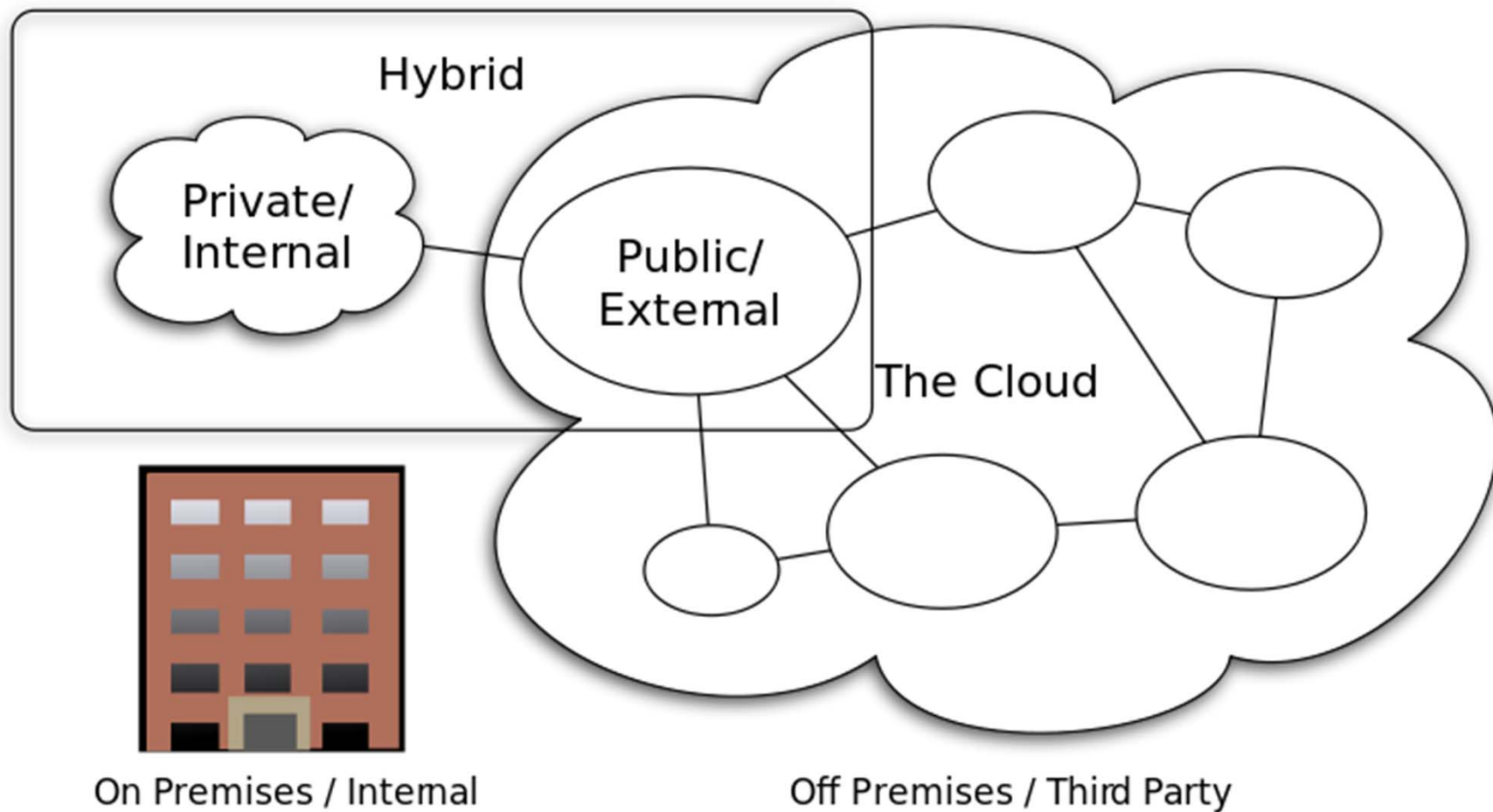
- Hybrid cloud is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models.
- Such composition expands deployment options for cloud services, allowing IT organizations to use public cloud computing resources to meet temporary needs.
- This capability enables hybrid clouds to employ cloud bursting for scaling across clouds.
- Cloud bursting is an application deployment model in which an application runs in a private cloud or data center and "bursts" to a public cloud when the demand for computing capacity increases. A primary advantage of cloud bursting and a hybrid cloud model is that an organization only pays for extra compute resources when they are needed.

Source: Wikipedia

HYBRID CLOUD (CONT'D)

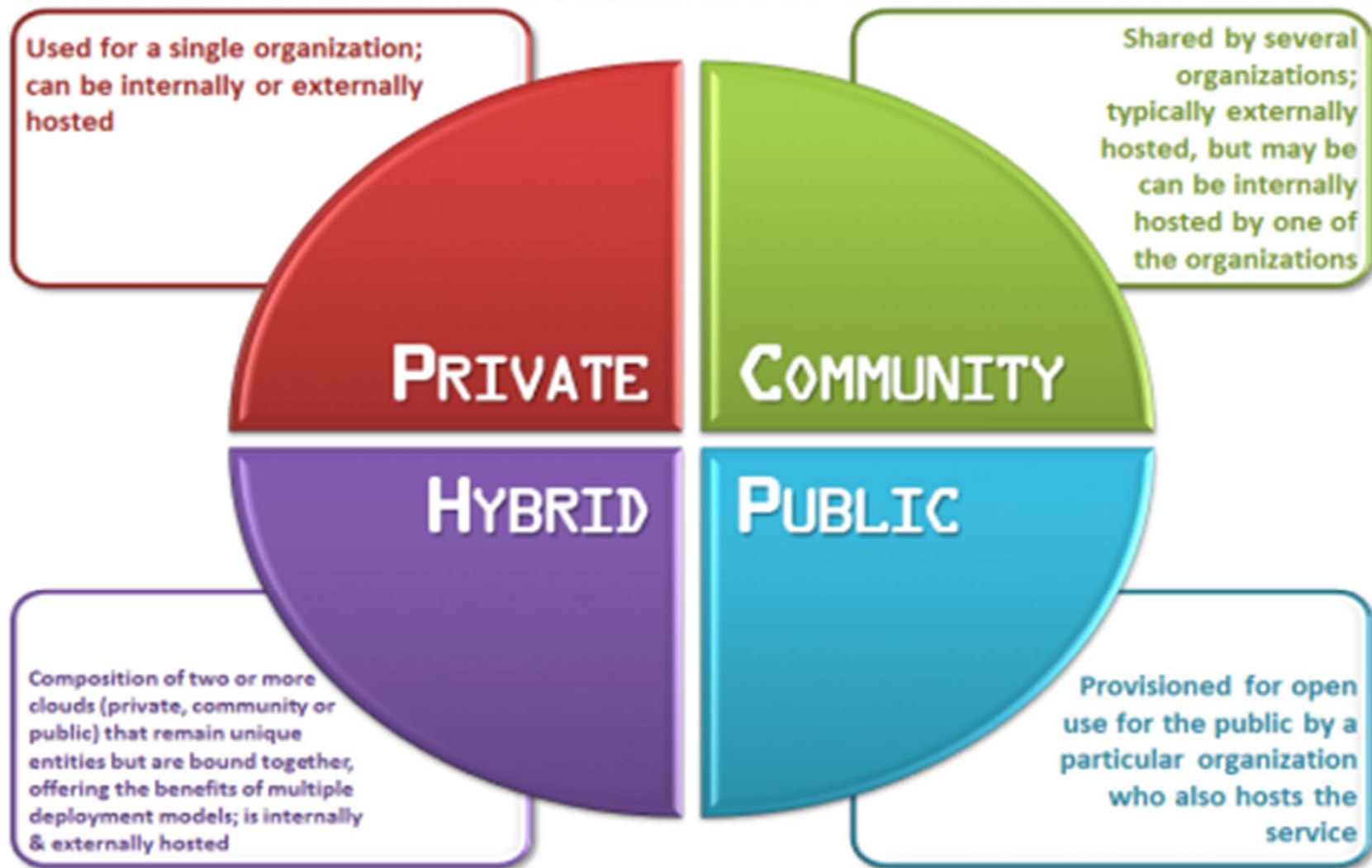
- Cloud bursting enables data centers to create an in-house IT infrastructure that supports average workloads, and use cloud resources from public or private clouds, during spikes in processing demands.
- By utilizing "hybrid cloud" architecture, companies and individuals are able to obtain degrees of fault tolerance combined with locally immediate usability without dependency on internet connectivity.
- Hybrid cloud architecture requires both on-premises resources and off-site (remote) server-based cloud infrastructure.
- Hybrid cloud provides the flexibility of in house applications with the fault tolerance and scalability of cloud based services.

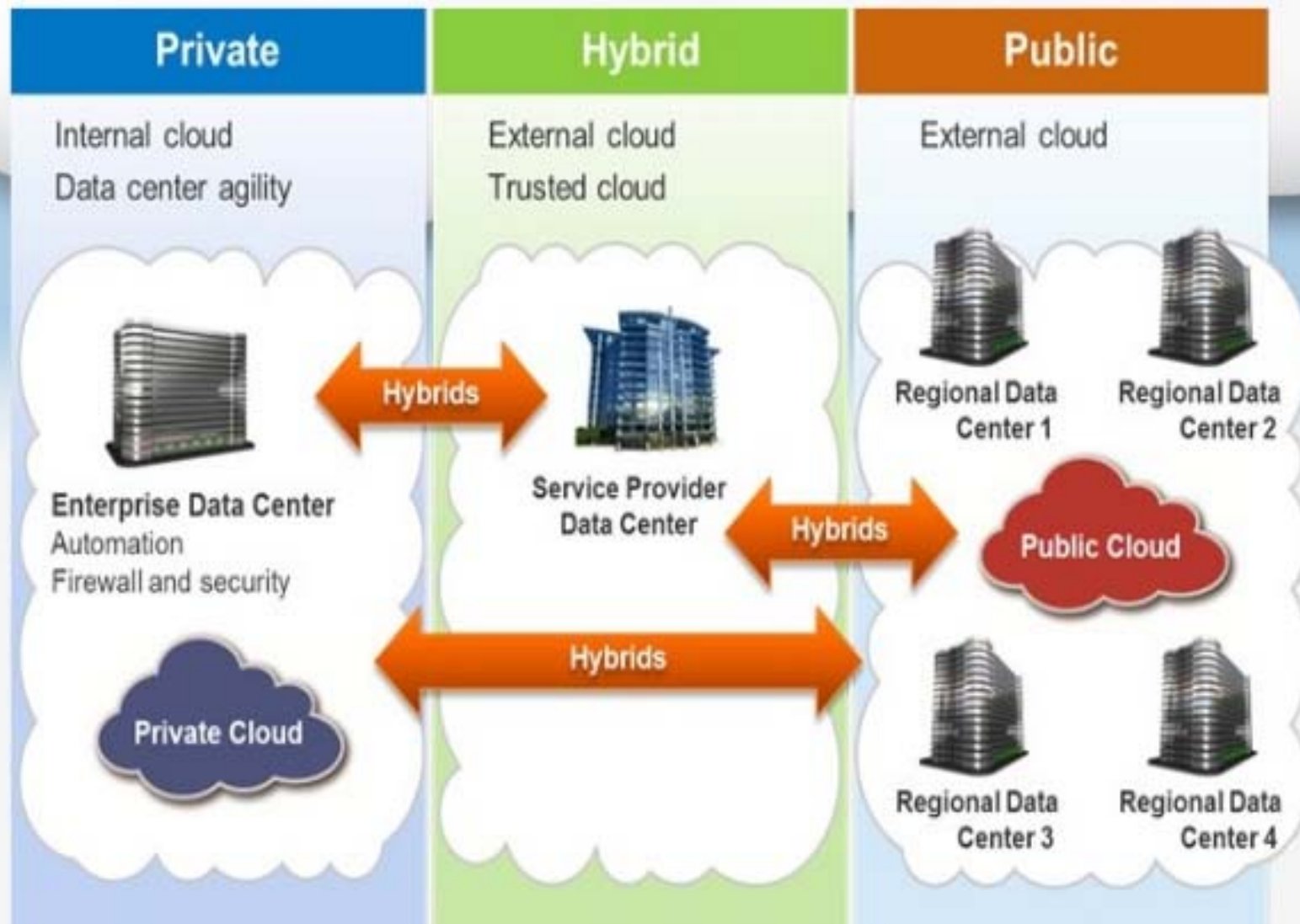
Source: Wikipedia



Cloud Computing Types

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<http://www.slideshare.net>

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CLOUD SERVICES

- **Infrastructure as a service (IaaS)**
- **Platform as a service (PaaS)**
- **Software as a service (SaaS)**

Recall the fundamental idea of the cloud:

“Why do it yourself if you can find/pay someone to do it for you?”

- **The key difference of those services depends on how much you would like the cloud to do it for you.**

SERVICE MODELS

Infrastructure-as-a-Service (IaaS)

- A service model that involves outsourcing the basic infrastructure used to support operations--including storage, hardware, servers, and networking components.
- The service provider owns the infrastructure equipment and is responsible for housing, running, and maintaining it. The customer typically pays on a per-use basis.
- Examples : Amazon EC2, Windows Azure, Rackspace.
- The customer outsources **hardware infrastructure** and uses their own **software infrastructure** (Windows, Unix), and **applications**

Source: the slide is form Madhav Panwar with some modification

SERVICE MODELS

Platform-as-a-Service (PaaS)

- A service model that involves outsourcing the basic infrastructure and platform (Windows, Unix)
- PaaS facilitates deploying applications without the cost and complexity of buying and managing the underlying hardware and software where the applications are hosted.
- Examples : AWS Elastic Beanstalk, Heroku, Force.com, Google App Engine.
- **The customer outsources hardware infrastructure and software infrastructure but uses their own applications**

Source: the slide is form Madhav Panwar with some modification

SERVICE MODELS

Software-as-a-Service (SaaS)

- Also referred to as “software on demand,” this service model involves outsourcing the infrastructure, platform, and software/applications.
- Typically, these services are available to the customer for a fee, pay-as-you-go, or a no charge model.
- The customer accesses the applications over the Internet.
- You don't need to worry about the installation, setup and running of the application. Service providers will do that for you. You just have to pay and use it through some clients.
- Examples : Google Apps, Microsoft Office 365.
- **The customer outsources all hardware infrastructure, software infrastructure and applications**

Source: the slide is form Madhav Panwar with some modification

WHAT WIKIPEDIA SAYS ON: INFRASTRUCTURE AS A SERVICE (IAAS)

- In the most basic cloud-service model, providers of IaaS offer **computers** – physical or (more often) **virtual machines** – and **other resources**.
- IaaS clouds often offer additional resources such as a virtual-machine disk image library, raw (block) and file-based storage, firewalls, load balancers, IP addresses, virtual local area networks (VLANs), and software bundles.
- IaaS-cloud providers supply these resources on-demand from their large pools installed in data centers. For wide-area connectivity, customers can use either the Internet or carrier clouds (dedicated virtual private networks).
- To deploy their applications, **cloud users install operating-system images and their application software** on the cloud infrastructure. In this model, the cloud user patches and maintains the operating systems and the application software. Cloud providers typically bill IaaS services on a utility computing basis: cost reflects the amount of resources allocated and consumed.

Source: Wikipedia

WHAT WIKIPEDIA SAYS ON: PLATFORM AS A SERVICE (PaaS)

- In the PaaS model, cloud providers deliver a **computing platform**, typically including operating system, programming language execution environment, database, and web server.
- **Application developers** can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers.
- With some PaaS offers, the underlying computer and storage resources scale automatically to match application demand so that the cloud user does not have to allocate resources manually.

Source: Wikipedia

WHAT WIKIPEDIA SAYS ON: SOFTWARE AS A SERVICE (SAAS)

- In the business model using software as a service (SaaS), users are provided access to application software and databases.
- Cloud providers manage the **infrastructure** and **platforms** that run the **applications**.
- SaaS is sometimes referred to as "on-demand software" and is usually priced on a pay-per-use basis. SaaS providers generally price applications using a subscription fee.
- In the SaaS model, cloud providers install and operate application software in the cloud and cloud users access the software from cloud clients. Cloud users do not manage the cloud infrastructure and platform where the application runs. This eliminates the need to install and run the application on the cloud user's own computers, which simplifies maintenance and support.

Source: Wikipedia

WHAT WIKIPEDIA SAYS ON: SOFTWARE AS A SERVICE (SAAS): CONT'D

- The pricing model for SaaS applications is typically a monthly or yearly flat fee per user, so price is scalable and adjustable if users are added or removed at any point.
- Proponents claim SaaS allows a business the potential to reduce IT operational costs by outsourcing hardware and software maintenance/support to the cloud provider. This enables the business to reallocate IT operations costs away from hardware/software spending and personnel expenses, towards meeting other goals.
- In addition, with applications hosted centrally, updates can be released without the need for users to install new software. One drawback of SaaS is that the users' data are stored on the cloud provider's server. As a result, there could be unauthorized access to the data.

Source: Wikipedia

SAAS/CLOUD EXAMPLE 1

“Instead of selling you a copy of **Microsoft Word** for US\$300, a cloud computing model would "rent" word processing software to you through the Internet for perhaps 5 dollars a month. You would not install any special software, nor would you be confined to your home machine to use this rented online product. You simply use your modern web browser to login from any web-enabled computer, and you can access your word processing documents in the same way that you would access your Gmail.”

Source: <http://netforbeginners.about.com>

SAAS/CLOUD EXAMPLE 2

“Your small car sales business would not spend thousands of dollars on a **sales database**. Instead, the company owners would "rent" access to a sophisticated online sales database, and all the car salesmen would access that information through their web-enabled computers or handhelds.”

Source: <http://netforbeginners.about.com>

SAAS/CLOUD EXAMPLE 3

“You decide to start a health club in your hometown, and need computer tools for your receptionist, financial controller, 4 salespeople, 2 membership coordinators, and 3 personal trainers. But you do not want the headaches nor the cost of paying part-time IT staff to build and support those computer tools. Instead, you give all your health club staff access to the cloud of the Internet, and rent their **office software** online, which will be stored and supported somewhere in Arizona. You will not need any regular IT support staff then; you will just need occasional contract support to ensure that your hardware is maintained.”

Source: <http://netforbeginners.about.com>

THE BENEFITS OF SAAS/CLOUD COMPUTING

- The primary benefit of Software as a Service is reduced cost for everyone involved. (a Win-Win case!!)
- Software vendors do not have to spend thousands of hours supporting users over the phone... they would simply maintain and repair a single central copy of the product online.
- Conversely, users wouldn't have to shell out the large up-front costs of fully purchasing word processing, spreadsheet, or other end user products. Users would instead pay nominal rental fees to access the large central copy.

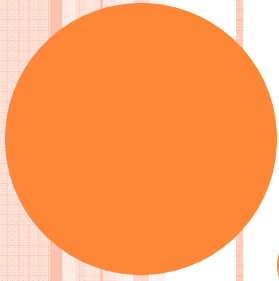
THE DOWNSIDES OF SAAS/CLOUD COMPUTING

- The risk of Software as a Service and cloud computing is that the users must place a high level of trust into the online software vendors that they will not disrupt the service.
- In a way, the software vendor holds its customers "hostage" because all of their documentation and productivity is now in the vendor's hands. ("hybrid cloud" may be a solution!)
- Security and protection of the file privacy becomes even more necessary, as the massive Internet is now part of the business network.

MORE WORDS ON THE BENEFITS AND DOWNSIDES OF SAAS/CLOUD COMPUTING

- When a 600-employee business switches to cloud computing, they must choose their software vendor carefully.
- There will be dramatically-reduced administration cost to use cloud computing software.
- But there will be an increase in the risks of service disruption, connectivity, and online security.
- **Again, “hybrid cloud” may be a solution!!**

Source: <http://netforbeginners.about.com>



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MORE EXAMPLES ON SAAS

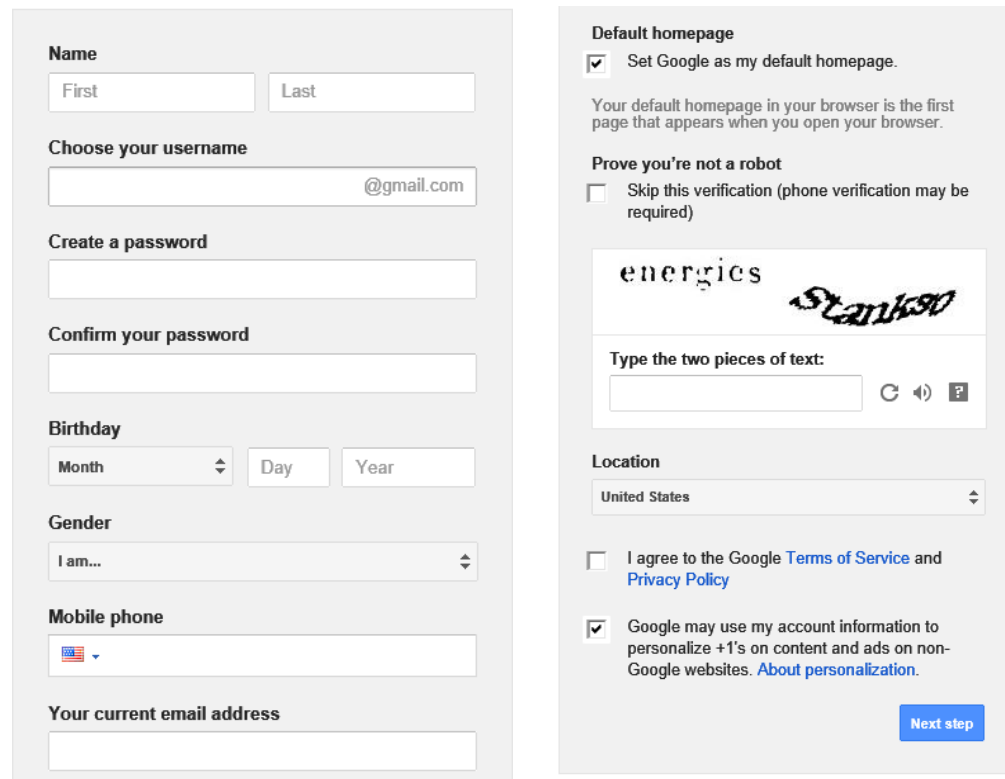
DO YOU USE THE CLOUD?



Source: <http://www.webjunction.org>

THE SAAS/CLOUD REQUIRES: USE GMAIL AS AN EXAMPLE

- An Internet connection
- An account - Created with a user name and a password

A screenshot of the Gmail account creation form. The form is divided into two main sections. The left section contains fields for 'Name' (First and Last), 'Choose your username' (with a '@gmail.com' suffix), 'Create a password', 'Confirm your password', 'Birthday' (Month, Day, Year), 'Gender' (I am...), 'Mobile phone' (with a country code dropdown), and 'Your current email address'. The right section contains 'Default homepage' (Set Google as my default homepage), 'Prove you're not a robot' (Skip this verification), a CAPTCHA image showing the words 'energies' and 'Stankso', 'Location' (United States), and checkboxes for 'I agree to the Google Terms of Service and Privacy Policy' and 'Google may use my account information to personalize +1's on content and ads on non-Google websites'. A 'Next step' button is at the bottom right.

ASK THE QUESTION AGAIN: WHAT IS THE SAAS/CLOUD?



Computing and software resources that are delivered on demand, as service.

(2013, January) A Walk in the Clouds. *Cloud Computing, CDW-G Reference Guide.*, 3-5.

From ground
to cloud

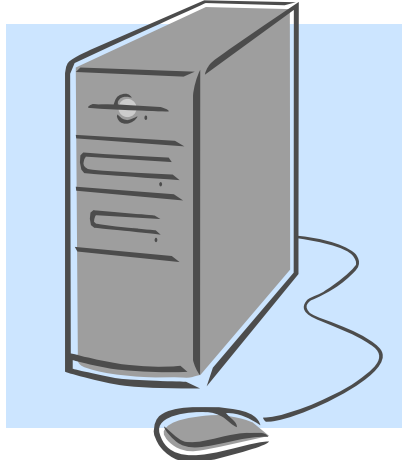
THE BACK STORY

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Source: the slide is from <http://www.webjunction.org>

COMPUTER STORAGE

- Computers have internal or hard drive storage (C: Drive)
- CPU has a drive for storing programs, documents, pictures, videos, presentations, etc...



Standard Computer
Tower or Central
Processing Unit (CPU)



Inside the Computer

Source: the slide is from <http://www.webjunction.org>

INTERNAL STORAGE

- Content is stored on THAT computer
- To use content must return to THAT computer
- Cannot access this content from another device or computer



PROGRAMS

- Purchase programs
- Load to the computer
- Each computer would need the program loaded and stored on the internal drive



EXTERNAL STORAGE

- Allows your content to become mobile
- Save to the storage device
- Take device to any compatible computer
- Open and use content

CD/DVD



Thumb Drive



SD Card



Micro SD Card



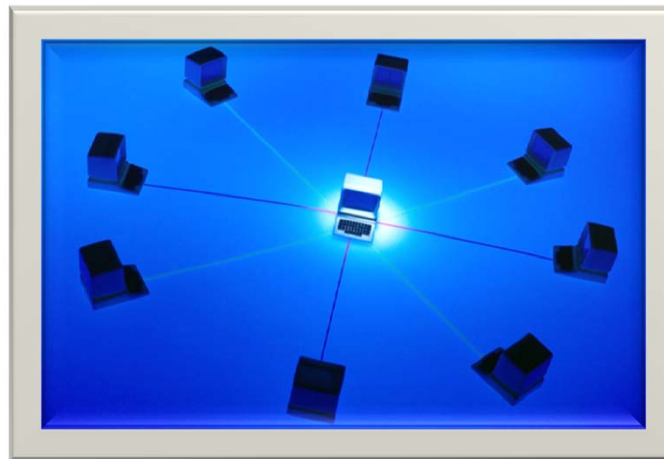
External Hard Drive



Source: the slide is from <http://www.webjunction.org>

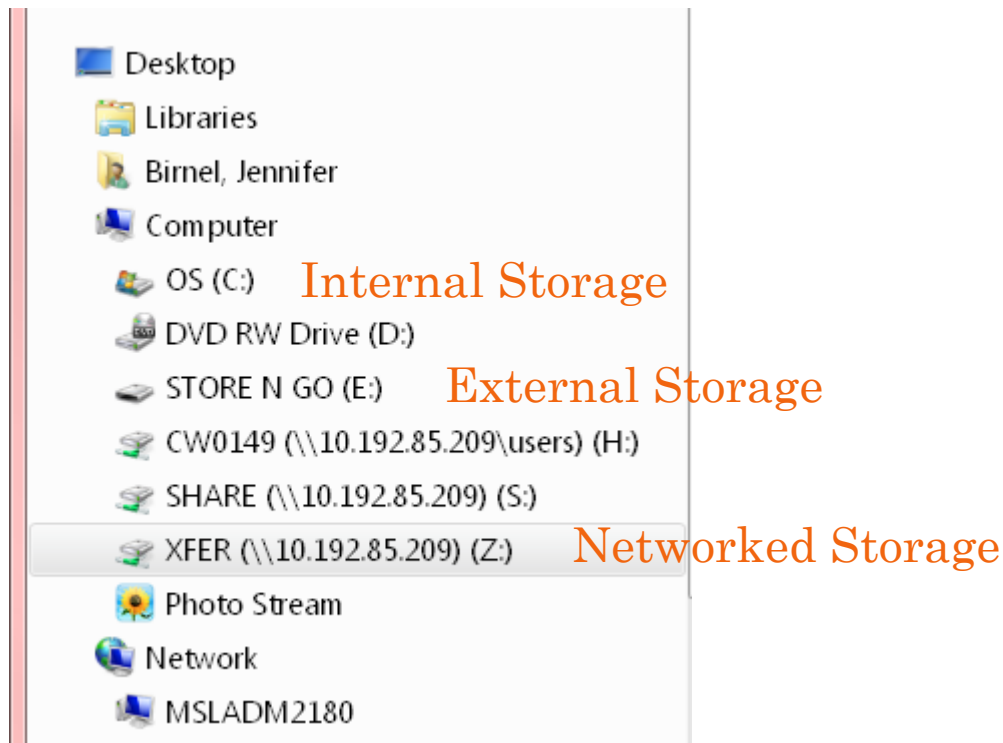
NETWORKED STORAGE

- Multiple work stations talk to one unit that stores information and data.
- Data is not saved to the C: drive, but to a network drive
- Can retrieve the data stored to the network from any of the connected workstations.



SAVING DOCUMENTS

- When you do a “save as” on your computer, you choose where to save the material.



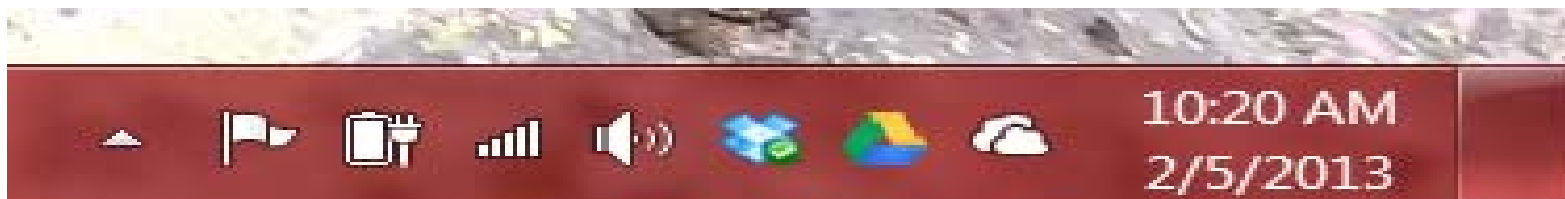
EXAMPLES OF SAAS: CLOUD STORAGE



- Create an Account – User name and password
- Content lives with the account in the cloud
- Log onto any computer with Internet connection to find your content

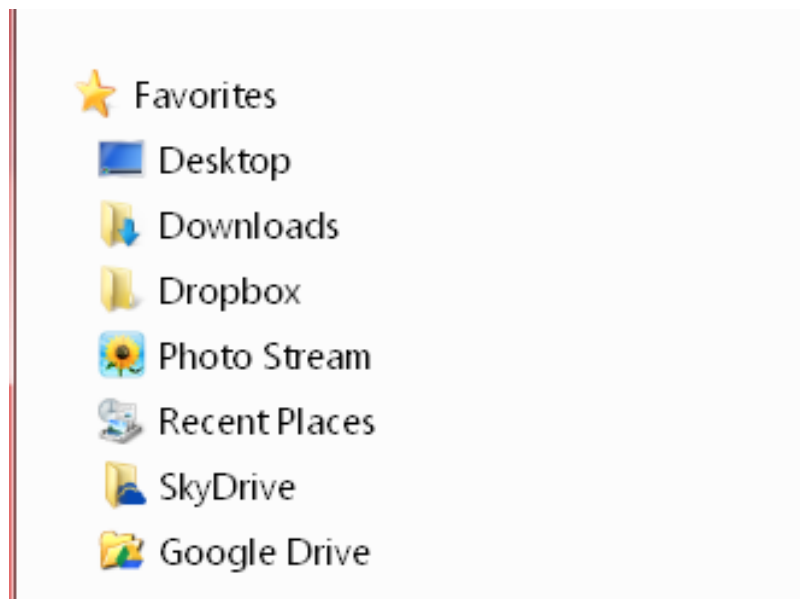
DOWNLOAD FOR CLOUD STORAGE

- Download a cloud-based app (e.g. Dropbox or Google Drive) to a computer **you own**
- The app lives on your Computer
- Save files to the app
- When connected to the Internet it will sync with the cloud
- The Cloud can be accessed from any Internet connection



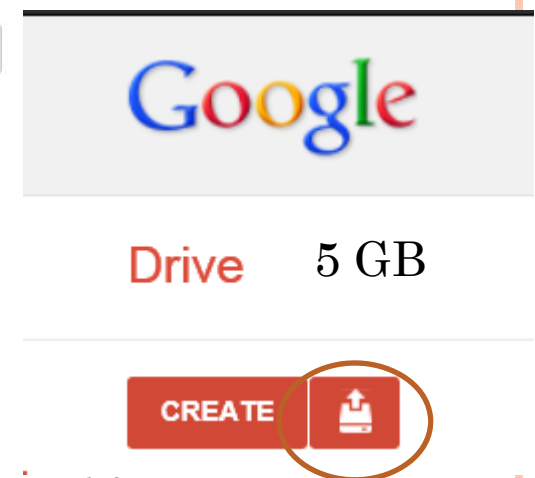
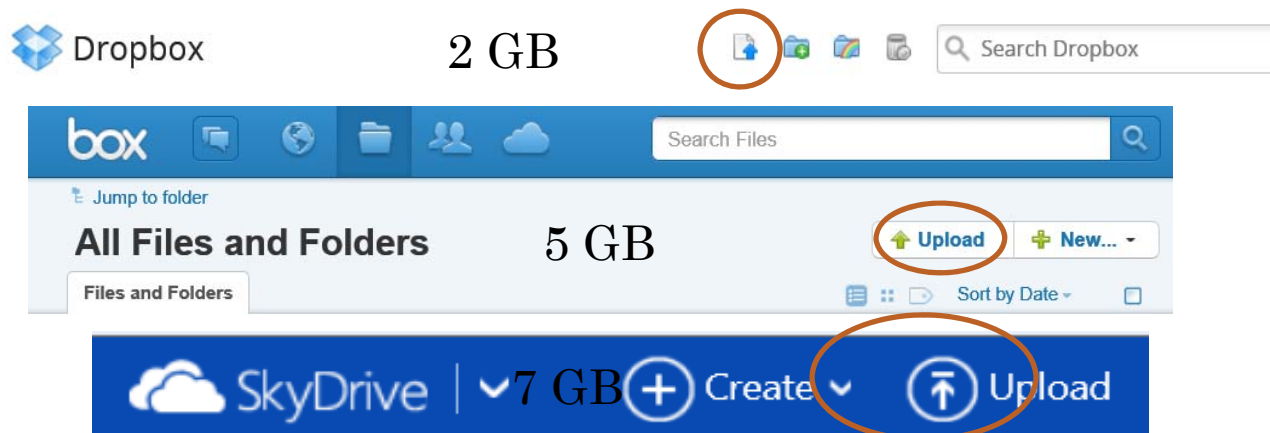
SAVE FILE TO CLOUD STORAGE AS IF SAVE FILE TO YOUR COMPUTER

- Do “save as” to save a file to your computer and the cloud
- The automatic synchronization between the folders in your computer and the cloud storage makes data retrieval easier



UPLOAD DOCUMENTS

- Log-in to the online storage account
- Click upload a file
- Find the file on internal hard drive, external storage or networked storage
- Upload to cloud storage



Source: the slide is from <http://www.webjunction.org> with some modification

**Software and
applications**

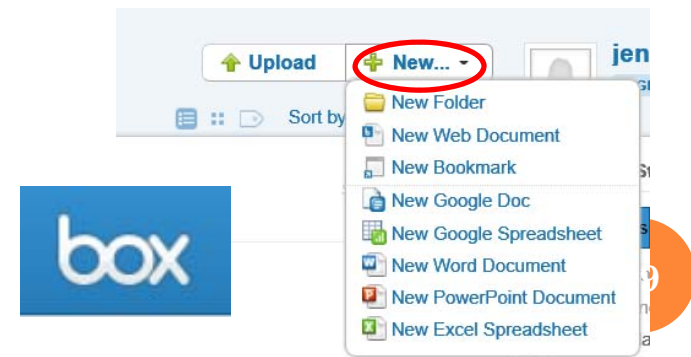
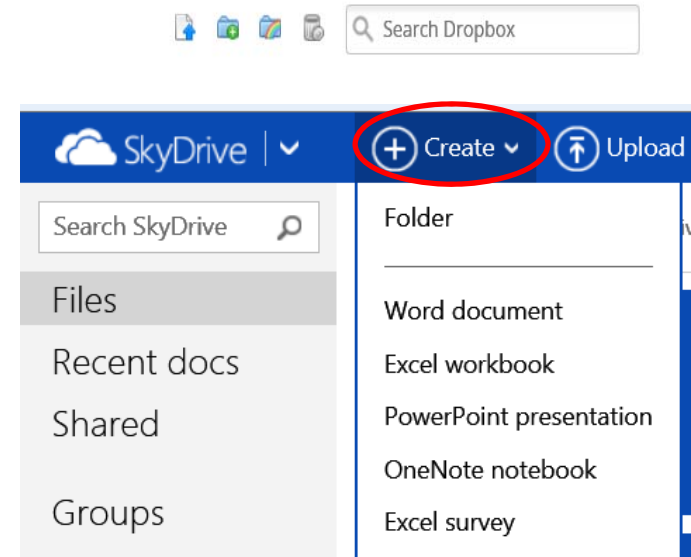
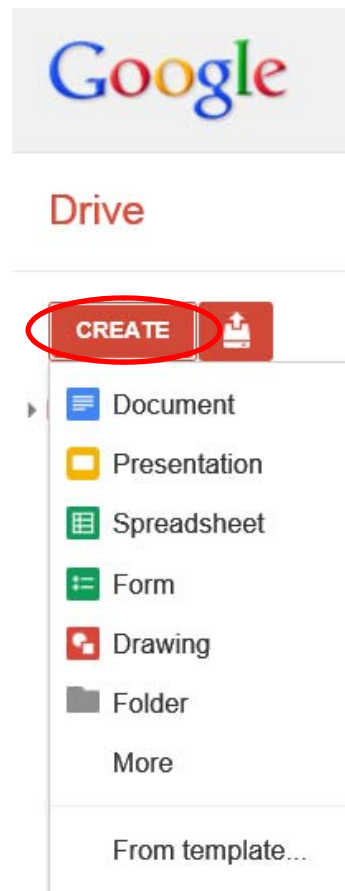
MORE THAN STORAGE

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Source: the slide is from <http://www.webjunction.org>

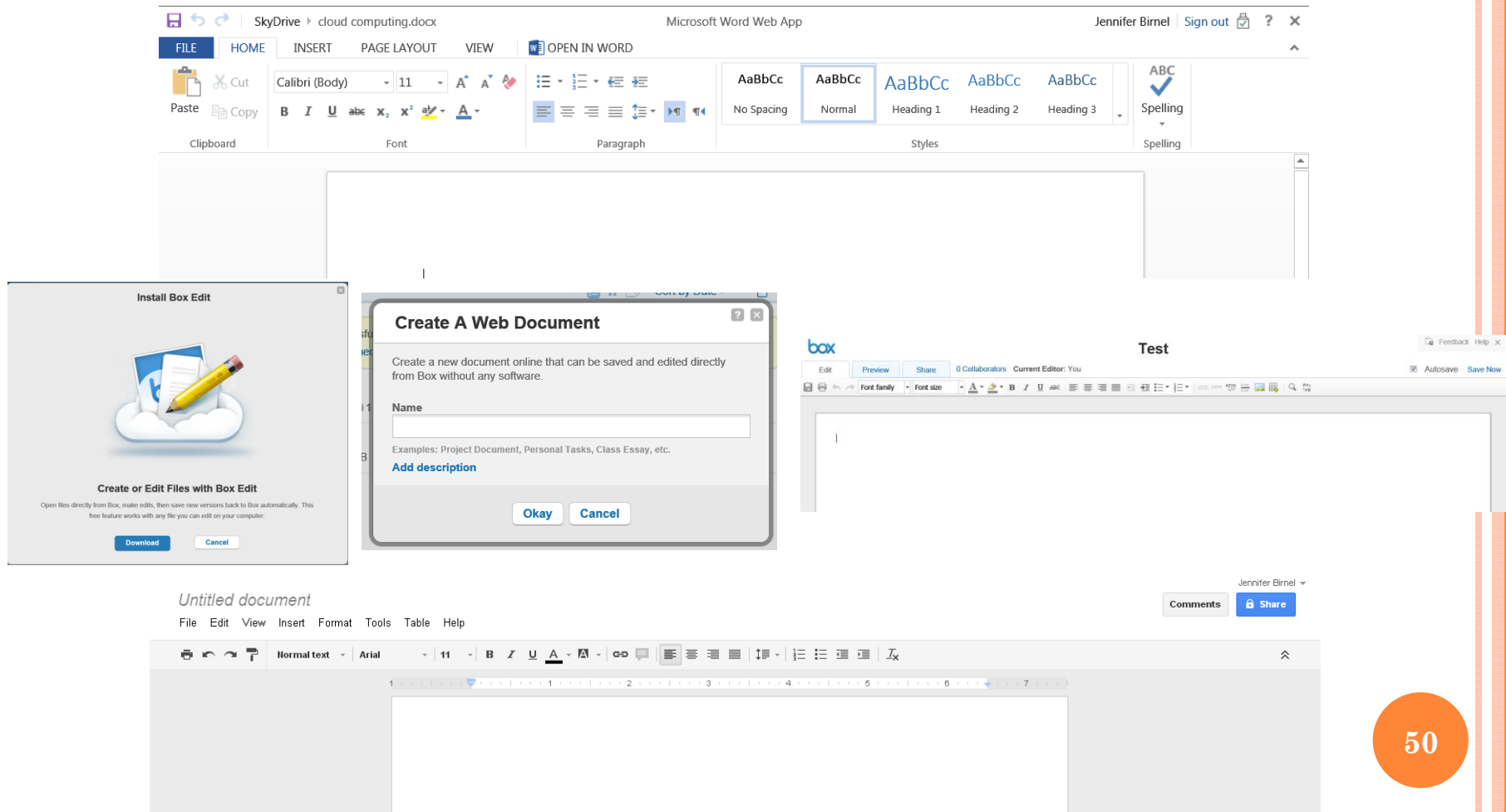
DOCUMENT CREATION

- Google Docs
- SkyDrive
- Box



Source: the slide is from <http://www.webjunction.org>

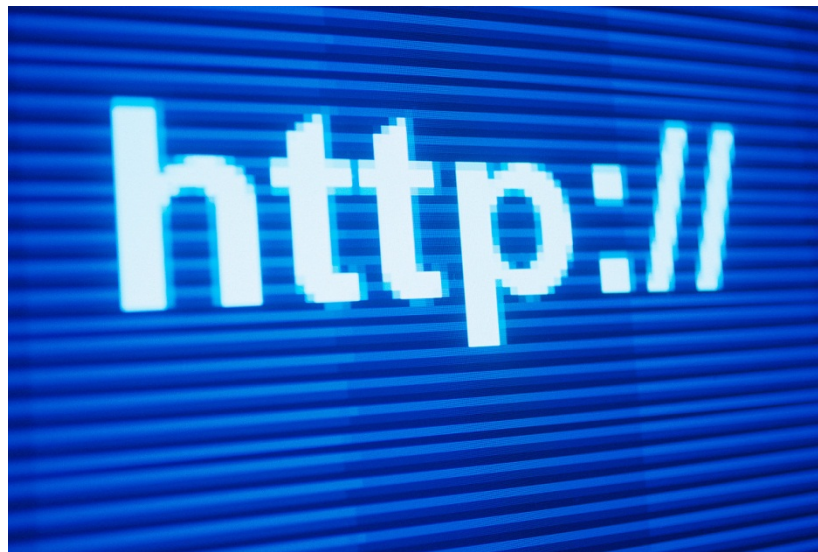
DOCUMENT CREATION (CONT'D)



Source: the slide is from <http://www.webjunction.org>

INTERNET IS REQUIRED

- Creation is happening in the cloud
- Saving is going to the cloud
- To retrieve files, must return to the cloud



Source: the slide is from <http://www.webjunction.org>

INTERNET CAPABLE DEVICES



BENEFITS OF USING CLOUD STORAGE

- Saving Large Files
- Multiple file types – Photos, videos, presentations, docs
- Back-up of stored files
- File Sharing
- Access from devices
- Nothing to forget (thumb drive, cd)
- Project collaboration



FILE SHARING: THIS IS AN EASY JOB IN CLOUD

Sharing settings

Link to share (only accessible by collaborators)

<https://docs.google.com/file/d/0B8hZL-kOGaSY1B6QWc0WIZGQUk/edit?usp=sharelink>

Share link via:    

Who has access

 Private - Only the people listed below can access [Change...](#)

 Jennifer Birnel (you) jennbirnel@gmail.com [Is owner](#)

Add people:

Enter names, email addresses, or groups...

Editors will be allowed to add people and change the permissions. [\(Change\)](#)

[Done](#)

Share

Send email

Post to   

Get a link

[Help me choose](#)

Permissions

This file is not shared

Send a link to "Professional Cover Letter.docx" in email

To

Include a personal message (optional)

☒ Recipients can edit

☐ Require everyone who accesses this to sign in

[Share](#) [Done](#)

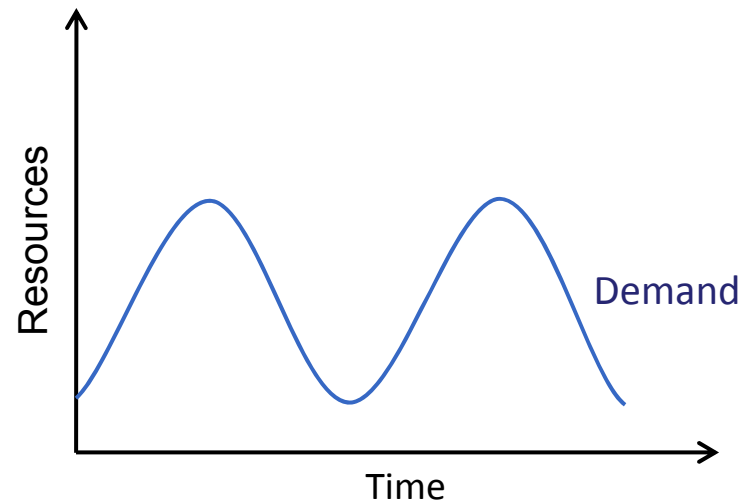
OTHER SOFTWARE SERVICES

- Photo editing software
- Online banking apps
- Social media apps
- Communication



CLOUD APPLICATION DEMAND

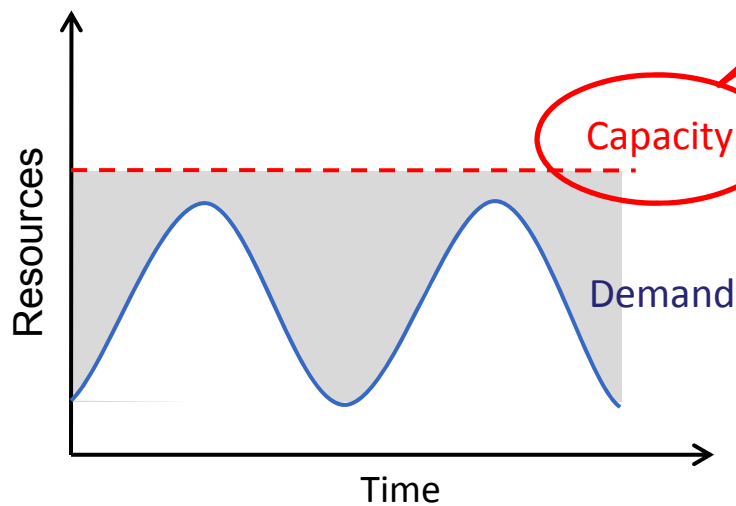
- Many cloud applications have cyclical demand curves
 - Daily, weekly, monthly, ...
- Workload spikes more frequent and significant
 - Death of Michael Jackson:
 - 22% of tweets, 20% of Wikipedia traffic, Google thought they are under attack
 - Obama inauguration day: 5x increase in tweets



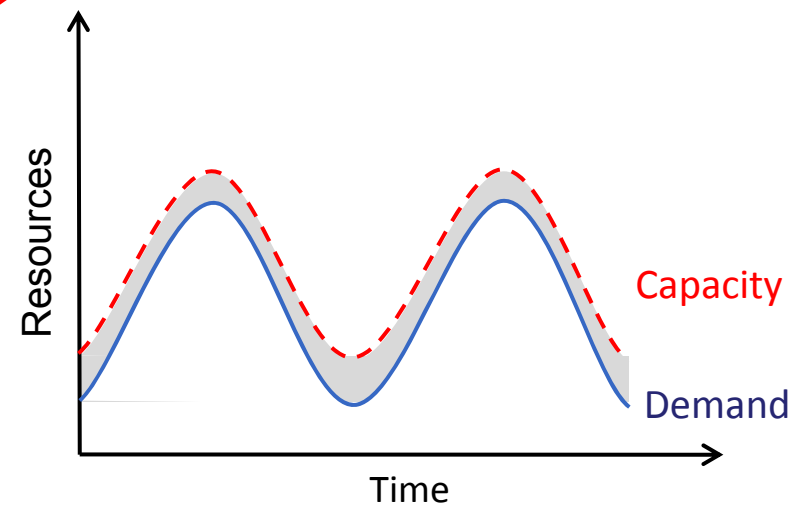
ECONOMICS OF CLOUD USERS

- Pay by use instead of provisioning for peak
- Data center costs > US\$150M and takes 24+ months to design and build

How do you pick a capacity level?



Static data center



Data center in the cloud

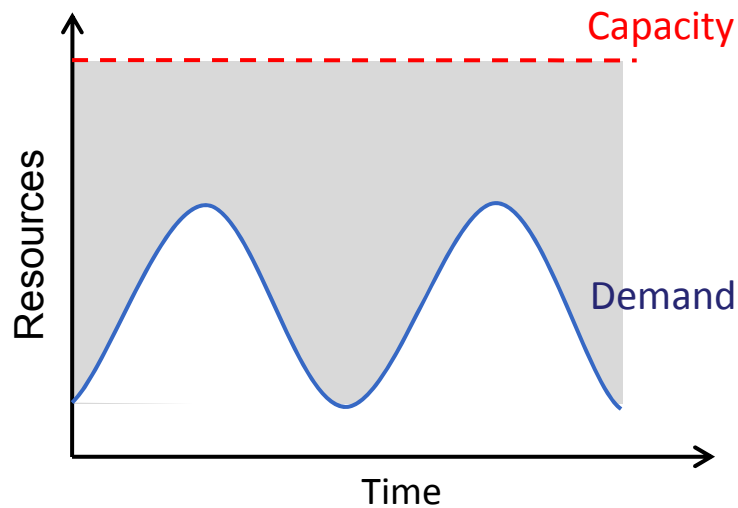
Source: the slide is from RAD Lab at UC Berkeley about the cloud and Jimmy Lin



Unused resources

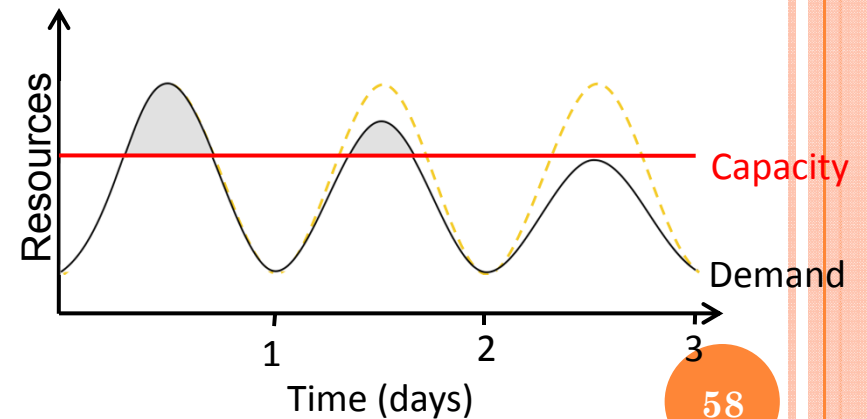
ECONOMICS OF CLOUD USERS

- Risk of over-provisioning: underutilization
 - Huge investment cost in infrastructure



Static data center

■ Unused resources



UTILITY COMPUTING ARRIVES

- Amazon Elastic Compute Cloud (EC2)
- “Compute unit” rental: US\$ 0.085-0.68/hour
 - 1 CU $\approx$ 1.0-1.2 GHz 2007 AMD Opteron/Intel Xeon core

	Platform	Units	Memory	Disk
Small - US\$.085/hour	32-bit	1	1.7GB	160GB
Large - US\$0.35/hour	64-bit	4	7.5GB	850GB – 2 spindles
X Large - US\$0.68/hour	64-bit	8	15GB	1690GB – 4 spindles
High CPU Med - US\$0.17	64-bit	5	1.7GB	350GB
High CPU Large - US\$0.68	64-bit	20	7GB	1690GB
High Mem X Large - US\$0.50	64-bit	6.5	17.1GB	1690GB
High Mem XXL - US\$1.20	64-bit	13	34.2GB	1690GB
High Mem XXXL - US\$2.40	64-bit	26	68.4GB	1690GB

- No up-front cost, no contract, no minimum
- Billing rounded to nearest hour

Northern VA cluster

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Source: the slide is from RAD Lab at UC Berkeley about the cloud and Jimmy Lin

UTILITY STORAGE ARRIVES

- **Amazon S3 and Elastic Block Storage offer low-cost, contract-less storage**

OPPORTUNITIES AND CHALLENGES

- The use of the cloud provides a number of opportunities:
 - It enables services to be used without any understanding of their infrastructure.
 - 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”.

Source: The slide is from Mark Baker

OPPORTUNITIES AND CHALLENGES (CONT'D)

- In parallel there has been backlash against cloud computing:
 - Use of cloud computing means dependence on others and that could possibly limit flexibility and innovation:
 - The others are likely become the bigger Internet companies like Google and IBM, who may monopolise the market.
 - Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against.

OPPORTUNITIES AND CHALLENGES (CONT'D)

- Security could prove to be a big issue:
 - It is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.
- There are also issues relating to policy and access:
 - If your data is stored abroad whose policy do you adhere to?
 - What happens if the remote server goes down?
 - How will you then access files?
 - There have been cases of users being locked out of accounts and losing access to data.

Q&A