

## CS 524 Homework #1

1. Using the formulae for the first software business model, find the year where the cumulative support expense equals that of the initial licensing fee  $p$ , where  $p = \$12,000$  per user, and  $c = 0.40$ . In how many years will the initial cost of software becomes 5% of the overall expenditure?

### Solution:

Given data:  $p = \$12000$ ;  $c = 0.40$

Let  $m$  be the number of years,  $n$  is the number of employees working in the company.

Overall expenditure can be calculated as:

$$\text{Overall expenditure} = np(1+mc) = np + npmc$$

$$5\% \text{ of Overall expenditure} = (5/100) * \text{Overall expenditure} = (5/100) * (np + npmc) \quad \text{Equation (1)}$$

$$\text{Cumulative support expense for } m \text{ years} = npc$$

Since for Initial expenditure, only one time per user license fee is paid, it can be calculated as:

$$\text{Initial expenditure} = np \quad \text{Equation (2)}$$

From equation (1) & (2), when Initial expenditure becomes equal to 5% of Overall expenditure:

$$np = (5/100) * (np + npmc)$$

$$np = 0.05 * np(1+mc)$$

$$20 = 1 + m * (0.4)$$

$$m = 47.5$$

Hence, it will take **47.5** years for the initial cost of software to be 5% of overall expenditure.

{Source: <https://blogs.cisco.com/datacenter/seven-software-business-models-part-1>}

2. In the definition of *Hybrid Cloud*, a term “Cloud bursting” is mentioned. Search the Web for its definitions. Do these definitions agree? If so, provide what you think is the best definition (you can rephrase it as you see fit). If not, explain the differences between the definitions.

**Solution:**

- Hybrid Cloud is a combination of public and private clouds. Here is a definition of “Cloud Bursting” provided by Microsoft:

“Cloud bursting” is a configuration deployed to deal with peak time usage. When an organization using a private cloud reaches 100% utilization, the traffic is directed to the public cloud. This gives the user interruption-free service.

Source: [ <https://azure.microsoft.com/en-us/overview/what-is-cloud-bursting/>]

- I agree with the definitions on the web. Consider, for example, a shopping website like Walmart, this website has huge traffic during specific times of the year, maybe on Black Friday or during Christmas sales. These businesses would suffer a lot if their website breaks especially during peak seasons. Cloud bursting gives these companies a way to deal with such situations. During the holiday season when the resource utilization is high, such companies can direct their traffic to public cloud as soon as their private cloud reaches its limit. During regular off-season days, there is no need for such companies to pay for Cloud services (since you pay only as and when you use the service) when the resource utilization is not high. This is a win-win situation for both the company as well as the user, as the company will direct their traffic to public cloud during peak times without paying for the extra services year-round and the consumer will have an uninterrupted shopping experience.

3. What are the essential differences between the *public* and *private* cloud that have made CIOs worry about legal consequences of Shadow IT? Read the original text of the US Government acts mentioned in the text (HIPAA and SOX) and summarize each in one paragraph.

**Solution:**

The essential differences between public and private cloud which have made CIOs worry about Shadow IT are:

- A private cloud is a cloud infrastructure which may be owned, managed and operated by the organization while a public cloud infrastructure is owned and managed by a business.
- A private cloud can exist on or off premises but public cloud exists on the premises of the cloud provider.
- A private cloud is provisioned for exclusive use by a single organization whereas a public cloud is provisioned for open use by the general public.

Having described the essential differences between public and private cloud, the concept of “Shadow IT” can be explained as:

- With services such as auto-deployment, auto-scaling, application monitoring, and auto healing being offered by Cloud companies, the work of application developers becomes easy as these actions are performed by the Cloud provider’s software. It is easier for a developer to pay by his/her credit card and start developing on a public Cloud rather than going to the company’s IT department, waiting for permissions to be granted, again waiting for hardware to arrive.
- Whereas, in Shadow IT, developers use Cloud services by using all the underlying infrastructure provided by the Cloud provider. Since the software or hardware on which the developer is running the company’s application is not on the company’s private cloud/on-premises, but is on a public Cloud, it leads to the concept being called “Shadow IT”. Since a public cloud is involved, which is not in control of the IT company, CIOs are worried. This also poses a risk to security as the company’s sensitive data is now being replicated on a public Cloud.

Source: [Cloud Computing: Business Trends and Technologies]

HIPAA & SOX:

The Health Insurance Portability and Accountability Act (HIPAA) includes provisions that require Health & Human Services (HHS) to adopt national standards for electronic health care transactions and code sets, unique health identifiers, and security. The Privacy Rule sets national standards for the protection of individually identifiable health information by three types of covered entities: health plans, health care clearinghouses, and health care providers who conduct the standard health care transactions electronically. Companies must comply with HIPAA. The Sarbanes-Oxley Law (SOX) was passed by US Government in 2002. The act sets deadlines for compliance and publishes rules on requirements. All public companies must comply with this law. The act sets rules on Destruction of corporate audit records, tampering with a record or otherwise impeding an official proceeding including Criminal penalties for altering documents among others.

Source: [ <https://www.hhs.gov/hipaa/index.html>]

[<https://www.govinfo.gov/content/pkg/PLAW-107publ204/html/PLAW-107publ204.htm>]

4. Consider the case of the *Instagram* as described in the textbook. How many employees and customers did it have at the time of the purchase by Facebook? How much did Facebook pay for it? What was the value that the purchased business has generated in the first two years, and what were the factors that enabled generating this value?

**Solution:**

At the time of its purchase, Instagram had **11 employees** who managed **30 million customers**. Facebook bought Instagram for **1 billion dollars**. Instagram had no physical infrastructure and only **3 people** managed the infrastructure which was on Amazon Cloud. Within two years of purchase, the company was able to generate **one billion dollars** in value. The factors that enabled generating this value were:

- There wasn't any need for physical infrastructure, no other expenses like payment for physical servers was needed.
- No payment had to be made to technicians to manage those servers as there were no physical servers.
- Since Cloud was used, it allowed the company to scale automatically as more users signed up on Instagram without the application crashing.
- Further, more efforts and money were put into customer acquisition and retaining the original customers.

Source: [Cloud Computing: Business Trends and Technologies]

5. Familiarize yourself with the description of the *Amazon Elastic Cloud Computing* (<http://aws.amazon.com/ec2/>). What kind of a service model does it provide (i.e., SaaS, PaaS, IaaS, or a combination of these)? Please list the features that support your answer.

**Solution:**

Amazon Elastic Compute Cloud (EC2) is a web service provided by Amazon which gives secure and elastic(resizable) computing capacity in the cloud. No upfront commitment for resources is required in this service. It provides functionality such as the users can load their custom application environments in the virtual computing environment. The NIST definition of Infrastructure as a Service states:

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

Amazon Elastic Cloud Computing (EC2) provides IaaS (Infrastructure as a Service). There are a number of features provided by EC2, which show how it provides IaaS features, including:

1. **Bare Metal Instances:** Direct access to the processor and memory of the underlying server is provided.

2. **Optimize Computing Performance and Cost with Amazon EC2 fleet:** User can Auto scale to provision computing capacity as needed (On-Demand and Spot)
3. **Pause and Resume Instances:** User can hibernate instances if he/she want to pause it for now and resume at a later date. User will not be charged during hibernation.
4. **GPU Compute Instances:** Customers requiring massive floating-point processing power can use GPU Compute Instances from Amazon which are suited for machine learning, computational finance, seismic analysis and high-performance computing among others.
5. **GPU Graphic Instances:** Customers who require high graphic capability ideally suited for 3D Visualizations, application streaming, video encoding can greatly benefit from GPU Graphic Instances with GPUs that provide high parallel processing cores and latest driver releases.
6. **High I/O Instances:** Amazon EC2 provides high I/O instances which have low latency for random I/O access. These instances are backed by Non-Volatile Memory Express based SSDs and are perfect for customers running very high performance NoSQL databases, transactional databases among others.
7. **Dense HDD Storage Instances:** For data-intensive applications, high sequential I/O and very high storage density per instance is required. Amazon EC2 Instance type -Dense Storage can provide customers with sequential I/O throughput of up to 3.9 GB/s and up to 48 TB of instance storage.
8. **Optimized CPU Configurations:** In this feature, user can specify a custom number of virtual CPUs when launching new instances. It also gives an option for disabling multithreading for workloads such as High Performance Computing (HPC) applications.
9. **Flexible Storage Options:** Amazon Elastic Block Store (EBS) provides persistent, highly available, consistent, low-latency block storage volumes for use with Amazon EC2 instances. Amazon Elastic File Storage (EFS) provides simple, scalable, persistent, fully managed cloud file storage for shared access; it is designed for high availability and durability.
10. **Paying for What You Use:** Users are charged at the end of the month for EC2 resources actually consumed by them.
11. **Multiple Locations:** EC2 provides the ability to place instances in multiple locations which are composed of Regions and Availability Zones. These zones provide inexpensive, low latency network connectivity to other Availability Zones in the same Region. Applications can be protected from failure of a single location by launching instances in separate Availability Zones.
12. **Elastic IP Addresses:** Elastic IP Addresses are basically static IP addresses which are associated with a user account rather than a particular instance such that the user can control the address until the user wishes to explicitly release it, thus providing dynamic cloud computing. Elastic IP Addresses allow the user to mask instance or Availability Zone failures by programmatically remapping the public IP addresses to any instance in the user account.
13. **Enhanced Networking:** This feature uses a new network virtualization stack that provides higher I/O performance and lower CPU utilization compared to traditional

implementations. It gives higher packet per second (PPS) performance, lower network jitter and lower latencies.

14. **Operating Systems and Software:** Amazon Machine Images (AMIs) are preconfigured with an ever-growing list of operating systems. User can choose from a wide range of partners (Examples: Amazon Linux, Windows Server 12, CentOS 6.5, Debian 7.4) AWS Marketplace features a wide selection of commercial and free software from well-known vendors, designed to run on EC2 instances (SAP Business Objects, LAMP Stacks, Drupal).

Source: [<https://aws.amazon.com/ec2/features/>]

6. Read the article on Fog Computing provided in the lecture. Familiarize yourself with the OpenFog Consortium ([www.openfogconsortium.org](http://www.openfogconsortium.org)) and answer the following questions:

- a. How many members does the consortium have?
- b. What is the definition (one sentence) of Fog computing according to the consortium?
- c. What is the goal of the consortium?

**Solution:**

- a. Prior to the merger with Industrial Internet Consortium in 2018, the OpenFog consortium had 57 members. (Source: [https://en.wikipedia.org/wiki/OpenFog\\_Consortium](https://en.wikipedia.org/wiki/OpenFog_Consortium))  
As of today, Industrial Internet Consortium has around 180 members.  
(Source: <https://www.iiconsortium.org/members.htm>)
- b. According to the consortium, Fog computing is defined as: A horizontal, system-level architecture that distributes computing, storage, control and networking functions closer to the users along a cloud-to-thing continuum.
- c. The OpenFog Consortium was formed on the principle that an open fog computing architecture is necessary in today's increasingly connected world. Through an independently run open membership ecosystem of industry, end users and universities, OpenFog can apply a broad coalition of knowledge to these technical and market challenges. The goal of the consortium is to ensure the OpenFog reference architecture results in fully interoperable and secure systems, supported by a vibrant supplier ecosystem. (Source: <http://conferences.sigcomm.org/sigcomm/2012/paper/mcc/p13.pdf>)

7. Consider the example of the *Zing Interactive Media* and explain how you would launch the same service today using Amazon EC2. Specifically list the steps (and costs) you would avoid by doing so.

**Solution:**

All the prices listed below are for On-Demand Instance pricing (EC2 server will charge me by hour with no long-term commitment for Zing Interactive Media)

- 1) I would not Rent space on a hosting site, so this cost is saved.
  - 2) I would not have to buy a server.
  - 3) There would not be any need to lease dedicated T1 lines for connectivity to the hosting site, no need to purchase networking gear like switches and cables.
  - 4) I will not hire an IT team to maintain my servers as there is nothing on-premises.
  - 5) Instead of buying servers, I will buy Windows and Web SQL Server on t3.2xlarge which will be available on-demand. It will cost around \$450 per month.
  - 6) I will also buy EC2 dedicated hosts which will cost around \$1500 per month
  - 7) I will also need Elastic IPs which will cost around \$100 per month
  - 8) Since everything is on an on-demand instance, whenever my application faces peak traffic, I will scale all these numbers up so that the user experiences uninterrupted service
  - 9) I can also get a database-as-a-service from Amazon RDS and get MySQL BD engine and License for approximately \$2000/month.
- These steps would lower my costs and will let me build a robust application.

Source: [<https://calculator.s3.amazonaws.com/index.html>]

8. Explain what *CPU pinning* is and how *Intel* supports it with API.

**Solution:**

- The process of assigning a virtual machine to a particular processor or a range of processes is called CPU pinning.
- When Cloud infrastructure is used, there is hardly any control over hardware choices and the choice of CPU, memory, network interface cards that would be used. If an application needs high computing power, the developers of that particular application have to solely trust the Cloud infrastructure to respond to calls of an API (Application Programming Interface) so that the demand of high computing power is met. Intel is solving these problems with its API. Intel's API promises that a certain percentage of the CPU is given to a particular virtual machine. This capability is exposed via hypervisor and the Cloud provider's systems, and can be consumed by the application.

Source: [Cloud Computing: Business Trends and Technologies]

9. Study the Amazon EC2 SLA. What service commitment (in percentage) does it guarantee? What is the bound on the downtime in a year?

**Solution:**

- The Amazon EC2 SLA (Service Level Agreement) is a policy governing the use of Amazon Elastic Compute Cloud (EC2) and Amazon Elastic Block Store (EBS) under the terms of the AWS Customer Agreement between Amazon Web Services, Inc. and its affiliates and the users.
- The service commitment guarantees that AWS will use commercially reasonable efforts to make Amazon EC2 and Amazon EBS each available with a Monthly Uptime Percentage of at least **99.99%**, in each case during any monthly billing cycle. Source: [<https://aws.amazon.com/compute/sla/>]
- Amazon EC2 guarantees its monthly uptime to be 99.99%, so the downtime would be 0.01% in a month. It comes out to 4 mins of downtime per month. The downtime in a year would be approximately **48 to 50 mins**.

10. What is the “telecom-grade” service commitment? Who were the ETSI NFV Industry Specifications Group founders? List the areas where the NFV is expected to act. (Optional recommended reading: the ETSI NFV White Papers.)

**Solution:**

- “Telecom grade” means that the hardware is:
  - a. Particularly designed for running in telecommunications networks.
  - b. It is engineered in such a way that it will survive in the network for more than 15 years.
  - c. It is functional for 99.999% of time (it has downtime of about 5 minutes)
- ETSI NFV Industry Specifications Group was founded in November 2012 by seven of the world’s leading telecom network operators (AT&T, BT, Deutsche Telekom, Orange, Telecom Italia, Telefonica, and Verizon); later 52 other network operators, along with telecom equipment, IT vendors, and technology consultants joined to form NFV. Source: [<https://www.etsi.org/technologies/nfv>]
- NFV is expected to act in the following areas:
  - I. Operational Improvements
  - II. Cost reductions
  - III. Streamlining high-touch processes
  - IV. Reduction of Development Time
  - V. Reduction of Replacement Costs
  - VI. Reduction of Equipment costs

Source: [Cloud Computing: Business Trends and Technologies]