CSC 547 - HW 3

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Regular Problems

Problem 1

Consider the internet, IP, its layer 3 protocol, and two layer 4 protocols, namely TCP and UDP.
 1. *The system in the definition of virtualization we gave in Section 3.1.1 is the internet. Explain how TCP virtualizes the internet. More specifically, what is the property TCP gives to the internet, that the internet does not (natively) have?*

    ○ The definition of virtualization says it is the process of giving a system a property it does not have. The system here is the internet, which is an unreliable network. It does not guarantee the delivery of packets. It also does not guarantee the orderly delivery of packets
    ○ TCP "virtualizes" the internet by providing it with a few properties it did not originally have. These are:
       i. Guaranteed delivery
       ii. Correct ordering of packets

 2. *Describe, in any detail you like, what mechanisms TCP uses in order to achieve the property.*
    ○ Sequence and acknowledgement numbers: The sender divides the data to be sent into segments and assigns a sequence number to each segment. Periodically, the receiver sends a segment to the sender with the acknowledgement number field set to a certain value. This value is the segment sequence number the receiver is expecting from the sender. In other words, if the receiver sends an acknowledgment number X back to the sender, it has confirmed that the first X segments have been received. The receiver now knows that it needs to transfer segments with sequence numbers >X. This mechanism ensures reliability.
    ○ Retransmission: If an acknowledgment for a segment is not received within a certain "timeout", the data is retransmitted. This timeout value is calculated dynamically.

 3. *Who (not which hat) benefits from this virtualization?*

The users of the applications that utilize TCP benefit. For example, without TCP, there would be no guarantee that an email would reach the recipient; and if it does, there would also be a chance that the text is garbled because of incorrect sequencing. TCP is such a ubiquitous protocol that pretty much everyone who uses the internet benefits from its implementation.

4. *Which hat benefits from this virtualization?*

The following hats benefit:
   ○ Cloud Architect, since he/she can incorporate the reliability offered by TCP into their designs instead of creating their own mechanisms for ensuring reliability.
   ○ Cloud Administrator, since the virtualization, troubleshooting and system management tasks that he/she performs are built on the promise that the commands sent are guaranteed to reach the target system.

5. *Which hat pays the price?*

The network engineers which implement the protocols in applications pay the price.

6. *Explain why UDP does not virtualize the internet like TCP does.*

UDP is a "bare-bones" protocol, which is obvious if we take a look at the UDP segment:
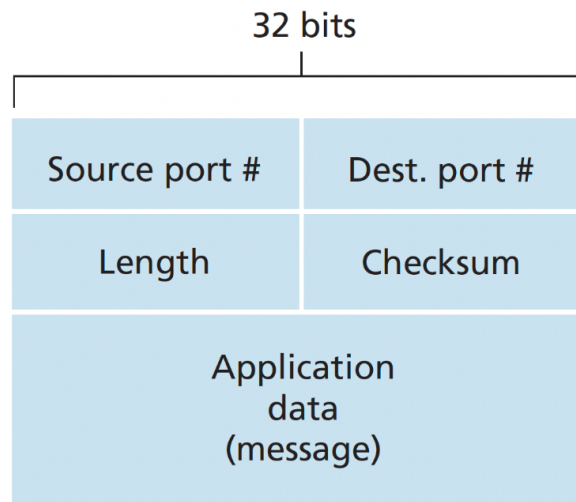
Apart from the checksum for error detection and multiplexing at source and destination, there are no additional services provided by UDP on top of IP. This is why it does not virtualize the internet like TCP.

7. *Search "what protocols use UDP" and "what protocols use TCP". Explain why some protocols don't care to use an internet full of virtues...*

Sometimes the extra features provided by TCP can cause problems/are not desired. TCP has a 3-way handshake stage that can cause delays. It also has a higher packet overhead compared to UDP. Therefore, when speed is a more important factor than reliability, UDP is generally preferred over TCP (e.g. online gaming, VoIP)

- DNS uses UDP because, by nature, DNS does not require continuous connections. DNS requests consist of a single query-response. Also, UDP does not introduce any connection establishment delays, and most DNS segments fit within the smaller UDP segment.
- SNMP uses UDP because it has no need for some of TCP's features, such as reliability and proper sequencing. In SNMP the monitor simply asks the device information about an OID, and the device responds with the requested information. If the monitor does not receive a response, it reissues the query.

Problem 2

Consider the bus service at NCSU.

1. *Describe the service in your own words.*

   The Wolfline bus service is a service offered by NCSU (the provider) to its students and employees (the receiver) that enables the receiver to go from point-to-point within or near NCSU's campus. The bus stops are placed strategically so as to maximize the amount of people that can benefit from the service. The frequency of buses on this service varies based on the amount of expected traffic (higher frequency on more popular routes; presence/absence of key routes on weekends etc)

2. *Who is the provider?*

   NC State is the provider.

3. *Who is the consumer?*

   NC State students and employees are the consumers.

4. *What are the benefits to the provider?*

   Benefits to the provider:
   a. Reduction in the amount of driving accidents around or inside campus.
   b. Increase in student safety especially at night.
   c. Lower greenhouse gas emissions around the campus.

d. Higher lecture attendance which is correlated to higher grades which is correlated to more lucrative job offers which is correlated to a better reputation of the university which is correlated to more money for the university.

5. *What are the benefits to the consumer?*

   Benefits to the consumer:
   a. Elimination or reduction of the need for private transportation.
   b. Elimination of maintenance or other reliability issues associated with owning a private vehicle. These costs and/or headaches are transferred to the provider.
   c. Elimination of the need to get a driver license. This requirement is passed on to the drivers contracted by the employer.

6. *How does the service get discovered by the consumer?*

   The service can be discovered via the TransLoc mobile application.

7. *How does the provider "advertise" the service?*

   The provider advertises the services via:
   a. Logos on the buses: To a completely new and uninformed NCSU student and employee, this is the first hint that such a service exists.
   b. Wolfline bus stops signs: These signs indicate to users that an NCSU bus stopping at that location might be able to take them close to their destination, free of cost. These signs often have QR codes that help the user download the TransLoc mobile application.
   c. LED boards on the buses: These boards display the route number and the main destination of that route (generally these are popular destinations like the Hunt Library, Wilson College, etc).

Problem 4

The following are offerings of services. The question is what kind? Justify your answer. (Google the name, if you are not familiar with the company that offers the service.)

1. *Overleaf*
   ○ Overleaf can be classified as a Software as a Service
   ○ Wikipedia definition of overleaf is "Overleaf is a collaborative cloud-based LaTeX editor used for writing, editing and publishing scientific documents."
   ○ At its core it is a software to edit documents using LaTeX

- ○ This also conforms to the NIST definition of SaaS - "The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure."
2. *Dropbox*
   - ○ We can classify Dropbox as a SaaS or as IaaS depending on the usage
   - ○ Dropbox can be used to store and share files and collaborate on projects. Since it is an end user service for storage and access management of files it can generally be classified as SaaS
   - ○ However, Dropbox can sometimes also be classified as IaaS as they can be used as storage and/or backup services as part of other application stacks with the APIs that they offer (https://www.dropbox.com/developers)
3. *Google Docs*
   - ○ Google Docs can be classified as a SaaS
   - ○ Google Docs allows users to create and edit documents online while collaborating with other users in real-time
   - ○ They also provide spell checking, auto complete, grammar correction, revision history tracking and other such features
   - ○ Similar to Overleaf, Google Docs is a document editing software at its core, but for more general purposes
   - ○ This also conforms to the NIST definition of SaaS
4. *Gmail*
   - ○ Gmail can be classified as a SaaS
   - ○ Gmail offers an electronic mail exchange software as a service over the internet and they take responsibility for the infrastructure, maintenance and enhancement
   - ○ Since the users only consume the services offered by Gmail, it once again conforms to the NIST definition of SaaS
5. *Netflix*
   - ○ Netflix can be classified as a SaaS
   - ○ Netflix offers subscriptions to their software to watch licensed content on demand
   - ○ It could be argued that users are actually paying for the content
   - ○ However, they are receiving personal recommendations and on demand content (some of which are proprietary to Netflix) curated and accessible by the software provided by Netflix
   - ○ Hence, this also conforms to the NIST definition of SaaS

Problem 5

Burstable compute instances. Search the AWS documentation about burstable compute instances.

1. *Describe the key concepts of this service*
   - Burstable compute instances are a class of compute instances offered by AWS for efficient workload management and to optimize CPU utilization
   - The main problem addressed by the Burstable compute instances from AWS is the under utilization of CPUs and hence a wastage of CPU cycles
   - AWS claims that "Many general purpose workloads are on average not busy, and do not require a high level of sustained CPU performance" (https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/burstable-performance-instances.html)
   - Burstable compute instances are "T instances" and they come with a baseline performance similar to that of other "T instances" but can "burst" above this baseline at any time and for as long as necessary

2. *State succinctly what is the benefit for the consumer*

   - The baseline CPU is already defined to meet the needs of the majority of general purpose workloads
   - The T instances offer a balance of compute, memory, and network resources
   - AWS also claim that "They can save you up to 15% in costs when compared to M instances, and can lead to even more cost savings with smaller, more economical instance sizes, offering as low as 2 vCPUs and 0.5 GiB of memory"
   - In short, the users can get the most of their needs met for lower prices along with the ability to handle "bursts" in CPU requirement

3. *State succinctly what is the benefit for the provider.*

   - Burstable compute instances allow AWS to oversell their server hardware while still maintaining performance
   - They can reduce wastage of resources
   - They can acquire and provide for more tenants at affordable prices

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Problem 6

The big three cloud providers offer several types of compute service; however, they may not use the same name or exactly the same features for them.
   1. *Find a compute service that has (almost) the same features in all three*

Following are the compute services which are provided by big three cloud providers -

Sr. No.	Service	Service Type	AWS product	Azure	Google Cloud

	Category			Product	Platform Product
1	Compute	Core compute	Amazon Elastic Compute Cloud (EC2) P3	GPU Optimized VMs	Cloud GPUs
2	Compute	Core compute	AWS UltraClusters	Azure Virtual Machines	Cloud TPU
3	Compute	Core compute	Amazon Elastic Compute Cloud (EC2)	Azure Virtual Machines	Compute Engine
4	Compute	Core compute	AWS Autoscaling	Azure Autoscale, Azure Virtual Machine Scale Sets	Compute Engine Autoscaler
5	Compute	Core compute	Amazon EC2 Instance Connect	-	OS Login
6	Compute	Core compute	Amazon Elastic Block Store (EBS)	Azure Managed Disks	Persistent Disk
7	Compute	Core compute	AWS EC2 Instance Connect	Azure Bastion	SSH from the browser
8	Compute	Dedicated VMs	Amazon EC2 Dedicated Host	Azure Dedicated Host	Sole-tenant nodes
9	Compute	FaaS	AWS Lambda	Azure Functions Serverless Compute	Cloud Functions
10	Compute	Infrastructure modernization	SAP on AWS	SAP on Azure	SAP on Google Cloud
11	Compute	PaaS	AWS Elastic Beanstalk	Azure App Service	App Engine
12	Compute	VMware	VMware	Azure	VMware

		connectivity	Cloud on AWS	VMware Solution	Engine

2. Describe the features. Outline the differences, if any.

From the above services let's take one service which is a core compute service -

	AWS	Azure	Google Cloud Platform
Product	Amazon Elastic Compute Cloud (EC2)	Azure Virtual Machines	Compute Engine
Feature	- It provides the ability to place instances in multiple locations. - Amazon Machine Images are preconfigured with many operating systems - We need to pay only for what we use - It provides the ability to autoscale up or down based on conditions we define. - It provides optimized vCPU configuration - Provides hibernation and we can resume instances from that state later time. - Optimal storage for every workload. - Provides high Packet-Per-Second performance and low latency with enhanced networking	- Provides the flexibility of virtualization without having to buy and maintain the physical hardware that runs it. - It can be used as extended datacenter as it can be connected easily to your organization's network - Can create resources at multiple locations around the world - It provides multiple options to manage the availability of virtual machine using Availability zones, Virtual machine scale sets, Proximity placement groups - It supports a variety of linux and windows distributions for virtual machine	- It is an Infrastructure-as-a-Service (IaaS) offering - It uses a Kernel-based Virtual Machine (KVM) as its hypervisor - It provides multiple storage option - persistent disks, Filestore, Local SSD, cloud storage - Two main types of images can be used with Google Cloud Engine: public and custom images. - Cloud engine's network input/output is much faster than AWS and Azure - It provides persistent block storage - Provides live migration

Differences	• Operates in 25 global regions • AWS auto scaling offers predictive scaling • AWS provides following billing models- On demand Reserved Spot Savings plan • AWS is the only cloud provider which offers hibernation.	• Operates in 33 global regions • Azure does not offer predictive scaling • Azure provides following billing models- On demand Reserved Spot • Azure does not offer hibernation	• Operates in 24 global regions • GCP offers auto scaling • GCP provides following billing models- On demand Sustained Use Committed Use Preemptible • GCP hibernation is in preview state and not generally available.

3. *Find out, if possible, the cost of the service (i.e., up-front, per hour charges)*

	AWS	Azure	Google Cloud Platform
Product	Amazon Elastic Compute Cloud (EC2)	Azure Virtual Machines	Compute Engine
Cost of the Service (factors to consider)	Amazon EC2 pricing is based on four components: the instance type you choose (EC2 comes in 40+ types of instances with options optimized for compute, memory, storage and more), the operating system you run, the region your instances are based in, and the pricing model(on-demand instances, reserved capacity, spot, etc.) m3.xlarge EC2 instance in the US East region. With on-demand pricing, your EC2 charges will amount to $0.81/hour	Azure virtual machines pricing is based on these factors - type of vm, time for which the vm instance run, the type of pricing model you choose(Pay-as-you-go, Reserved instances, Spot Vms), Data transfer over the network, load balancing fees, persistent storage	In the GCP, you pay only for the computing time you have consumed. The Compute Engine uses the per-second billing plan Models - Pay-as-you-go, Long-term plan, Free tier option

	($593.71/month).		

Instances/ VMs selected for price comparison (Hourly based) - (Source-
https://cast.ai/blog/cloud-pricing-comparison-aws-vs-azure-vs-google-cloud-platform/)

Cloud provider	Instance type	vCPU	RAM (GB)
AWS general purpose	t4g.xlarge	4	16
AWS compute optimized	c6a.xlarge	4	8
Azure general purpose	B4ms	4	16
Azure compute optimized	F4s v2	4	8
Google Cloud Platform general purpose	e2-standard-4	4	16
Google Cloud Platform compute optimized	c2-standard-4	4	16

On demand price compare -
1. General purpose -

Cloud provider	Instance type	Price
AWS	t4g.xlarge	$0.1344
Azure	B4ms	$0.166
Google Cloud Platform	e2-standard-4	$0.150924

2. Compute optimized -

Cloud provider	Instance type	Price
AWS	c6a.xlarge	$0.153
Azure	F4s v2	$0.1690
Google Cloud Platform	c2-standard-4	$0.2351

Pricing with a 1 year upfront commitment -
1. General purpose -

Cloud provider	Instance type	Price	Discount
AWS	t4g.xlarge	$0.079	41%
Azure	B4ms	$0.0974	41%
Google Cloud Platform	e2-standard-4	$0.095092	63%

2. Compute optimized -

Cloud provider	Instance type	Price	Discount
AWS	c6a.xlarge	$0.094	38%
Azure	F4s v2	$0.10	41%
Google Cloud Platform	c2-standard-4	$0.13156	63%

Bonus Problems

Problem 7

1. *Feedback-based control. Give an example from your personal, college life in which feedback was used to achieve an objective. Describe the problem using the terminology of the MAPE framework we presented in Figure 3.1, page 55. More specifically:*

   a. *State the objective clearly.*
   b. *What is the managed element?*
   c. *What is the sensor and actuator?*
   d. *What analysis is done? Where? Who did the analysis?*
   e. *How were the results of the analysis communicated to the actuator?*
   f. *Discuss the benefits, if any.*
   g. *Discuss the challenges, if any.*

Ans:

1) State the objective clearly -
   To develop a final year project(Online shopping application). So we will divide the project into different components like front-end, backend, storage.
2) What is the managed element?

In our project, suppose we want to perform the MAPE analysis on buying an item. So a managed element would be the complete buy an item workflow.

3) What is the sensor and actuator?

Sensor would be a software used to analyze the time taken by the API calls, handling multiple requests at the same time.

Actuator would be the application on which we are performing the buy a item task. For eg- We can use the Postman API platform as an actuator which uses http endpoints to hit the internal APIs.

4) What analysis is done? Where? Who did the analysis?

Analysis of API response timings, how the load balancing is done, response verification at each component is done.

A software like locust tool is used to analyze all the API responses and load balancing.

5) How were the results of the analysis communicated to the actuator?

After analysis and changes made in the application we can again do API Testing using an actuator and see the results.

6) Discuss the benefits, if any.

a) Multiple cycles are involved in this framework which contributes to the better quality of the application.

b) We can save the knowledge(like important observations, behavior of the application) gained through this framework for future use as multiple reviews are involved.

7) Discuss the challenges, if any.

a) It can be time consuming as multiple cycles are involved.