CS553 Homework #4

Understanding the Cost of Cloud Computing

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Instructions:

- *Assigned date: Thursday October 6th, 2022*
- *Due date: 11:59PM on Friday October 14th, 2022*
- *Maximum Points: 100%*
- *This homework can be done in teams of up to 3 students*
- *Please post your questions to BB*
- *Only a softcopy submission is required; submission is a 2-step process: 1) push changes to GIT repository, and email confirmation will be sent to your HAWK email address at the deadline; a confirmation document with all team member names and A# must be submitted through BlackBoard for your submission to be graded; only 1 student must submit the assignment, and only the submitting student will receive the confirmation email*
- *Late submission will be penalized at 10% per day*

1. Introduction

You are hired by a startup company who is considering to use cloud computing instead of building its own infrastructure. There is concensus that a cloud computing software stack at the layer of IaaS will be used, but its not clear whether the computing resources should be rented from a public cloud on-demand, or whether a private cloud should be purchased. You are tasked to find the cost breakdown of a private cloud, and compare that to what Amazon would charge. You can find many instance types defined at http://aws.amazon.com/ec2/instance-types/, and their prices are set at http://aws.amazon.com/ec2/pricing/. For pricing purposes, please stick to Linux on- demand pricing. There are a variety of Amazon caluclators for S3 (https://calculator.aws/#/createCalculator/S3) and EC2 (https://calculator.aws/#/createCalculator/EC2), please use them if you find them useful.

Since you have to estimate the cost of the hardware when building a private cloud, you can use hardware prices found at ThinkMate website (https://www.thinkmate.com) as good sources for server hardware (for configuration #1 and #3). For configuration #2, you will need to use the Apple website (https://www.apple.com/mac-mini/). You must include a printout of your shopping cart in your final writeup report for this assignment; include this as an appendix at the end of your report.

You are to estimate the cost of different configurations for 3 different set of requirements; compute prices for a 5- year period:

- Configuration 1: Hadoop/Spark Cluster with 160K-cores, 128TB memory, 24PB HDD, and 100Gb/s Ethernet Fat-Tree network (each VM should be equivalent to the d3.8xlarge instance); in addition to the compute resources, a 48PB distributed storage shared across the entire cloud should be procured, with the expectation that 48PB of data will be read and written to S3 every year from outside of Amazon with enough capacity for 1GB/sec throughput (for pricing comparison, see S3 Standard). For EC2, you must use the reserved instance pricing with a standard 5-year term.
- Configuration 2: Support 1K application developers who are designing MacOS and iPad OS

applications. They require a MacOS system with 6-cores (3GHz), 32GB RAM, 1TB storage, and 10Gb/s network (Amazon has mac1.metal instances that have everything you need except the 1TB storage, which you can provision through EBS). The developers work 40 hours/week, 48 weeks/year (they get 4 weeks of vacation per year). You must use on-demand EC2 pricing as developers are expected to provision their systems at the beginning of each working day, and release their systems at the end of each working day.

- Configuration 3: Ethereum crypto currency mining; you have an investor who has $10M to buy hardware

to mine Raven Coin RVN (and pay for maintenance / sys admin, power, and cooling), or rent resources from Amazon EC2 to mine Raven Coin. Configure the best hardware you can from ThinkMate. For buying hardware solution, make sure to leave funds to pay for power, cooling, and system administrator. Raven Coin mining can be done on any compute hardware (CPUs or GPUs), but you will likely find that its most profitable to mine using GPUs. Since Ethereum mining is compute intensive, your processor, memory, hard drive, and network requirements are minimal (4-cores, 8GB RAM, 100GB HDD, and 1Gb/sec network). Identify the best Amazon instance (you must use Spot Instances to make sure you get the best hardware for the cheapest price); although spot pricing fluctuates over time, you can assume the spot price will remain fixed for the duration of your evaluation. For the purchase of the hardware scenario, you are free to locate the hardware in any state in the USA (for a full list of average electricity cost by state, see https://www.chooseenergy.com/electricity-rates-by-state/); since this will be a business venture, use the business electricity rates. If electricity is too expensive to make a profit, invest part of the $1M in solar power (solar panels), and estimate the amount of energy you can extract. For an overview of various GPUs and their respective hashrates (the higher the hashrates, the more Raven Coin that can be mined), see https://whattomine.com (KawPow); this online resource has an even more exhaustive list of GPUs and their hashrate; https://www.betterhash.net/mining/gpu/?page=1. Once you have a hashrate, you can estimate how much money can be made mining Ethereum by using an online caluclator such as https://www.cryptocompare.com/mining/calculator/eth?HashingPower=0&HashingUnit=MH%2Fs&PowerConsumption=0&CostPerkWh=0&MiningPoolFee=1. The mining calculator gives an instantanous mining number, although in reality the amount of coin that can be mined would vary based on many factors (hash rate, hash difficulty, fees, etc). The profit similarly can vary based on the Raven Coin pricing, which can vary wildly. When computing the mining coins and expected profit, you can use the caluclator above to compute it for a 5-year period, assuming the mining continues at the same rate, and the price remains at the same level. Your task is to compute the amount of profit that is expected after $10M is invested in buying hardware and running it for 5-years, vs. renting the hardware from Amazon. Its possible that the profits you make will be less than the original investment (especially with the Amazon scenario).

2. What you will submit?

Your deliverables for this project are to be written in a report, which will include the following:

- Report: A written document (typed, named hw4-report.pdf) describing your answers to the above questions.

- Compare the costs of the 3 different configurations between the public cloud (Amazon AWS) and the private cloud
    - you may assume a 5-year amortization cost
    - you will have to factor in things other than hardware, such as cooling, power, administration costs, network infrastructure (e.g. switches); you can assume 1 system administrator is needed for every 500 servers
    - show your data in three different tables with the costs of each of the 3 configurations, broken down by components (e.g. servers, network switches, cables, racks, cooling, power, administration, etc)
    - summarize your data in a 4th table, comparing the public cloud cost to the private cloud cost

- Explain in words if it is better to rent or buy, and by how much.

- Include your shopping cart of the 3 configurations. Your submission should be a single large PDF file, starting with your report, and followed by the shopping carts.

Configuration 1

Table 1: Table summarizing each of the three configurations; please include 1 table per configuration, for a total of 3 tables

	Description	Price per Item	Quantity	Total Price
Compute Servers	**RAX QN24-22E2 (754.2W)**	**$32,104**	**1250**	**$40,130,000**
Network Switches	**NVIDIA MSN4600-CS2RO Spectrum-3 100GbE 2U Open Ethernet Switch**	**$32,600**	**22**	**$717,200**
Network Cables	**Mellanox 100GbE QSFP28 Direct Attach Copper Cable**	**$259**	**1300**	**$336,700**
Racks	**151DC 48U**	**$2162**	**54**	**$116,800**
Storage Servers	**STX-JB JE60-0420-TL**	**$39,399**	**19**	**NA**
Electric Power	**Consumption*$0.0882*43800**	**$ 0.0882 $/kWh**	**942.75 kWh**	**$3,641,994**
Cooling	**In-line with power cost**	**NA**	**NA**	**$3,641,994**
Administration	**150,000/yr (per head)**	**$150,000**	**3**	**$2,250,000**
TOTAL				**$50,834,688**

- *Electric Power = rates are taken for Utah = $0.0882 $/kWh*
- ***For config 1 power consumption for Network Switches is not included, as was not able to find it for the mentioned switch,*
- *Power Consumption is only computed for Compute Servers i.e (0.7542 kWh*1250 and could not do it for the network switches, I tried a lot to find it but was unable to find it.*

Configuration 2

Table 1: Table summarizing each of the three configurations; please include 1 table per configuration, for a total of 3 tables

	Description	Price per Item	Quantity	Total Price (5years)
Compute Servers	**Mac Mini (3GHz 6Core, 8th Gen - i5, 32GB Ram, ITB storage, 10Gb/s Ethernet) (122 W)**	**2124**	**1000**	**2,124,000**
Network Switches	**Mellanox MSN2410-BB2F Spectrum Based 10gbe40gbe (295 W)**	**10,230**	**22**	**102,300**
Network Cables	**NVIDIA MFA1A00-C100 AOC Cable Ethernet 100GbE QSFP + 25G SFP28 SFP+ DAC Cable**	**160+17**	**24+1000**	**20,840**
Racks	**NA**	**NA**	**NA**	**NA**
Storage Servers	**NA**	**NA**	**NA**	**NA**
Electric Power	**Consumption*$0.0882 (Utah)*1920 hrs*5**	**122W(per node) + 295W(per switch)**	**1000 + 22**	**$108,864**
Cooling	**In-line with power cost**	**NA**	**NA**	**$108,864**
Administration	**Per Hw2, $150,000/yr**	**150,000**	**2**	**$1,500,000**
TOTAL	**N/A**	**N/A**	**N/A**	**$3,964,868**

- *Electric Power = rates are taken for Utah = $0.0882 $/kWh*
- *Power Consumption is computed for both Compute Servers and network switches i.e 122W*1000 + 295W*22*

Configuration 3

Table 1: Table summarizing each of the three configurations; please include 1 table per configuration, for a total of 3 tables

	Description	Price per Item	Quantity	Total Price
Compute Servers	**GPX QT8-12E2-8GPU 274W GTX 3080Ti 350W**	**$8,717 $1,300**	**89 712**	**$775,813 $925,600**
Network Switches	**Mellanox Spectrum SN2700 32-Port 40GbE Open Ethernet Switch with ONIE - Part ID: MSN2700-BS2FO - Colfax Direct**	**$11,204**	**3**	**$33,612**
Network Cables	**3m (10ft) FS for Mellanox MCP2M00-A003 Compatible 25G SFP28 Passive Direct Attach Copper Twinax Cable**	**$45**	**96**	**$4,320**
Racks	**42u LA Server Rack Enclosure**	**$1,602.86**	**45**	**$72,128.70**
Storage Servers	**NA**	**NA**	**NA**	**NA**
Electric Power	**Consumption*$0.0882 (Utah)*1920 hrs*5**	**$ 0.0882 $/kWh**	**17231966.4 kwh**	**$1,550,876.98**
Cooling			**67911906.3**	**$6,112,071.57**
Administration	**150,000/yr**	**150,000/yr**	**1**	**$150,000**
TOTAL				**$9,974,422**

Table 2: Summary table comparing the 2 configurations between the public and private cloud; your cost of power, cooling, and administration should be to cover 5 years of costs

	Configuration 1	Configuration 2
Public Cloud (including EC2 and S3) Cost over 5 years	**239,292,660 (EC2) + 5,194,740(S3) = $244,487,400**	**10,396,800+6,144,000= $16,540,800**
Private Cloud cost over 5 years	**$50,834,688**	**$3,964,868**

Table 3: Summary table comparing the profits with configuration #3 between the public and private cloud over a 5-year period

	Configuration 3
Public Cloud Mining Profit over 5 years (p4d.24xlarge)	**-$9,454,662**
Private Cloud Mining Profit over 5 years	**-$76,478,422**

- Taking p4d.24xlarge instance for public cloud with 235.92 spot price/day, the instance comes with 8x Tesla A100 GPU
- so cost for 5yrs is $430,554, and would be taking 23 instances (total 9,902,742)

- Hashrate produced by this server is 23*1404 = **32,292 MH/s (Public Cloud)**

- hence profit for over 1 month is **7,468.84**
- and profit for public cloud over 5 yr is 7468*60 = **$448,080**

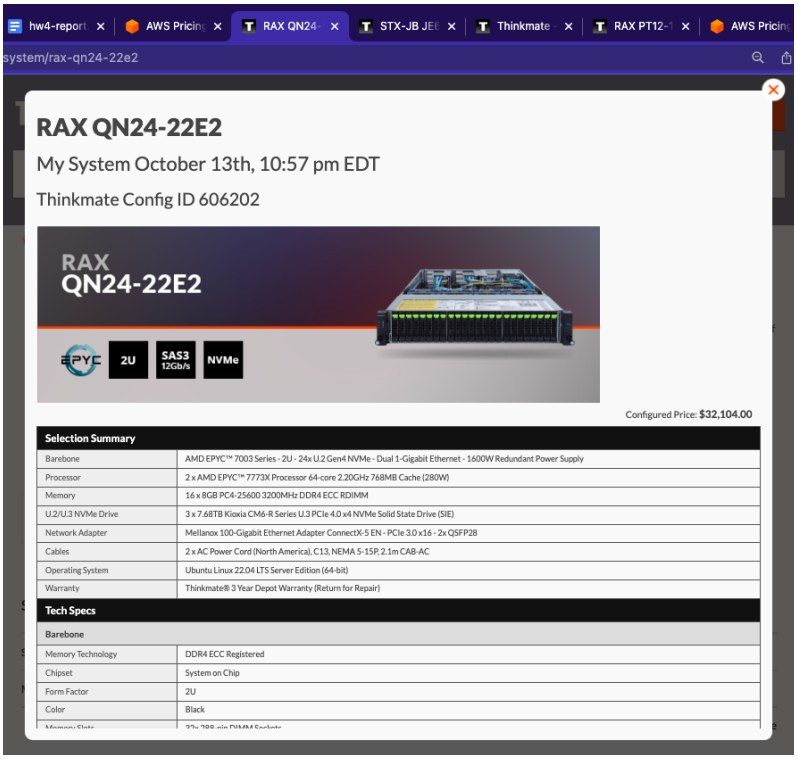
- hence, **total profit for public cloud $9,902,742 - 448,080 = $9,454,662**

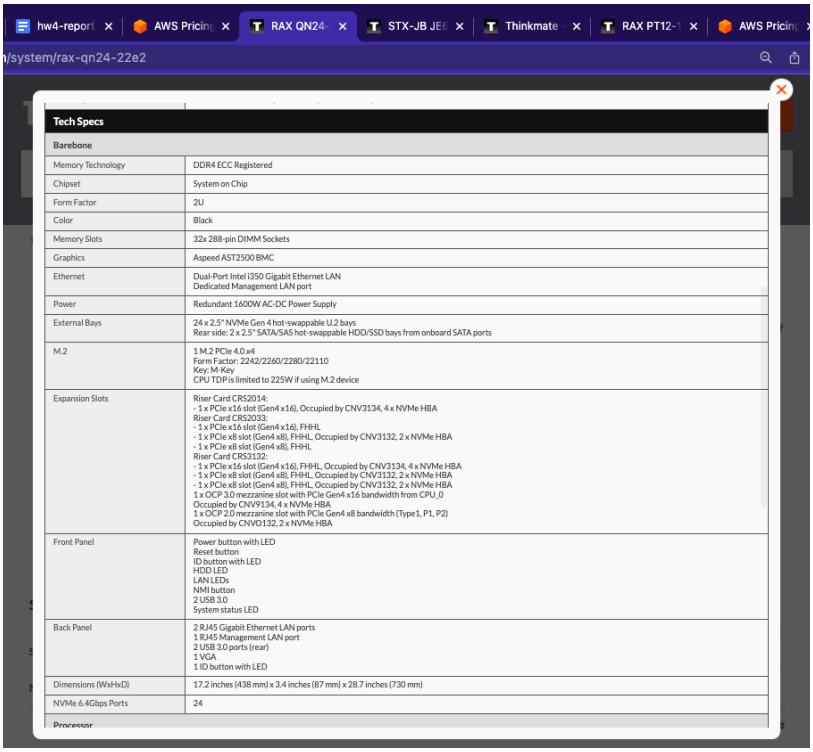
For private cloud:
the total hash rate would be 50 MH/s * 712 = 35,600 MH/s
Profit for Private Cloud for 1month = -$1,108,400.51

Profit for private cloud for 5 years = -$1,108,400.51* 60 = -$66,504,000
hence, total profit for private cloud -$9,974,422 - 66,504,000 = -$76,478,422

Shopping Carts -

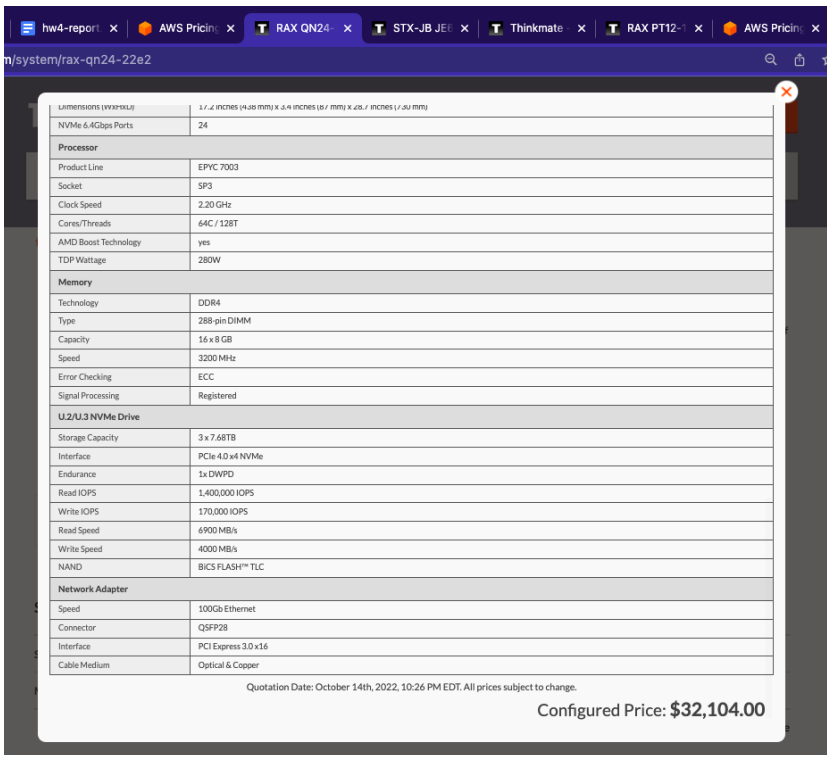
Configuration 1





Tech Specs

Barebone	
Memory Technology	DDR4 ECC Registered
Chipset	System on Chip
Form Factor	2U
Color	Black
Memory Slots	32x 288-pin DIMM Sockets
Graphics	Aspeed AST2500 BMC
Ethernet	Dual-Port Intel i350 Gigabit Ethernet LAN Dedicated Management LAN port
Power	Redundant 1600W AC-DC Power Supply
External Bays	24 x 2.5" NVMe Gen 4 hot-swappable U.2 bays Rear side: 2 x 2.5" SATA/SAS hot-swappable HDD/SSD bays from onboard SATA ports
M.2	1 M.2 PCIe 4.0 x4 Form Factor: 2242/2260/2280/22110 Key: M-Key CPU TDP is limited to 225W if using M.2 device
Expansion Slots	Riser Card CRS2014: - 1 x PCIe x16 slot (Gen4 x16), Occupied by CNV3134, 4 x NVMe HBA Riser Card CRS2033: - 1 x PCIe x16 slot (Gen4 x16), FHHL - 1 x PCIe x8 slot (Gen4 x8), FHHL, Occupied by CNV3132, 2 x NVMe HBA - 1 x PCIe x8 slot (Gen4 x8), FHHL Riser Card CRS3132: - 1 x PCIe x16 slot (Gen4 x16), FHHL, Occupied by CNV3134, 4 x NVMe HBA - 1 x PCIe x8 slot (Gen4 x8), FHHL, Occupied by CNV3132, 2 x NVMe HBA - 1 x PCIe x8 slot (Gen4 x8), FHHL, Occupied by CNV3132, 2 x NVMe HBA 1 x OCP 3.0 mezzanine slot with PCIe Gen4 x16 bandwidth from CPU_0 Occupied by CNV9134, 4 x NVMe HBA 1 x OCP 2.0 mezzanine slot with PCIe Gen4 x8 bandwidth (Type1, P1, P2) Occupied by CNVO132, 2 x NVMe HBA
Front Panel	Power button with LED Reset button ID button with LED HDD LED LAN LEDs NMI button 2 USB 3.0 System status LED
Back Panel	2 RJ45 Gigabit Ethernet LAN ports 1 RJ45 Management LAN port 2 USB 3.0 ports (rear) 1 VGA 1 ID button with LED
Dimensions (WxHxD)	17.2 inches (438 mm) x 3.4 inches (87 mm) x 28.7 inches (730 mm)
NVMe 6.4Gbps Ports	24
Processor	



Dimensions (WxHxD)	17.2 inches (438 mm) x 3.4 inches (87 mm) x 28.7 inches (730 mm)
NVMe 6.4Gbps Ports	24
Processor	
Product Line	EPYC 7003
Socket	SP3
Clock Speed	2.20 GHz
Cores/Threads	64C / 128T
AMD Boost Technology	yes
TDP Wattage	280W
Memory	
Technology	DDR4
Type	288-pin DIMM
Capacity	16 x 8 GB
Speed	3200 MHz
Error Checking	ECC
Signal Processing	Registered
U.2/U.3 NVMe Drive	
Storage Capacity	3 x 7.68TB
Interface	PCIe 4.0 x4 NVMe
Endurance	1x DWPD
Read IOPS	1,400,000 IOPS
Write IOPS	170,000 IOPS
Read Speed	6900 MB/s
Write Speed	4000 MB/s
NAND	BiCS FLASH™ TLC
Network Adapter	
Speed	100Gb Ethernet
Connector	QSFP28
Interface	PCI Express 3.0 x16
Cable Medium	Optical & Copper

Quotation Date: October 14th, 2022, 10:26 PM EDT. All prices subject to change.

Configured Price: **$32,104.00**

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Do you have a loading dock? *

Yes

Qty

27

Total Price:

$58,400.73

Help

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Product details

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Brand: Mellanox

$259.50

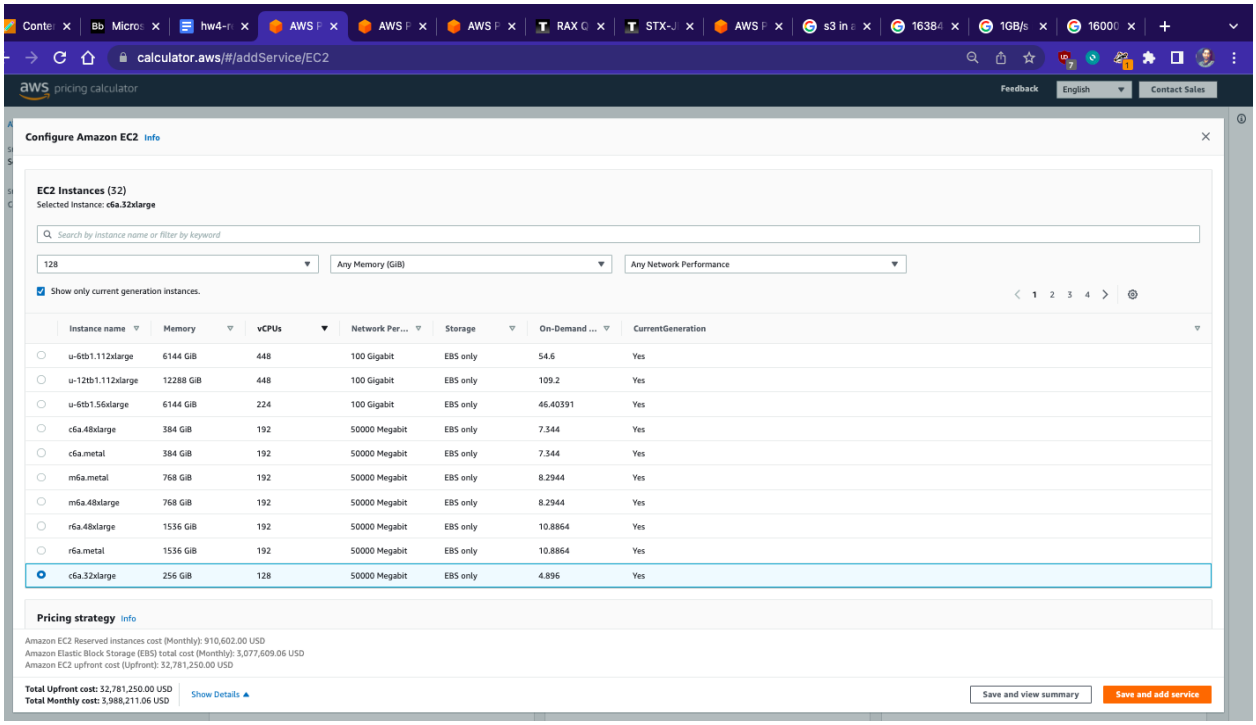
Pay $21.62/month for 12 months, interest-free upon approval for the Amazon Rewards Visa Card

Product details

Brand	Mellanox
Connector Type	RJ45
Cable Type	Ethernet
Color	Black
Item Weight	0.45 Kilograms
Series	NVIDIA MCP1600-C005E26L Direct Attach Copper Cable

For EC2, in config 1, I used

c6a.32xlarge 256 GiB 128 50000 Megabit



Configuration 2

Mac mini 1 $1,999.00

Pay 0% APR for 12 months: $166.58/mo.

Hide product details Remove

Hardware

- 3.0GHz 6-core 8th-generation Intel Core i5 (Turbo Boost up to 4.1GHz)
- 32GB 2666MHz DDR4
- Intel UHD Graphics 630
- 1TB SSD storage
- 10 Gigabit Ethernet
- Accessory Kit

Software

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Total	**$2,123.94**

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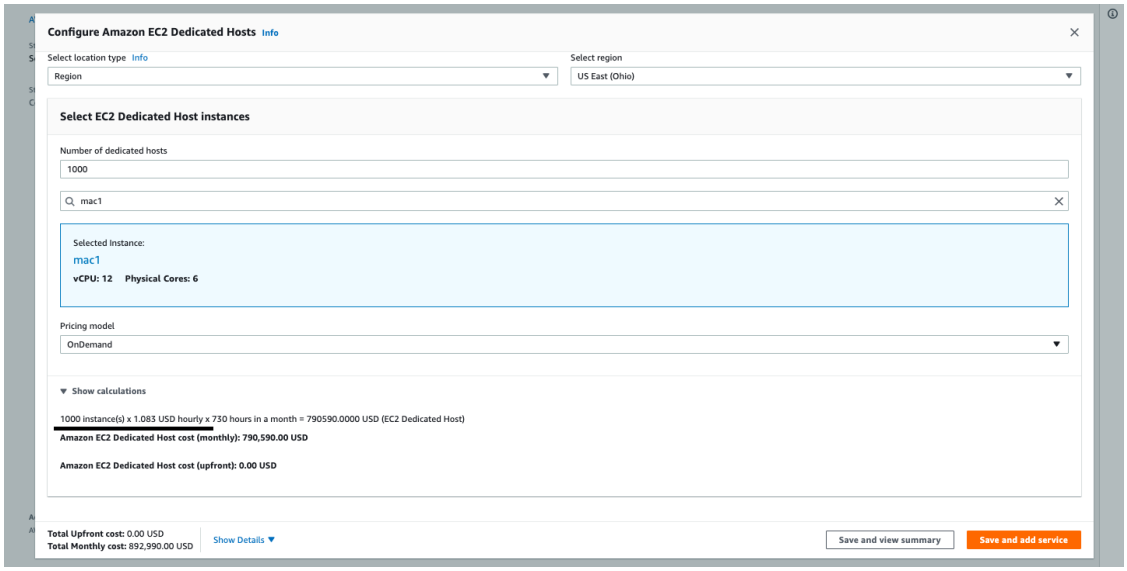
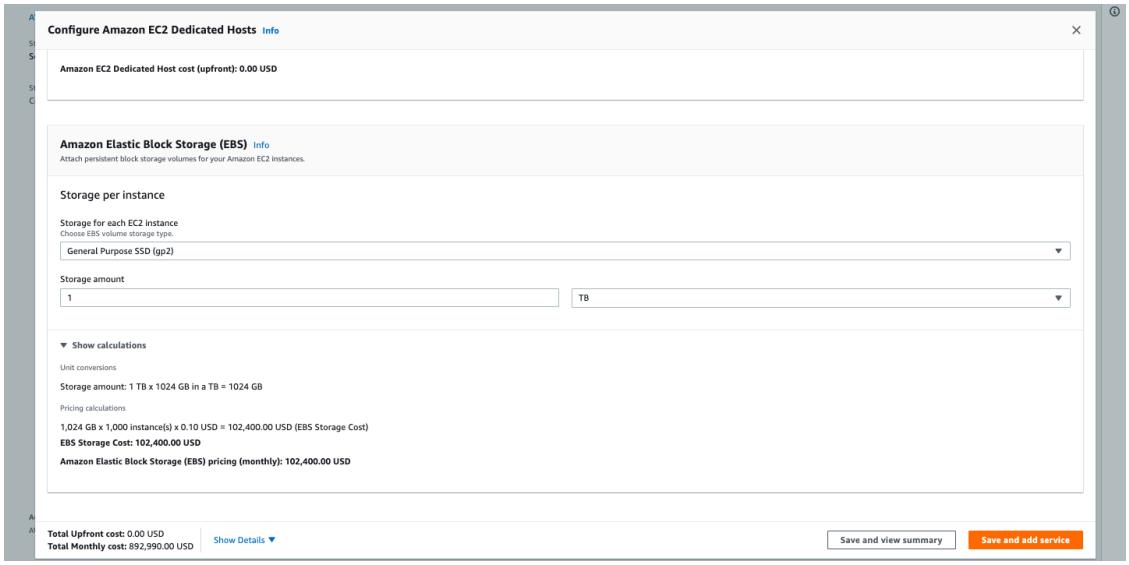
For public Cloud took up hourly rate, and computed it for 5years, and same for EBS, took up monthly rate and computed it for 5 years





Other referred Links:

Electricity Rates by State (October 2022) | ChooseEnergy.com®

Mellanox MSN2410-BB2F Spectrum Based 10gbe40gbe 1U

NVIDIA MFA1A00-C100 AOC Cable Ethernet 100GbE QSFP 100m

NVIDIA MSN2410-BB2FC Spectrum™ based 10GbE/100GbE 1U Open Ethernet switch with Cumulus Linux,

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Mellanox Spectrum-3 MSN4600-CS2R Ethernet Switch

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https://www.racksolutions.com/datacenter-racks.html

Mellanox 100GbE QSFP28 Direct Attach Copper Cable - 100GBase Direct Attach Cable

NVIDIA MFA1A00-C100 AOC Cable Ethernet 100GbE QSFP 100m

https://calculator.aws/#/addService/EC2

https://classroom.github.com/a/36GEvn29.