HW4

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1 Assumptions

1.1 Network Switches and Cables

We calculate the number of switches and cables as follows [9]:

k is the number of ports on a switch
N is the number of computers
$N_s = k/2$ is the number of switches per pod
$N_p = \lceil N/(N_s * k/2) \rceil$ is the number of pods
$N_e = N_p * N_s$ is the number of edge switches
$N_a = N_e$ is the number of aggregate switches
$N_c = \lceil N_s * (k/2)/(k/N_p) \rceil$ is the number of core switches

Thus, the number of switches is: $T_s = N_c + N_a + N_e$
Thus, the number of links is: $k * T_s$

We used [3] and [2] for the cost of network switches in the 25gbps and 10gbps cases respectively
We used [1] (25gbps ethernet) for both the 25gbps and 10gbps cases.
We create fat tree networks for both storage and compute servers.

1.2 Energy

According to [8], North Virginia has an hourly power rate of roughly .083 $/KWH. We assume we are operating at full power 24hrs a day.

1.3 Cooling

According to [4] and [5], we can estimate the cooling cost by considering the cooling cost of the server equipment and the area of the room. According to [4], we can assume that it takes exactly as much power to cool the server equipment as the amount of power the server generates. Furthermore, we can assume that we need to use 20 BTU/hr of cooling energy per square foot of area [5]. In order to estimate the area of the room, we assume that the racks are placed side-by-side with no space in between. We multiply the area (width*depth) of each rack by the number of racks in the configuration. We use the cabinets in [7] to house the server racks. Overall, we can calculate the cooling cost as follows:

[(Server Energy Consumption in KW) + (20 (BTU/hr)/sqft)*(.000293 KW/(BTU/hr)*(Server Room Area)*(24*365*5 hours)]*[.083 $/KWH]

We assume the building has AC in the server room already. No additional hardware is purchased. Only the energy cost is considered.

1.4 Administration

According to [10], the average network administrator salary is $59,323. We will assume that there needs to be one administrator for every 1000 server nodes.

1.5 Storage Throughput

When estimating the number of storage devices for storage servers, we use the following inequality to make sure that we meet the minimum throghput requirement:

(Minimum Throughput) <(Bandwidth of HDD)*(Number of HDDs)

We assume HDD has a bandwidth of 120 MB/s.

2 Configuration 1

COMPUTE:
384GB * 6400 = 2,457,600GB = 2.34PB of RAM
4*16TB * 6400 = 409,600TB = 400PB of Storage
40 cores * 6400 = 256,000 cores

STORAGE:
36*16TB * 1389 = 800,064TB = 800PB
36*120 MBPS * 1389 = 6,000 GBPS

	Description	Price Per Item	Quantity	Total
Compute Servers	384GB RAM 4x 16TB HDD 2x 20-core CPU 426.4 Watts 1U	$10,359.00	6,400.00	$66,297,600.00
Network Switches	48-port, 25GB/s switch	$6,200.00	900	$5,580,000.00
Network Cables	25GB/s 2m cable	$78.00	43,200.00	$3,369,600.00
Racks	42U Cabinet	$992.99	307	$303,949.51
Storage Servers	32GB RAM 36x 16TB HDD 793.5w 4U	$24,414.00	1,389.00	$33,911,046.00
Electric Power	Energy cost of server (compute and storage) hardware in North Virginia	$0.0830/kwh	161,160,028.2600 kwh	$13,376,282.35
Cooling	Energy cost of AC in North Virginia	$0.0830/kwh	161,162,448.2197 kwh	$13,376,483.20
Administration	Those who manage the server.	$59,323.00	8	$462,066.85
Total				$136,676,827.05

Figure 1: Private Cloud Configuration-1

	Description	Price Per Item (Monthly)	Quantity (Monthly)	Total (Monthly)	Total (5 Years)
Compute Servers	d2.8 Large 36vCPU 244GB RAM 24x 2TB HDD	$4,032.60	8,334.00	$33,607,688.40	$2,016,461,304.00
Storage Servers	800PB of S3 Storage	$17,616,640.00	1.00	$17,616,640.00	$1,056,998,400.00
Total					$3,073,459,704.00

Figure 2: Public Cloud Configuation-1

3 Configuration 2

COMPUTE:
1TB * 16,000 = 16,000TB = 16PB of RAM = 16GB RAM per VM
(2TB + 2*1.5TB) * 16,000 = 80,000TB = 80PB of Storage = 80GB storage per VM
2*64 cores * 16,000 = 2048000 cores = 2.048 cores per VM

STORAGE:
36*16TB * 24 = 13,824TB = 13.824PB
36*120 MBPS * 24 = 103.68 GBPS

	Description	Price Per Item	Quantity	Total
Compute Servers	1TB RAM 1x 2TB NVME 2x 1.5TB NVME 2x 64 core CPU 793.5 watt 1U	$35,966.00	16,000.00	$575,456,000.00
Network Switches	48-port, 10GB/s switch	$3,600.00	1,740.00	$6,264,000.00
Network Cables	25GB/s 2m cable	$78.00	83,520.00	$6,514,560.00
Racks	42U Cabinet	$992.99	425	$421,689.75
Storage Servers	32GB RAM 36x 16TB HDD 682.7 watt 4U	$24,439.00	24	$586,536.00
Electric Power	Energy cost of server (compute and storage) hardware in North Virginia	$0.0830/kwh	556,802,454.2400 kwh	$46,214,603.70
Cooling	Energy cost of AC in North Virginia	$0.0830/kwh	556,804,874.1997 kwh	$46,214,804.56
Administration	Those who manage the server.	$59,323.00	17	$950,591.75
Total				$682,622,584.91

Figure 3: Private Cloud Configuration-1

	Description	Price Per Item (Monthly)	Quantity (Monthly)	Total (Monthly)	Total (5 Years)
Compute Servers	2vCPU 16GB RAM 75GB NVME	$108.12	1,000,000.00	$108,120,000.00	$6,487,200,000.00
Storage Servers	10PB of S3 storage	$220,764.16	1.00	$220,764.16	$13,245,849.60
Total					$6,500,445,849.60

Figure 4: Public Cloud Configuation-1

4 Configuration 3

According to [6], the NVIDIA v100 GPU has 7tflops of double-precision performance.

COMPUTE:
8*7tflops * 17,858 = 1,000,048tflops = 1 exaflop

STORAGE:
36*16TB * 3 = 1,727TB = 1.7PB
36*120 MBPS * 3 = 12.96 GBPS

	Description	Price Per Item	Quantity	Total
Compute Servers	512GB RAM 64 core CPU 8x NVIDIA V100 GPU 2310 watt 1TB HDD 2U	$80,698.00	17,858.00	$1,441,104,884.00
Network Switches	48-port, 25GB/s switch	$6,200.00	1,980.00	$12,276,000.00
Network Cables	25GB/s 2m cable	$78.00	95,040.00	$7,413,120.00
Racks	42U Cabinet	$992.99	898	$891,515.88
Storage Servers	32GB RAM 36x 16TB HDD 691.5 watt 4U	$24,351.00	3	$73,053.00
Electric Power	Energy cost of server (compute and storage) hardware in North Virginia	$0.0830/kwh	1,806,927,587.1000 kwh	$149,974,989.73
Cooling	Energy cost of AC in North Virginia	$0.0830/kwh	1,806,930,007.0597 kwh	$149,975,190.59
Administration	Those who manage the server.	$59,323.00	18	$1,059,568.10
Total				$1,762,768,120.44

Figure 5: Private Cloud Configuration-1

	Description	Price Per Item (Monthly)	Quantity (Monthly)	Total (Monthly)	Total (5 Years)
Compute Servers	488GB RAM 64 core CPU 8x NVIDIA V100 GPU	$17,873.40	17,858.00	$319,183,177.20	$19,150,990,632.00
Storage Servers	1PB of S3 Storage	$22,583.30	1.00	$22,583.30	$1,353,998.00
Total					$19,150,990,632.00

Figure 6: Public Cloud Configuation-1

5 Comparison

	Configuration 1	Configuration 2	Configuration 3
Public Cloud (Includign Ec2 and S3) Cost over 5 years, 24/7 Operation with 100% usage	$3,073,459,704.00	$6,500,445,849.60	$19,150,990,632.00
Private Cloud cost over 5 years, 24/7 operation, with 100% usage	$136,676,827.05	$682,622,584.91	$1,762,768,120.44
What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud?	4.45%	10.50%	9.20%

Figure 7: Public vs Private Clouds

From this figure, it is apparent that purchasing is better than renting. It requires between 4% and 10.5% utilization in order to make it worth purchasing this equipment.

6 Appendix

6.1 Configuration 1

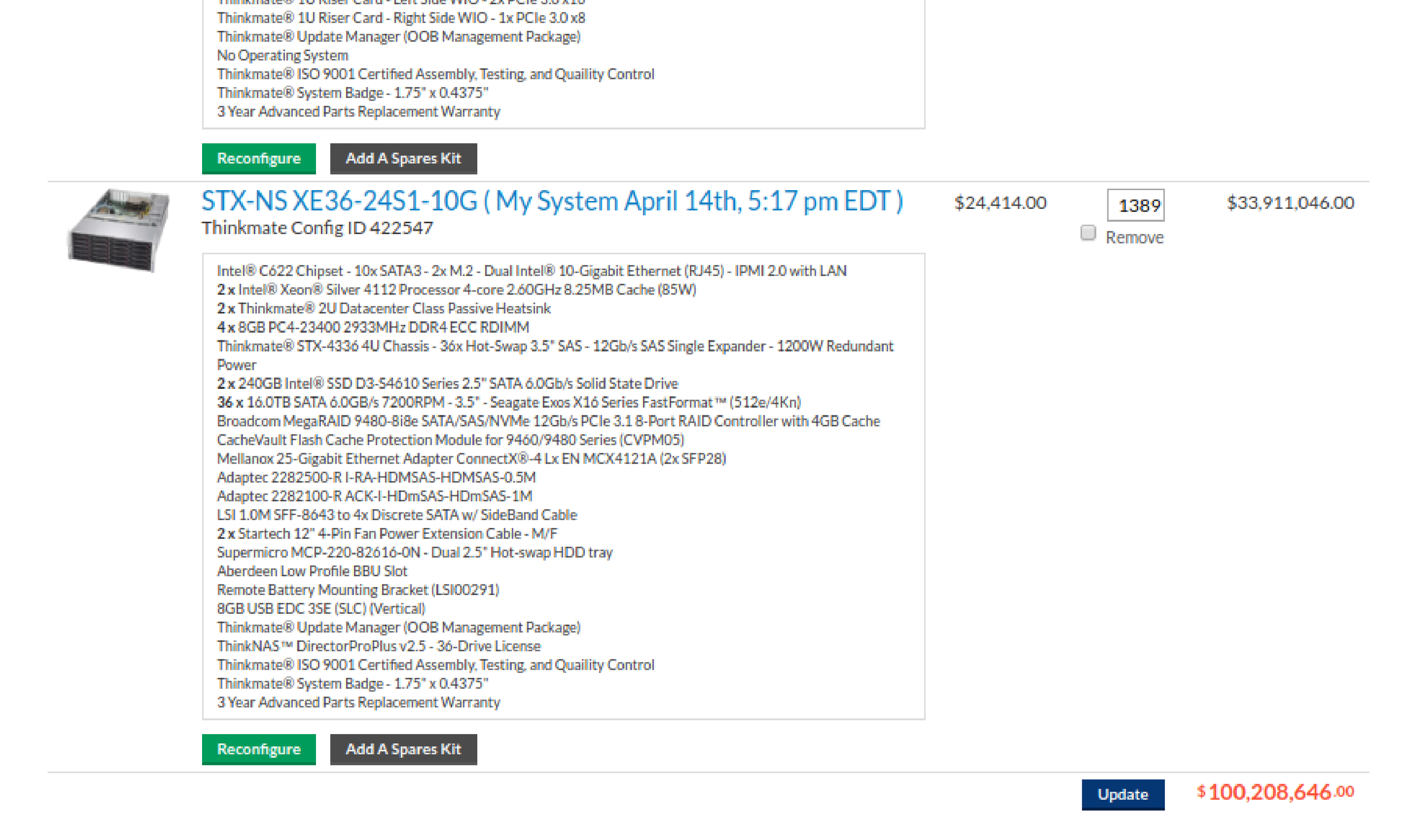

Figure 8: Private Cloud Configuration-1 Shopping Cart

Figure 9: Public Cloud Configuation-1 AWS Estimation

6.2 Configuration 2

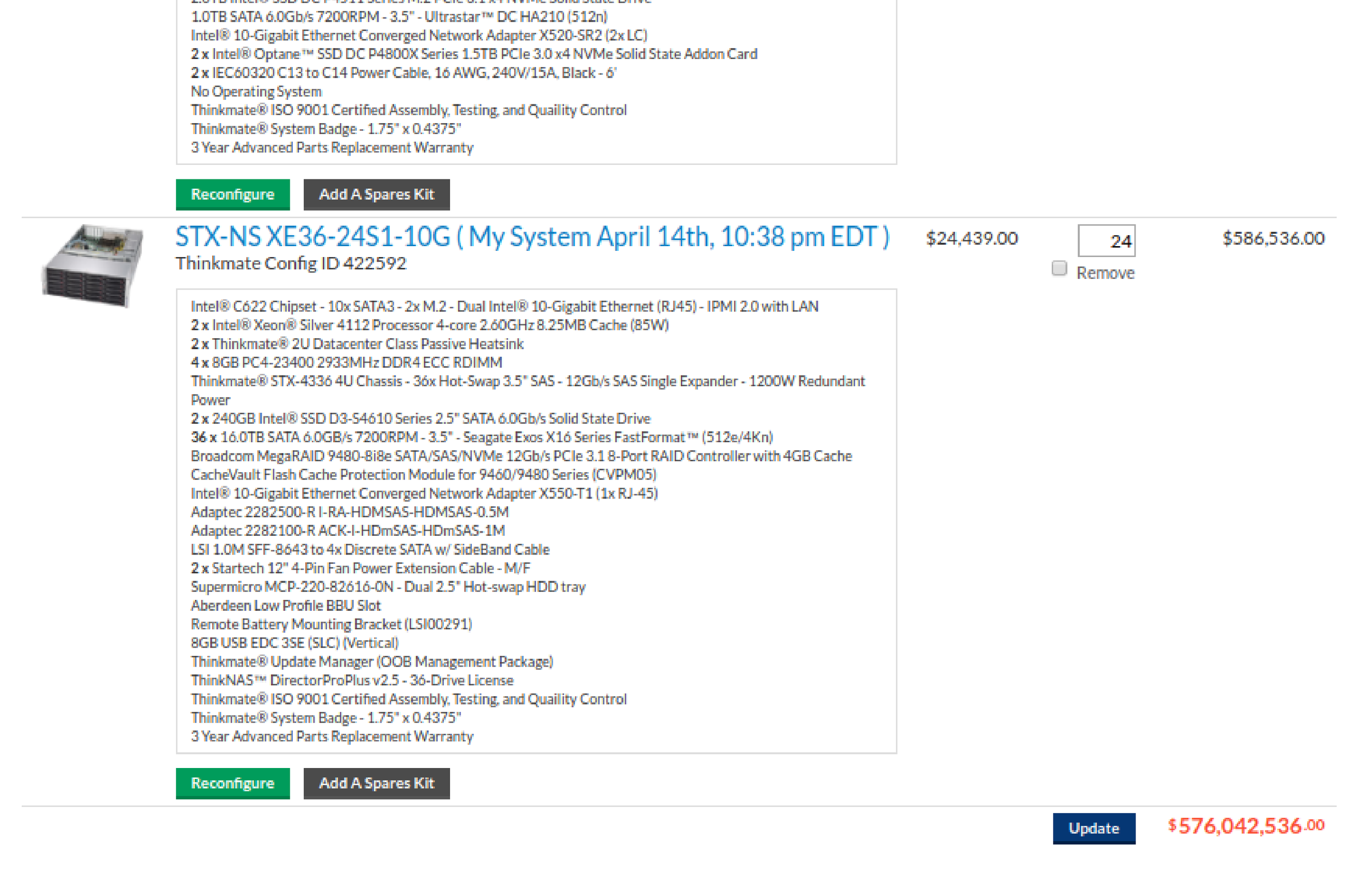

Figure 10: Private Cloud Configuration-2 Shopping Cart

Figure 11: Public Cloud Configuation-2 AWS Estimation

6.3 Configuration 3

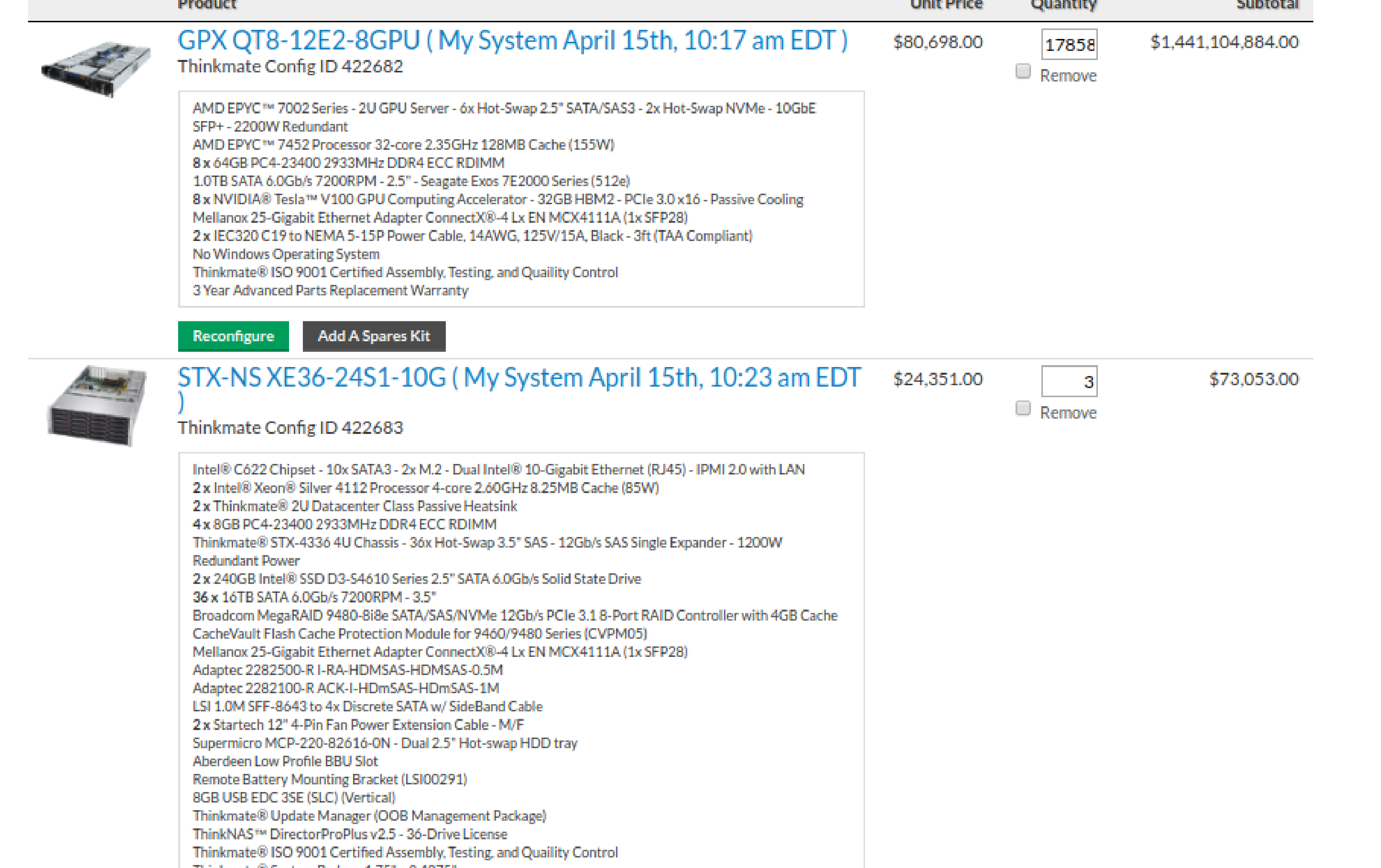

Figure 12: Private Cloud Configuration-3 Shopping Cart

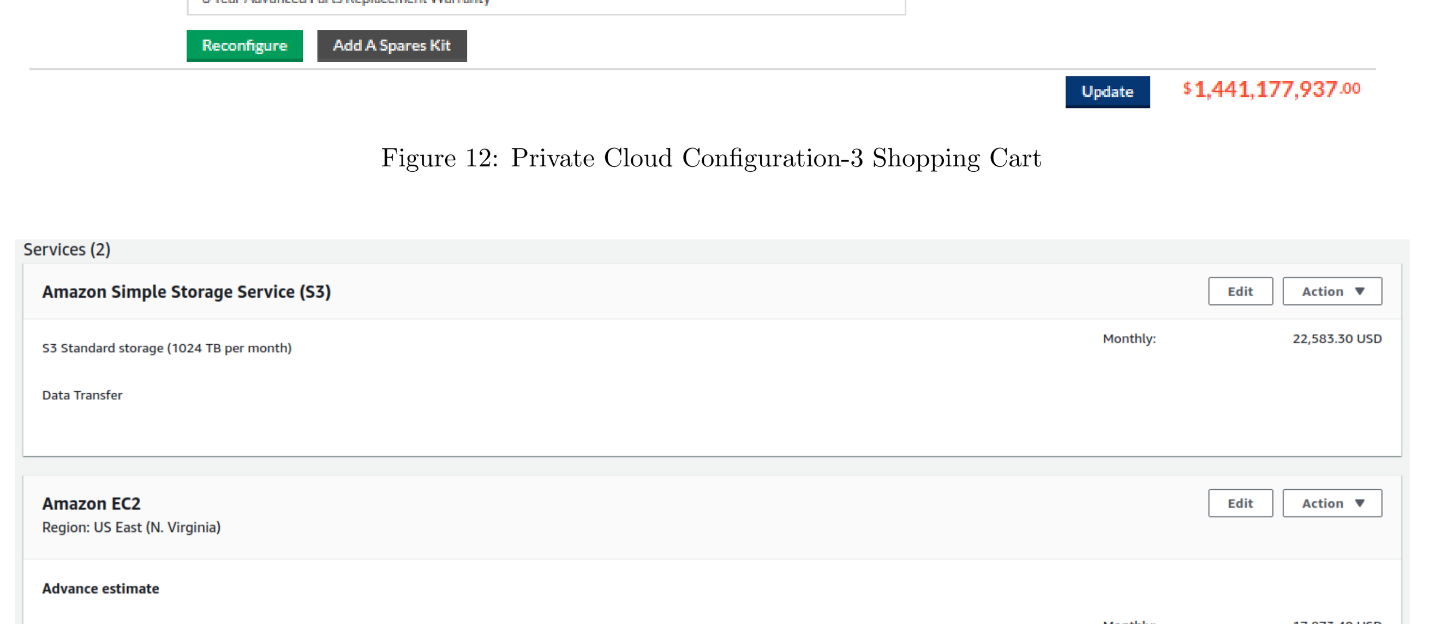

Figure 13: Public Cloud Configuation-3 AWS Estimation

References

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