

UNDERSTANDING THE COST OF CLOUD COMPUTING

CS553 PROJECT

under the guidance of : PROFESSOR IOAN RAICU

Team:

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CLOUD COMPUTING PROJECT

Public Cloud:

Configuration 1:

| Name | vCPUs | Cores | ECU | Memory(GiB) | Storage(GB) | Linux/UNIX Usage |
|------------|-------|-------|-----|-------------|-------------|------------------|
| d2.8xlarge | 36 | 18 | 116 | 244 | 24*2000HDD | \$5.52 per hour |

Calculations of the number of instances we need of d2.8xlarge to get the total public cloud cost.

- 1) With respect to the number of cores:
 As mentioned in the question, we want 32K cores.
 $\text{Total number of d2.8xlarge instances} = 32,000 / 18$
 $= 1777.77$
 $= 1778 \text{ approx.}$
- 2) With respect to the memory:
 As mentioned in the question, we want 256 TB of memory.
 As we know, 1 GiB = 1.07374 GB
 Therefore 244 GiB = 261.993 GB = 262 GB
 $\text{Total number of d2.8xlarge instances} = 256,000 / 262$
 $= 977.09$
 $= 977 \text{ approx.}$
- 3) With respect to the storage:
 As mentioned in the question, we want 50PB HDD of storage.
 $\text{Total number of d2.8xlarge instances} = 50,000 / 48$
 $= 1041.667$
 $= 1042 \text{ approx.}$

As the number of instance is highest when calculated using the number of cores, we would consider 1778 instances of d2.8xlarge for the calculations of public and private cloud.

Total cost of public cloud:

Cost of 1778 d2.8xlarge instances monthly cost is as follows:

Compute: Amazon EC2 Instances:

| | Description | Instances | Usage | Type | Billing Option | Monthly Cost |
|--|-------------|-----------|-------------------|---------------------|--------------------|---------------|
| | | 1778 | 100 % Utilized/Mo | Linux on d2.8xlarge | On-Demand (No Cor) | \$ 7184257.92 |
| | Add New Row | | | | | |

Cost of 1778 d2.8xlarge instances yearly cost is as follows = $7184257.92 * 12$
 $= \$86,211,095.04$

Cost of 1778 d2.8xlarge instance for 5 years = $86211095.04 * 5$
 $= \$431,055,475.2$

Cost of 100 PB distributed storage for one month is = \$2202572.8

Cost of 100 PB distributed storage for 5 years is = $\$2202572.8 * 12 * 5$
 $= \$132,154,368$

COST OF CLOUD COMPUTING

| | | |
|---|------------------------------|---------------|
| + | Amazon EC2 Service (US-East) | \$ 7184272.56 |
| + | Amazon S3 Service (US-East) | \$ 2202572.80 |
| + | AWS Support (Basic) | \$ 0.00 |
| | Free Tier Discount: | \$ -14.76 |
| | Total Monthly Payment: | \$ 9386830.60 |

Therefore, the total cost of 1778 d2.8xlarge instances for 5 years is as follows:

$$= 9386830.6 * 12 * 5$$

$$= \$563,209,836$$

Private Cloud for Configuration 1:


| | | Description | Price per Item (USD) | Quantity | Total Price (USD) |
|-----|-------------------------------|---|-------------------------|----------|----------------------|
| 1. | Computer Servers | | | | |
| 1.1 | Processor & Memory | Intel Xeon E5-2695 v4 Processor LGA2011-3 Broadwell 18 Core with 1.5TB Memory | 2,599 | 1778 | 4,621,022 = 4.6M |
| 1.2 | Motherboard | Intel Server Board S2600BPB DP Xeon Socket P LGA-3647 C621 chipset DDR4 16x DIMM SATA3 RAID PCIe 2x 10GbE Custom 6.8" x 19.1" | 950 | 889 | 946,550 |
| 1.3 | Network Adopter | Supermicro Superserver 2028BT-HTR+ 2U 4-node DP Xeon LGA2011-R3 DDR4X24 SATA3 drive HotSwap 1 NIC or SIOM card R2200W | 3908 | 889 | 3,474,212=3.47M |
| 2. | Network Switches | Cisco Catalyst 4500-X -Switch - 32 x 1 Gigabit SFP/ 10 Gigabit SFP+ - rack-mountable | 7475 | 39 | 291525 |
| 3. | Network Cables | Mellanox MCP1600-C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG | 79.99 | 1834 | 146701.66 |
| 4. | Racks | APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Endosure | 2432.24 | 38 | 92425.12 |
| 5. | Storage Servers | HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply | 48,999 | 246 | 12,053,754 = 12 M |
| 6. | Electric Power | 1685W @ 12 cents per KWH in IL (246*1.6*0.12) + (1777*0.12*0.12)+(39*0.75*0.12)+(2*.12*889) | 2,608,598/yr | 5 years | 13.04M |
| 7. | Cooling | N+1 redundant fans (fans integrated in PSU) | 1,217,124.16/yr | 5 years | 5.23M |
| 8. | Administration | (Maintenance, Security, Deployment) per 500 nodes | 120,000 * (1778/500) | 5 | 2,133,600 = 2.13M |
| | TOTAL | N/A | N/A | N/A | 46.53M |

Screenshots:

CPU

Home > My Cart

My Shopping Cart

| Product | Product Code | Unit Price | Quantity | Sub Total |
|--|-------------------|------------|----------|-----------|
| Intel Xeon E5-2695 v4 Processor LGA2011-3 Broadwell 18 Core 2.10 GHz 45MB BX80660E52695V4 Box  Remove Item | CPJT-XE52695V4BOX | \$2,599 | 1 | \$2,599 |

[Continue Shopping](#) | [Update Shopping Cart](#)

Calculate Tax And Estimated Shipping Cost

Zip Code [Update](#)

Choose a delivery method

Enter your zip code to get delivery cost update.

☐ Expedited Process Order for only

Tax Estimate: N/A

Shipping Estimate: N/A


Subtotal (1 item): **\$2,599.00**

Return Policy
 Acme Micro System will accept returns on all products within seven days from the invoice date with a restocking fee of 25% exclude special order items and the manufactures listed. If it is after seven days, all returns must go through RMA process for repair or replacement.

Network Cable:

Home > My Cart

My Shopping Cart

| Product | Product Code | Unit Price | Quantity | Sub Total |
|---|---------------------|------------|----------|-----------|
| Mellanox MCP1600-C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG  Remove Item | CAB-ML-MCP1600-C001 | \$79.99 | 1 | \$79.99 |

[Continue Shopping](#) | [Update Shopping Cart](#)

Calculate Tax And Estimated Shipping Cost

Zip Code [Update](#)

Tax Estimate: N/A

Shipping Estimate: N/A

COST OF CLOUD COMPUTING

Racks:

The screenshot shows a web browser window displaying the Newegg product page for the APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure. The browser's address bar shows the URL: <https://www.newegg.com/Product/Product.aspx?Item=9SIA0ZX6KU0614>. The product image is a tall, black server rack. The product title is "APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure". The price is \$2,432.24, with a crossed-out original price of \$2,918.99, indicating a 17% discount. The product is sold and shipped by BeachAudio. The page also shows a "FREE SHIPPING AVAILABLE" banner, a "SHARE" button, and a "Customers Also Bought" section. The Windows taskbar at the bottom shows the search bar and various application icons.

APC
by Schneider Electric

APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure

Be the first to review this product... [Ask Or Answer A Question](#) [SHARE](#)

In stock. Ships from United States. Most customers receive within 2-8 days.
Sold and Shipped by [BeachAudio](#)

- Black
- 1363.64 KG (static load), 1022.73 KG (dynamic load) Weight Capacity
- Rack Enclosure

5 New from **\$2,432.24** 1 Used from **\$1,343.59**

FREE SHIPPING AVAILABLE

~~\$2,918.99~~
\$2,432.24
Save: \$486.75 (17%)

Sold and Shipped by:
BeachAudio (4,161)

1 [+](#) [-](#) [ADD TO CART](#)

☐ ADD TO COMPARE ☐ PRICE ALERT

☐ ADD TO WISH LIST

Best Service Sellers

| | |
|---|------------------------------|
| Newegg \$2,686.99 + \$119.99 Shipping | VIEW DETAILS |
| IPC Store \$2,888.33 + FREE SHIPPING AVAILABLE | VIEW DETAILS |
| PC Supply \$2,561.00 + \$59.15 Shipping | VIEW DETAILS |
| Neonbits | VIEW DETAILS |

Customers Also Bought

Recommendations

Storage Servers:

The screenshot shows a web browser window displaying the ACME Micro Systems shopping cart page. The browser's address bar shows the URL: www.acmemicro.com/Cart/Index. The page features the ACME Micro Systems logo and navigation links for Solutions, Products, Promotion, Customer Service, and About Us. The cart is titled "My Shopping Cart" and contains one item: HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply. The item details include the product code SR-HG-1ES0094, a unit price of \$49,888, a quantity of 1, and a subtotal of \$49,888. The page also includes a "Calculate Tax And Estimated Shipping Cost" section with a zip code field and an "Update" button. The subtotal for 1 item is \$49,888.00. The Windows taskbar at the bottom shows the search bar and various application icons.

ACME
MICRO SYSTEMS


[My Account](#) [Shopping Cart](#)

All Products

[Solutions](#) [Products](#) [Promotion](#) [Customer Service](#) [About Us](#)

Home > [My Cart](#)

My Shopping Cart

| Product | Product Code | Unit Price | Quantity | Sub Total |
|---|---------------|------------|----------|-----------|
| HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply  Remove Item | SR-HG-1ES0094 | \$49,888 | 1 | \$49,888 |

[Continue Shopping](#) | [Update Shopping Cart](#)

Calculate Tax And Estimated Shipping Cost

Zip Code [Update](#)

Tax Estimate: N/A

Shipping Estimate: N/A

Subtotal (1 item): **\$49,888.00**

COST OF CLOUD COMPUTING

Configuration 2:

| Name | vCPUs | ECU | Memory(GiB) | Storage(GB) | Linux/UNIX Usage |
|----------|-------|-----|-------------|-------------|------------------|
| r3.large | 2 | 6.5 | 15 | 1*32 SSD | \$0.166 per hour |

| | | Description | Price per Item (USD) | Quantity | Total Price (USD) |
|------------|-------------------------|---|----------------------|-----------|----------------------------|
| 1. | Computer Servers | | | | |
| 1.1 | Processor | Intel Xeon E5-2670 v2 (Ivy Bridge) | 1527.50 | 200,000 | 305.5M |
| 1.2 | MotherBoard | Intel Server Board S2600BPB DP Xeon Socket P LGA-3647 C621 chipset DDR4 16x DIMM SATA3 RAID PCIe 2x 10GbE Custom 6.8" x 19.1" | 950 | 100,000 | 95M |
| 1.3 | Network Adopter | Supermicro Superserver 2028BT-HTR+ 2U 4-node DP Xeon LGA2011-R3 DDR4X24 SATA3 drive HotSwap 1 NIC or SIOM card R2200W | 3908 | 100,000 | 390.8M |
| 1.4 | Memory | 16GB PC4-19200 DDR4-2400Mhz Registered ECC DIMM 1.2V Major Brand | 199.99 | 1M | 199.99M |
| 2. | Network Switches | Cisco Catalyst 4500-X -Switch - 32 x 1 Gigabit SFP/ 10 Gigabit SFP+ - rack-mountable | 7475 | 221,38 | 165,481,550 = 165.5M |
| 3. | Network Cables | Mellanox MCP1600-C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG | 79.99 | 1,040,443 | 83,225,035.57 = 83.22M |
| 4. | Racks | APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure | 2432.24 | 21295 | 51,793,436.02 = 51.8M |
| 5. | Storage Servers | HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply | 49,888 | 17 | 848,096 |
| 6. | SSD | Intel 32GB MEMPEK1W032GAXT Optane Memory Series NVMe PCIe M.2 2280 1350MB/sec Read 20nm 3D Xpoint, Retail | 96.99 | 1M | 96.99M |
| 7. | Electric Power | 1685W @ 12 cents per KWH in IL (17*1.6*0.12) + (1M*0.035*0.12)+(100000*2*0.12) + (100000*2*0.12) | 475,139,351.2/yr | 5 years | 2,375,696,756=2.375Billion |
| 8. | Cooling | N+1 redundant fans (fans integrated in PSU) | 158.379M/yr | 5 years | 791.898M |
| 9. | Administration | Maintenance, Security, Deployment per 500 nodes | 120,000*(1M/500) | 5 | 240M |
| | TOTAL | N/A | N/A | N/A | 5.036 Billion |

COST OF CLOUD COMPUTING

Calculations of the number of instances we need of r3.large to get the total public cloud cost.

Cost of 1 million r3.large instances monthly cost is as follows:

Compute: Amazon EC2 Instances:

| | Description | Instances | Usage | Type | Billing Option | Monthly Cost |
|--|-------------|-----------|-------------------|-------------------|--------------------|-----------------|
| | | 1000000 | 100 % Utilized/Mo | Linux on r3.large | On-Demand (No Cor) | \$ 121520000.00 |
| | Add New Row | | | | | |

Cost of 1 million r3.large instances for 5 years is as follows:

$$= 121520000 * 12 * 5$$

$$= \$7,291,200,000$$

Cost of 10 PB distributed storage for one month is = \$220764.16

The total cost of 1million r3.large instances for 1 month is as follows:

| | | |
|-------------------------------|------------------------------|-----------------|
| | Amazon EC2 Service (US-East) | \$ 121520000.00 |
| | Amazon S3 Service (US-East) | \$ 220764.16 |
| | AWS Support (Basic) | \$ 0.00 |
| Free Tier Discount: | | \$ -0.12 |
| Total Monthly Payment: | | \$ 121740764.04 |

Therefore, the total cost of 1million r3.large instances for 5 years is as follows:

$$= 121740764.04 * 12 * 5$$

$$= \$7,304,445,840$$

Private Cloud for Configuration 2:

Screenshots:


Processor:

The screenshot shows the Newegg website interface. At the top, there's a navigation bar with the Newegg logo, 'CYBER MONDAY SALE STARTS NOW', and links for 'Log in or Register', 'Try PREMIER', '0 Items', 'Wish List', and 'Customer Service'. Below this is a search bar and a 'TRENDING NOW' section. The main content area displays the product page for the Intel Xeon E5-2670 v2. The product image is on the left, showing the processor box. To the right, the product name and specifications are listed: 'Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor'. The price is \$1,550.00, and it's marked as 'FREE SHIPPING AVAILABLE'. There are buttons for 'ADD TO CART', 'ADD TO WISH LIST', and 'PRICE ALERT'. The bottom of the page shows a Windows taskbar with the date and time as 1:50 PM 11/26/2017.

Motherboard:

The screenshot shows the ACME Micro Systems website's shopping cart page. The browser's address bar displays www.acmemicro.com/Cart/Index. The website header includes the ACME Micro Systems logo, a search bar, and links for "My Account" and "Shopping Cart". A navigation menu contains "Solutions", "Products", "Promotion", "Customer Service", and "About Us".

The main content area is titled "My Shopping Cart" and lists the following item:

| Product | Product Code | Unit Price | Quantity | Sub Total |
|--|-----------------|------------|----------|-----------|
| Supermicro SuperWorkstation 7048GR-TR 4U DP Xeon E5-2600v4 LGA2011-3 DDR4 8x3.5" Hot-Swap SATA3 2xGb R2000W SY5-7048GR-TR  Remove Item | SY-SM-7048GR-TR | \$1,950 | 1 | \$1,950 |


Below the table are links for [Continue Shopping](#) and [Update Shopping Cart](#).

At the bottom, there is a section for "Calculate Tax And Estimated Shipping Cost" with a "Zip Code" input field and an "Update" button. To the right, the "Tax Estimate:" and "Shipping Estimate:" are both listed as "N/A".

Network Cable:

This screenshot shows the same ACME Micro Systems website, but with a different item in the shopping cart. The browser's address bar still shows www.acmemicro.com/Cart/Index. The website layout is identical to the previous screenshot.

The main content area is titled "My Shopping Cart" and lists the following item:

| Product | Product Code | Unit Price | Quantity | Sub Total |
|---|---------------------|------------|----------|-----------|
| Mellanox MCP1600-C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG  Remove Item | CAB-ML-MCP1600-C001 | \$79.99 | 1 | \$79.99 |

Below the table are links for [Continue Shopping](#) and [Update Shopping Cart](#).

At the bottom, the "Calculate Tax And Estimated Shipping Cost" section and the "Tax Estimate:" and "Shipping Estimate:" (both "N/A") are visible.

Racks:

The screenshot shows a web browser window displaying the Newegg product page for the APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure. The browser's address bar shows the URL: <https://www.newegg.com/Product/Product.aspx?Item=9SIA0ZX6KU0614>. The product image is a tall, black server rack. The product title is "APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure". The price is \$2,432.24, with a crossed-out original price of \$2,918.99, indicating a saving of \$486.75 (17%). The product is sold and shipped by BeachAudio. The page also features a "Customers Also Bought" section with recommendations and a "Best Service Sellers" section listing Newegg, IPC Store, and PC Supply.

APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure

Be the first to review this product... Ask Or Answer A Question

In stock. Ships from United States. Most customers receive within 2-8 days.

Sold and Shipped by **BeachAudio**

- Black
- 1363.64 KG (static load), 1022.73 KG (dynamic load) Weight Capacity
- Rack Enclosure

5 New from **\$2,432.24** 1 Used from **\$1,343.59**

FREE SHIPPING AVAILABLE

\$2,432.24
Save: \$486.75 (17%)

Sold and Shipped by: **BeachAudio** (4,161)

1 **ADD TO CART**

☐ ADD TO COMPARE ☐ PRICE ALERT

☐ ADD TO WISH LIST

Best Service Sellers

| Seller | Price | Shipping | Action |
|-----------|------------|---------------------------|---------------------|
| Newegg | \$2,686.99 | + \$119.99 Shipping | VIEW DETAILS |
| IPC Store | \$2,888.33 | + FREE SHIPPING AVAILABLE | VIEW DETAILS |
| PC Supply | \$2,561.00 | + \$559.15 Shipping | VIEW DETAILS |
| Neonbits | | | |

Customers Also Bought

Recommendations

Storage Servers:

The screenshot shows a web browser window displaying the ACME Micro Systems shopping cart page. The browser's address bar shows the URL: www.acmemicro.com/Cart/Index. The page features the ACME Micro Systems logo and navigation links for Solutions, Products, Promotion, Customer Service, and About Us. The main heading is "My Shopping Cart". The cart contains one item: HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply. The item details include the product code SR-HG-1ES0094, a unit price of \$49,888, a quantity of 1, and a sub-total of \$49,888. The page also includes a "Calculate Tax And Estimated Shipping Cost" section with a Zip Code field and an "Update" button. The tax estimate is N/A, and the shipping estimate is N/A. The subtotal for 1 item is \$49,888.00. The page also features a "Continue Shopping" and "Update Shopping Cart" link.

ACME MICRO SYSTEMS

My Account Shopping Cart

All Products Product keywords, Model Name, Item #

Solutions Products Promotion Customer Service About Us

Home > My Cart

My Shopping Cart

| Product | Product Code | Unit Price | Quantity | Sub Total |
|---|---------------|------------|----------|-----------|
| HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply | SR-HG-1ES0094 | \$49,888 | 1 | \$49,888 |

Calculate Tax And Estimated Shipping Cost

Zip Code **Update**

Tax Estimate: N/A

Shipping Estimate: N/A

Subtotal (1 item): **\$49,888.00**

[Continue Shopping](#) [Update Shopping Cart](#)

Configuration 3:

| Name | vCPUs | GPU | Memory(GiB) | GPU Memory(GiB) | GPU P2P |
|-------------|-------|-----|-------------|-----------------|---------|
| p3.16xlarge | 64 | 8 | 488 | 128 | NV Link |

The performance expected = 1 exaflop (10^{18})

Performance of p3.16xlarge instance = 960 Teraflops

Therefore, number of p3.16xlarge instances needed = 1 exaflop / 960 teraflops

$$= 1041.66$$

$$= 1042 \text{ approx.}$$

Cost of 1 p3.16xlarge instance for one hour = \$24.48

Cost of 8333 p3.16xlarge instances for 5 years = $1042 * 24.48 * 24 * 365 * 5$

$$= \$1,117,257,408$$

Cost of 1PB of storage for one month :

| | | | |
|---|-------------------------------|----|----------|
| + | Amazon S3 Service (US-East) | \$ | 22583.30 |
| + | AWS Support (Basic) | \$ | 0.00 |
| | Free Tier Discount: | \$ | -0.12 |
| | Total Monthly Payment: | \$ | 22583.18 |

Cost of 1PB of storage for 5 years:

$$= 22583.18 * 12 * 5$$

$$= \$1,354,990.8$$

Total cost of 1042 p3.16xlarge instances for 5 years for public cloud:

$$= \$1,117,257,408 + \$1,354,990.8$$

$$= \$1,118,612,398.8$$

Private Cloud for Configuration 3:

The performance expected = 1 exaflop (10^{18})

Performance of NVIDIA DGX-1 with TESLA V100 instance = 960 Teraflops

Therefore, number of NVIDIA DGX-1 with TESLA V100 instances needed = 1 exaflop / 960 teraflops

$$= 1041.66$$

$$= 1042 \text{ approx.}$$

COST OF CLOUD COMPUTING

| | | Description | Price per Item(USD) | Quantity | Total Price(USD) |
|------------|-----------------------------|--|--------------------------|----------|-----------------------|
| 1. | Computer Servers | | | | |
| 1.1 | CPU | INTEL® XEON® PROCESSOR E5-2699 V4 | 4115 | 1042 | 4,863,490=4.8M |
| 1.2 | GPU & Memory | NVIDIA DGX-1 with TESLA V100 with 128GB per GPU. | 1,49,000 | 1042 | 155,258,000 = 155M |
| 2. | Network Switches | Cisco Catalyst 4500- X -Switch - 32 x 1 Gigabit SFP/ 10 Gigabit SFP+ - rack- mountable | 7475 | 34 | 254,150 |
| 3. | Network Cables | Mellanox MCP1600- C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG | 79.99 | 1043 | 83,429.57 |
| 4. | Racks | APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure | 2432.24 | 23 | 55,941 |
| 5. | Storage Servers | HGST 4U60 1ES0094 600TB 60 x 10TB drives SAS3 12Gbps JBOD storage subsystem 2x 1650W power supply | 49,888 | 2 | 99,776 |
| 6. | Electric Power | 1650W @ 12 cents per KWH in IL (246*1.6*0.12) + (1042*3.2*0.12) | 3,918,873.6/yr | 5 years | 19,594,368= 19.5M |
| 7. | Cooling | N+1 redundant fans (fans integrated in PSU) | 1,268,929.84/yr | 5 years | 6,744,649.22= 6.7M |
| 8. | Administration | Maintenance, Security, Deployment | 200,000 per year | 5 | 1M |
| 9. | CPU Admin | 100 processor per person | Number of people = 32 | | 32M |
| 10. | GPU Admin | 50 NVIDIA processor per person | Number of people = 21 | | 21M |
| | TOTAL | N/A | N/A | N/A | 246.29M |

Screenshots:**CPU:**

The screenshot shows the Intel website's product page for the Intel® Xeon® Processor E5-2699 v4. The page is viewed in a Chrome browser with the URL https://ark.intel.com/products/91317/Intel-Xeon-Processor-E5-2699-v4-55M-Cache-2_20-GHz. The Intel logo is in the top right, and the page is in English (USA). The breadcrumb trail is: Support Home > Product Specifications > Processors. A search bar is present. The processor is shown with its icon and name: Intel® Xeon® Processor E5-2699 v4, 55M Cache, 2.20 GHz. A sidebar on the left lists various specification categories. The main content area has an 'Essentials' section with a table of key specifications.

| Essentials | |
|----------------------------|-------------------------------------|
| Product Collection | Intel® Xeon® Processor E5 v4 Family |
| Code Name | Products formerly Broadwell |
| Vertical Segment | Server |
| Processor Number | E5-2699V4 |
| Status | Launched |
| Launch Date | Q1'16 |
| Lithography | 14 nm |
| Recommended Customer Price | \$4115.00 |

Below the Essentials section, the 'Performance' section is partially visible.

GPU:

The screenshot shows a news article on the Tweaktown website. The URL is <https://www.tweaktown.com/news/57487/nvidias-new-volta-powered-dgx-1-costs-149-000/index.html>. The website has a blue header with navigation links: NEWS, REVIEWS, ARTICLES, GUIDES, GAMING, DEALS, ASK THE EXPERTS, TWEAKIPEDIA, and FORUMS. Below this is a sub-navigation bar for 'Video Cards'. The article title is 'NVIDIA's new Volta-powered DGX-1 costs \$149,000'. The sub-headline reads: 'NVIDIA unveils its new DGX-1 with Tesla V100, has 8 x Tesla V100s for \$149,000'. The byline is 'By: Anthony Garreffa | Video Cards News | Posted: May 11, 2017 3:10 am'. There are links for 'Comment', 'Email to a Friend', and 'Font Size: A A'. A 'Subscribe to our Newsletter' box is on the right. At the bottom, there is a 'Latest News Posts' section with three items: 'Pokemon franchise has now sold over 300 million games', 'XFX's new Radeon RX Vega 56, Vega 64 cards not factory OC'd', and 'Sharkoon release the S1000 Micro-ATX case range'. A small text at the bottom left says 'Waiting for www.google-analytics.com...'. The Windows taskbar is visible at the bottom.

Network Cable:

The screenshot shows the ACME Micro Systems website. The browser address bar displays www.acmemicro.com/Cart/Index. The website header includes the ACME Micro Systems logo, a navigation menu with links to Solutions, Products, Promotion, Customer Service, and About Us, and a search bar. The main content area is titled "My Shopping Cart" and shows a single item in the cart:

| Product | Product Code | Unit Price | Quantity | Sub Total |
|--|---------------------|------------|----------|-----------|
| Mellanox MCP1600-C001 Passive Copper Cable Ethernet 100GbE 100Gb/s QSFP PVC 1m 30AWG | CAB-ML-MCP1600-C001 | \$79.99 | 1 | \$79.99 |

Below the cart table, there are links for "Continue Shopping" and "Update Shopping Cart". At the bottom of the page, there is a section for "Calculate Tax And Estimated Shipping Cost" with a "Tax Estimate" of N/A and a "Shipping Estimate" of N/A. The Windows taskbar at the bottom shows the time as 1:38 PM on 11/26/2017.

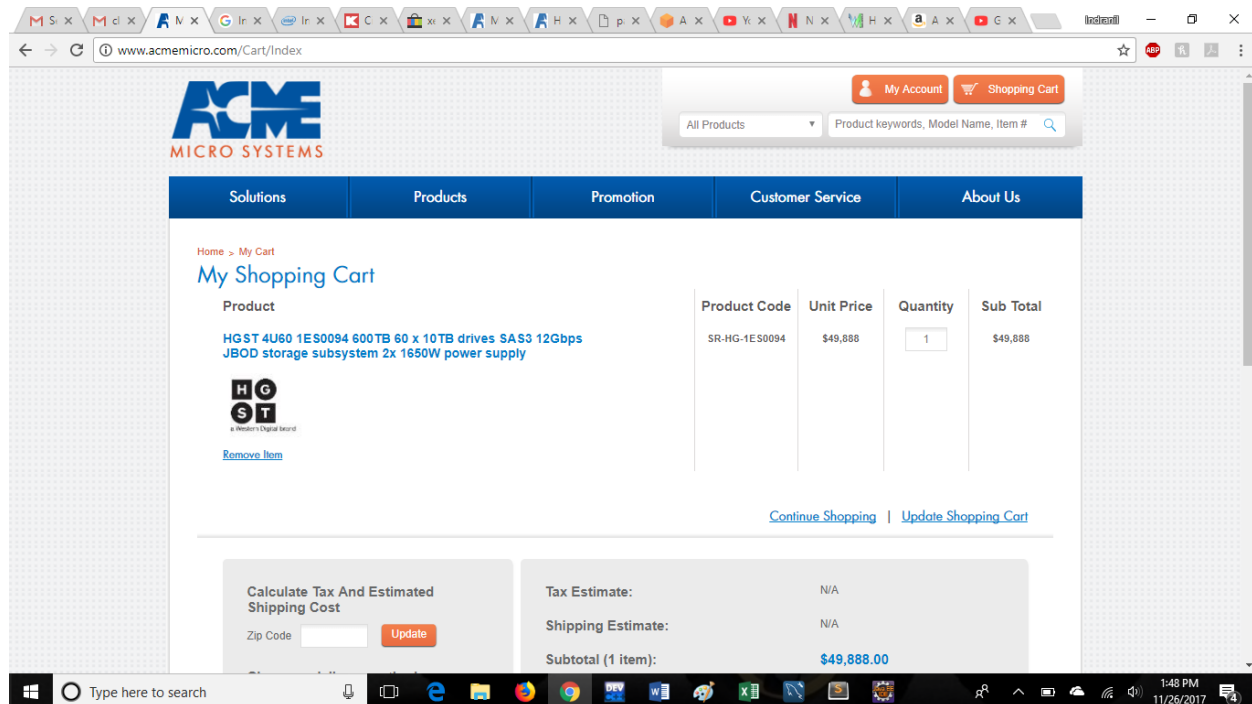
Racks:

The screenshot shows the Newegg website product page for the APC AR3357 48U NetShelter SX 750mm Wide x 1200mm Deep Enclosure. The browser address bar displays <https://www.newegg.com/Product/Product.aspx?Item=9SIA0ZX6KU0614>. The product is shown with a large image and a list of features:

- Black
- 1363.64 KG (static load), 1022.73 KG (dynamic load) Weight Capacity
- Rack Enclosure

The price is listed as \$2,432.24, with a "FREE SHIPPING AVAILABLE" badge. The product is sold and shipped by BeachAudio. The Windows taskbar at the bottom shows the time as 1:47 PM on 11/26/2017.

Storage Servers:



| | Configuration 1 | Configuration 2 | Configuration 3 |
|---|---|--|---|
| Public Cloud (including EC2 and S3) Cost over 5 years, 24/7 operation, with 100% usage | \$563,209,836 | \$7,304,445,840 | \$ 1.1B |
| Private Cloud cost over 5 years, 24/7 operation, with 100% usage | 46.53M | 5.036Billion | 246.9M |
| What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud? | <p>>= 4.8% private cloud remains an attractive option.</p> <p>(Explained in detail in the break-even section below)</p> | <p>>= 45% private cloud remains an attractive option.</p> <p>(Explained in detail in the break-even section below)</p> | <p>>=16% private cloud remains an attractive option.</p> <p>(Explained in detail in the break-even section below)</p> |

Explain in words if it is better to rent or buy. If it is better to buy, what utilization must you maintain over the 5-year lifetime of the private cloud in order to break even on the investment?

I would like to place an analogy here to discuss the break even and make the appropriate choice between private and public cloud.

For instance, if we ought to travel everyday and we chose Uber/Lyft as our mode of commute, then we would of course end up paying a huge amount in just an year's span. Had we rather chosen to buy our own car, we could've hired a driver and still ended up paying way lesser than the we did for renting the car.

But however, car-pooling would be the best fit if we did just travel to and from the work place and needed a private vehicle for nothing else.

So, this is where the cloud kicks in. "**Pay per usage**".

Therefore, if we are having a requirement which demands a 100 % utilization of the resources all through the 5-year period, then buying our own resources would pay up better than using cloud. Whereas, If we know for sure that the utilization of the resources would not be anywhere close to 100% all through 5 years, which is the case in most of our requirements in practice, then it is a better option to go with cloud. We should also keep in mind the "Durability of the hardware". Because, if we do not tend to use the resources close to 100% and also that if our utilization period (not the percentage of utilization), for example, our project would go on for more than 5 years but not using the resources to their fullest, then we would have a penalty of replacing the resources all together post the 5 year period as their performance to power consumption ratio would have gone really low and bad by then with time. Even in this case, public cloud would prove worthier than the private.

- In addition to the points above, public cloud establishment even waives us off the burden of maintenance and upgradation processes which would happen so seamlessly with public cloud like AWS.
- Furthermore, we cannot ignore the fact that private cloud has a bottle neck of scalability as it cannot scale horizontally with load increase as flexibly as the public cloud assures us with the high availability.
- Locality awareness and replication factors are the other valuable factors of the public cloud implementation which is an inherent advantage of the wide spread network of public cloud giants like AWS, Azure, Bluemix etc.

Finally, when it comes to the **break-even** points between the private and the public cloud for the 3 configurations then, the following is the substantiations with the current market rates for both public cloud and private cloud resources in context.

We have the **constant** and the **variable** parts for all the configurations of the private cloud.

Power consumption, Cooling and Administration costs vary with their utilization.

Whereas, the rest of the investment stays invariable which is the cost of buying the required hardware.

Configuration 1:

This configuration makes the private cloud play a very clear winner role with a pretty low percentage of utilization sufficing its usage being more attractive than the public cloud for a vast range of utilization.

| Private Cloud | | | | Public Cloud |
|---------------|---------------------|---------------------|------------------|---------------------|
| % Utilization | Constant Part (USD) | Variable Part (USD) | Total cost (USD) | Variable Part (USD) |
| 4.7 | 26.1M | 0.95M | 27.05M | 26.45M |
| >= 4.8 | 26.1M | 0.97M | 27.07M | 27.068M |
| 4.9 | 26.1M | 0.99M | 27.09M | 27.587M |

Configuration 2:

| Private Cloud | | | | Public Cloud |
|---------------------|---------------------|---------------------|------------------|---------------------|
| % Utilization (USD) | Constant Part (USD) | Variable Part (USD) | Total cost (USD) | Variable Part (USD) |
| 40 | 1.63B | 1.36B | 3.071B | 2.921B |
| >=45 | 1.63B | 1.53B | 3.251B | 3.258B |
| 47 | 1.63B | 1.60B | 3.321B | 3.432B |

Configuration 3:

| Private Cloud | | | | Public Cloud |
|---------------|---------------------|---------------------|------------------|---------------------|
| % Utilization | Constant Part (USD) | Variable Part (USD) | Total cost (USD) | Variable Part (USD) |
| 15 | 166M | 12.03M | 178.03M | 167.7M |
| 16 | 166M | 12.83M | 178.83M | 178.9M |
| 17 | 166M | 13.63M | 179.63M | 190M |

REFERENCES:

<https://www.nvidia.com/content/dam/en-zz/Solutions/Data-Center/dgx-1/NVIDIA-DGX-1-Volta-AI-Supercomputer-Datasheet.pdf>

<https://aws.amazon.com/ec2/instance-types/>

http://www.acmemicro.com/Product/15529/Supermicro-Superserver-2028BT-HTR+-2U-4-node-DP-Xeon-LGA2011-R3-DDR4X24-SATA3-drive-HotSwap-1-NIC-or-SIOM-card-R2200W?c_id=183

http://www.acmemicro.com/Product/14973/Intel-Xeon-E5-2695-v4-Processor-LGA2011-3-Broadwell-18-Core-2-10-GHz-45MB-BX80660E52695V4-Box?Crits_CheckValue=Brand+-+Processors%7CIntel&Crits_CheckValue=Product+Type%7CServer+CPU&Crits_CheckValue=Core+Quantity%7C18&pager_index=

<https://www.newegg.com/Product/ProductList.aspx?Submit=ENE&N=100161264%20600054636&IsNodeld=1&bop=And&Order=PRICED&PageSize=36>

http://www.acmemicro.com/Product/15146/HGST-4U60-1ES0094-600TB-60-x-10TB-drives-SAS3-12Gbps-JBOD-storage-subsystem-2x-1650W-power-supply?Crits_CheckValue=%23+of+drives%7C+up+to+72&Crits_CheckValue=%23+of+drives%7C+up+to+99&pager_index=