CS553

Understanding the Cost of Computing in the Cloud

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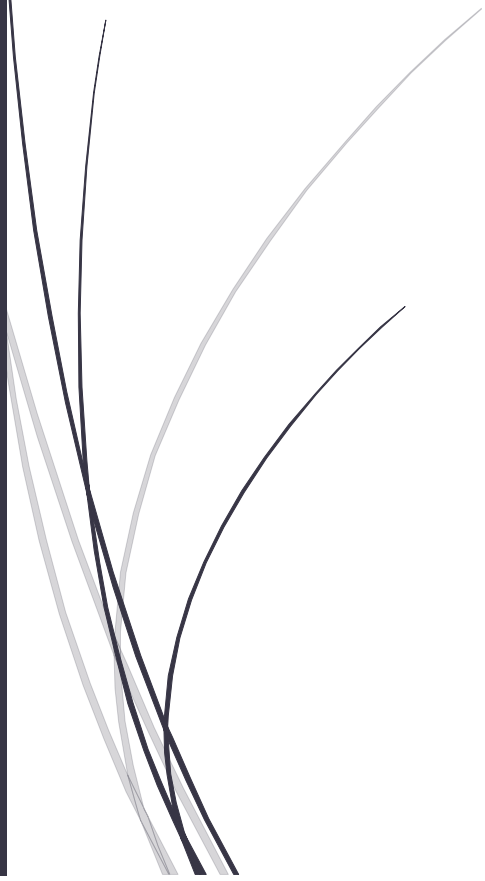

Hadoop/Spark Cluster with 32K-cores, 256TB memory, 50PB HDD, and 10Gb/s Ethernet Fat-Tree network (each VM should be equivalent to the d2.8xlarge instance); in addition to the compute resources, a 100PB distributed storage shared across the entire cloud should be procured, with enough capacity for 100GB/sec throughput

AWS Cloud:

Each d2.8xlarge has on-demand price of $5.52 per hour for each instance and for S3 Standard cloud storage costs at $0.021 per GB for a month.

Cost of 1000 instances over 5 years period = 5*5.52*1000*365*24 = $ 241,776,000

Cost of S3 Cloud storage for 100PB of data over 5 years = 5 * 12 * 100 *1000 * 1000 * 0.021

= $ 126,000,000

Total Cost for the AWS Service = $ 241,776,000 + $ 126,000,000 = **$ 367,776,000**

Private Cloud:

	Description		UNITS	PRICE/UNIT	COSTS (in $)
SERVER	Supermicro Superserver 5018R-WR 1U UP Xeon E5-2600v4 LGA2011-3 DDR4 4x3.5" Hot-Swap SATA3		3	$949.00	$ 2,847.00
CPU	Intel Xeon E5-2650 v4 Processor LGA2011-3 Broadwell 12 Core 2.20 GHz 30MB 105W BX80660E52650V4 Box	12 cores	3	$1,270.00	$ 3,810.00
MEMORY	SAMSUNG 32GB 288-Pin DDR4 SDRAM Load Reduced DDR4 2133 (PC4 17000) Server Memory	32GB	9	$352.00	$ 3,168.00
STORAGE	12TB Seagate ST12000NM0027 - SAS 512e HDD 12TB Enterprise Capacity SAS 12Gb/s 7200rpm 256MB 3.5-inch Bulk	12TB	3	$479.99	$ 1,439.97
	8TB Seagate ST8000NM0055 - SATA 512e HDD 8TB V.5 Enterprise SATA	8TB	3	$299.00	$ 897.00

	6.0GB/s 7200rpm 256MB 3.5-inch Bulk				
NETWORK ADAPTER	Intel X520-DA2/E10G42BTDA 10-Gigabit Ethernet Server Adapter PCIe Dual-Port 2xSFP+ Copper 10GSFP+Cu Low-Profile	10GB/s	3	$335.52	$ 1,006.56
				TOTAL COST of Single Server Unit with 36 cores	**$ 13,168.53**

Table 1.1 : Compute Server configuration

Each Server Rack consists of 3 compute servers with total of 36 cores , 288GB of Memory , 120TB Disk Memory and such 889 Server racks make up the Private cloud setup.

889 * 36 cores = 32,004
889 * 288GB = 256 TB
889 * 60TB =50 PB

Compute Servers		3 Servers per rack	889	$13,168.53	$ 11,706,823.17
Network Switches	CISCO N5K-C56128P Nexus 56128P 2RU, 48 x 10G SFP+, 4 x 40G QSFP+ Fixed Ports (Base)	48 Ports	19	$9,649.00	$ 183,331.00
	NETGEAR ProSAFE 24-Port Gigabit PoE Smart Managed Switch	24 Port	1	$339.00	$ 339.00
Network Cables	10Gtek for Mellanox MC3309124-005, 10GBASE-CU SFP+ Copper Twinax Direct-attach Cable, Passive, 5-Meter		1000	$49.00	$ 49,000.00
Rack	12U Portable Server Rack from racksolutions.com		889	$360.00	$ 320,040.00

Storage Server	Iris 428-60 of 600TB Enterprise HDD	600TB	170	$44,659.00	$ 7,592,030.00
Cooling Cost		1335kW			$ 1,954,036.00
Power Consumption at 5.99¢ / kWh		1335kW			$ 3,502,532.00
Administration Cost	Single admin for 890 servers		1	$ 80,000	$ 400,000.00
				TOTAL COST	**$ 25,708,131.17**

Table 1.2 : Configuration 1 summary

1 million virtual machines (VM) where each VM requires 2-core, 15GB RAM, 32GB SSD storage, and 1Gb/s Fat-Tree network with each VM equivalent to the r3.large instances. In addition to the compute resources, a 10PB distributed storage shared across the entire cloud should be procured, with enough capacity for 10GB/sec throughput.

AWS Cloud:

Each r3.large instance has on-demand price of *$0.175* per hour per instance and S3 Standard cloud storage costs at $0.021 per GB for a month.

Cost of 1000000 instances over 5 years period = 5*0.175*1000000*365*24 = $ 7,665,000,000

Cost of S3 Cloud storage for 10PB of data over 5 years = 5 * 12 * 10 *1000 * 1000 * 0.021 = $ 12,600,000

Total Cost for the AWS Service = $ 7,665,000,000 + $ 12,600,000= **$ 7,677,600,000**

Private Cloud:

	Description		PRICE/UNIT	Quantity	COST
SERVER	Supermicro Superserver 1028TR-T 1U Twin 2 Nodes DP Xeon E5-2600 v4/v3 LGA2011-3 DDR4 4x2.5-in SATA3 1000W SYS-1028TR-T	2 sockets	$1,409.00	5	$ 7,045.00
CPU	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	10 cores	$1,550.00	10	$ 15,500.00

MEMORY	SAMSUNG 32GB 288-Pin DDR4 SDRAM Registered DDR4 2400 (PC4 19200) Server Memory Model M393A4K40BB1-CRC	32GB	$389.00	25	$ 9,725.00
STORAGE	SanDisk 32GB Mini-SATA (mSATA) Internal Solid State Drive (SSD) X110	32GB	$85.00	50	$ 4,250.00
NETWORK ADAPTER	Mellanox MCX311A-XCAT ConnectX-3 EN 10-Gigabit Ethernet Adapter PCIe3 8.0GT/s Single-Port SFP+ 10GbE Copper/Fiber		$199.00	10	$ 1,990.00
				TOTAL COST of one Server unit with 50 VM instances	$ 38,510.00

Table 2.1 : Compute Server configuration

Each Server Rack consists of 20 compute servers with total of 100 cores (Twin Node server) , 800GB of Memory , 1600GB SSD Disk Memory and such 20000 Server racks make up the Private cloud setup.

20000 * 100 cores = 2,000,000 cores
20000 * 800 GB = 16,000,000 GB (15GB * 1 million)
20000 * 1600GB = 32,000,000 GB (32GB * 1 million)

Compute Servers	50 VMs per rack with total of 20000 servers		$38,510	20000	$ 770,200,000
Network Switches	CISCO N5K-C56128P Nexus 56128P 2RU, 48 x 10G SFP+, 4 x 40G QSFP+ Fixed Ports		$9,649.00	418	$ 4,033,282
	Dell 463-6162 X4012 Ethernet Switch		$1,079.00	1	$ 1,079
Network Cables	3-Meter SFP+ Cable, for Mellanox MC3309130-003, 10Gbase-CU Direct Attach Copper Cable, Passive AWG30		$35.00	20500	$ 717,500

Rack	12U Portable Server Rack from racksolutions.com		$360.00	20000	$ 7,200,000
Storage Server	Iris 428-60 of 600TB Enterprise HDD	600TB	$44,659.00	17	$ 759,203
Cooling cost		20,010KW			$ 10,780,929
Power Consumption at 5.99¢ / kWh		20,010KW			$ 52,734,762
Administration Cost	Single admin per 1000 server	5 years	$80,000.00	20	$ 8,000,000
				TOTAL COST	**$ 854,426,755**

Table 2.2 : Configuration 2 Summary

Deep learning with 1 exaflop of mixed precision performance with each VM equivalent to p3.16xlarge instances; with NVIDIA V100 GPUs (8 GPUs per node), and allocate 8-cores per GPU (64-cores per node) with 8GB of memory per core (512GB per node); the network to use is at least 10Gb/s per GPU (100Gb/s should work), and should be organized in a Fat-Tree network; in addition to the compute resources, a 1PB distributed storage shared across the entire cloud should be procured, with enough capacity for 10GB/sec throughput

AWS Cloud:

AWS p3.16x large instance consists of 8 Tesla V100 GPU's with 64 cores per GPU and 125 TFlops per GPU . Each p3.16xlarge instance has on-demand price of $24.48 per hour per instance and S3 Standard cloud storage costs at $0.021 per GB for a month.

Cost of 1000 instances over 5 years period = 5*24.48*1000*365*24 = $ 1,072,224,000

Cost of S3 Cloud storage for 1PB of data over 5 years = 5 * 12 * 1 *1000 * 1000 * 0.021

= $ 1,260,000

Total Cost for the AWS Service = $ 1,072,224,000 + $ 1,260,000 = **$ 1,073,484,000**

Private Cloud:

Each compute server used here is a NVIDIA DGX-1 [2] system which gives Mixed precision performance at 1 Petaflops with 256GB memory (GPU memory) and 5,120 cores. This cluster setup example is taken from the Nvidia Saturn V DGX Cluster [1].

	Description	PRICE/UNIT	Quantity	COST
COMPUTING SERVER	NVIDIA DGX-1	$164,986.00	1000	$ 164,986,000
Network Switches	MSB7800-ES2F MELLANOX 36-Port Qsfp28 EDR 1U Managed Infiniband Switch System	$14,135.00	28	$ 395,780
Network Cables	3-Meter SFP+ Cable, for Mellanox MC3309130-003, 10Gbase-CU Direct Attach Copper Cable, Passive AWG30	$35.00	1027	$ 35,945
Rack	RackSolutions RACK-117-12U 12U Portable Server Rack	$296.00	1000	$ 296,000
Storage Server	Iris 428-60 of 600TB Enterprise HDD	$44,659.00	2	$ 89,318
Cooling cost				$ 7,353,264
Power Consumption at 5.99¢ / kWh	3503kW			$ 9,191,330
Administration Cost	Single admin per 1000 server	$80,000.00	1	$ 400,000
			TOTALCOST	**$ 182,747,637.00**

Table 3.1 : Configuration 3 Summary

Comparison of Public and Private Cloud:

	Configuration 1	Configuration 2	Configuration 3
Public Cloud (including EC2 and S3) Cost over 5 years, 24/7 operation, with 100% usage	$ 367,776,000	$ 7,677,600,000	$ 1,073,484,000
Private Cloud cost over 5 years, 24/7 operation, with 100% usage	$ 25,708,131	$ 854,426,755	$ 182,747,637
What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud?	7%	11%	17%

The cost described in the afore table is for 100% usage . If the usage is reduced for the Private cloud, the infrastructure and components cost will remain the same. The only cost which varies will be power consumption cost which is comparatively less than the component cost.

Hence, to achieve minimum utilization of the Private cloud with respect to Public Cloud for the above three configurations, with 7% utilization for Configuration 1, 11% utilization for Configuration 2 and 17% utilization for Configuration 3. Thus it can be inferred that, if the utilization of Private cloud for these specific configuration is less than the computed percent, we should prefer Public cloud over private cloud.

As par the results we got, It can be concluded that its better to go with Private cloud setup than renting Public cloud with assumption of 100% utilization over a period of 5 years.

References:

1. https://www.nextplatform.com/2016/11/14/nvidias-saturn-v-dgx-1-cluster-stacks/
2. https://www.nvidia.com/content/dam/en-zz/Solutions/Data-Center/dgx-1/dgx-1-volta-datasheet-update-nv-us-r4-web.pdf
3. http://images.nvidia.com/content/volta-architecture/pdf/volta-architecture-whitepaper.pdf
4. https://www.electricrate.com/ratefinder/pub/index.php?action=ViewForm:Customer&rid=a76b81c4-464e-11e8-881e-f0fd23b5238d&zip=&state=OH&a_aid=ercontent

APPENDIX:

Shopping Cart snaps from www.newegg.com, acmemicro.com, racksolutions.com

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Product	Product Code	Unit Price	Quantity	Sub Total
Intel Xeon E5-2650 v4 Processor LGA2011-3 Broadwell 12 Core 2.20 GHz 30MB 105W BX80660E52650V4 Box  Remove Item	CP-IT-XE52650V4BOX	$1,270	2	$2,540
2TB Seagate ST2000NM0008 - SATA 512n HDD 2TB Enterprise Capacity 3.5 SATA 6.0GB/s 7200rpm 128MB 3.5-inch Bulk  Remove Item	HD-ST-2000NM0008	$129.99	1	$129.99
12TB Seagate ST12000NM0027 - SAS 512e HDD 12TB Enterprise Capacity SAS 12Gb/s 7200rpm 256MB 3.5-inch Bulk  Remove Item	HD-ST-12000NM0027	$479.99	3	$1,439.97
Intel X520-DA2/E10G42BTDA 10-Gigabit Ethernet Server Adapter PCIe Dual-Port 2xSFP+ Copper 10GSFP+Cu Low-Profile 	NW-IT-10G42BTDA	$335.52	1	$335.52

Newegg Marketplace Direct Delivery Service Important Shipping Information

Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz LGA 2011 115W BX80635E52670V2 Server Processor

1 IN STOCK

$1,550.00

# of Cores: 10-Core / **Operating Frequency:** 2.5 GHz

Sold by E.O.L. Tech Inc,.

Subtotal: **$1,550.00**

3 Item(s) in your shopping cart: $2,394.00

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Newegg Marketplace Direct Delivery Service Important Shipping Information

DELL 64GB DDR4 PC4-19200 2400MHz ECC REGISTERED RDIMM Memory for Dell PowerEdge R530 Server

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PRODUCT		PRICE	QTY	SUBTOTAL
	**12U Portable Server Rack** *SKU: RACK-117-12*	$359.99	1	$359.99

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CISCO N5K-C56128P Nexus 56128P 2RU, 48 x 10G SFP+, 4 x 40G QSFP+ Fixed Ports (Base)

Sold by DataQDirect.com

1 IN STOCK

$9,649.12

Subtotal:	$9,649.12
Shipping:	$0.00

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10Gtek for Mellanox MC3309124-005, 10GBASE-CU SFP+ Copper Twinax Direct-attach Cable, Passive, 5-Meter

Length: 16.40 ft. / **Color:** Black

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$49.88

Save: 50.12%

Subtotal:	$49.88

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Intel E10G42BFSR 10Gbps PCI Express 2.0 x8 X520-SR2 Ethernet Server Adapter

Sold by Made PC

1 IN STOCK

$211.00

SquareTrade Protection Plan

3 Year Network Protection Plan: $29.99 (remove)

Subtotal:	$211.00
Extended Warranty:	$29.99
Shipping:	$0.00

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Product	Product Code	Unit Price	Quantity	Sub Total
Supermicro Superserver 5018R-WR 1U UP Xeon E5-2600v4 LGA2011-3 DDR4 4x3.5" Hot-Swap SATA3 R500W SYS-5018R-WR  Remove Item	SY-SM-5018R-WR	$949	1	$949

Newegg Marketplace Direct Delivery Service Important Shipping Information

3-Meter SFP+ Cable, for Mellanox MC3309130-003, 10Gbase-CU Direct Attach Copper Cable, Passive AWG30

Sold by 10Gtek

1

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$35.99

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- 3 Year Network Protection Plan: $174.99
- 4 Year Network Protection Plan: $219.99

SAMSUNG 32GB 288-Pin DDR4 SDRAM Registered DDR4 2400 (PC4 19200) Memory (Server Memory) Model M393A4K40BB1-CRC

Standard Return Policy

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Product	Product Code	Unit Price	Quantity	Sub Total
Supermicro Superserver 1028TR-T 1U Twin 2 Nodes DP Xeon E5-2600 v4/v3 LGA2011-3 DDR4 4x2.5-in SATA3 1000W SYS-1028TR-T  Remove Item	SY-SM-1028TRT	$1,409	1	$1,409
Mellanox MCX311A-XCAT ConnectX-3 EN 10-Gigabit Ethernet Adapter PCIe3 8.0GT/s Single-Port SFP+ 10GbE Copper/Fiber  Remove Item	NW-ML-MCX311A	$199	1	$199

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NVIDIA CORP 8-GPU/512GB DGX-1 DL WITH V100
Part Number: 920-22787-2510-000, Item #: 2707240
$18,148.51/unit for Hot Swap Warranty

$164,986.46
1 Remove

US$ Sub-Total: $164,986.46

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1 + −

$14135.00

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Newegg Large Item Delivery Service

Important Shipping Information

RackSolutions RACK-117-12U 12U Portable Server Rack with Casters

Standard Return Policy

1 IN STOCK

$296.17

Subtotal:	$296.17
Shipping:	$0.00

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Qty	System	Description			
1	Iris 428-60	view components	$44,659.05	$44,659.05	Edit System Delete System
	CPU: 2x Intel Xeon E5-2603v4 6C 1.7GHz 15MB Cache **Memory:** 1x 16GB DDR4 ECC Reg 2400MHz (2 x 8GB) **Mirrored OS Disks - Mounted in Rear Bays:** 2x Micron M510DC 480GB 2.5" Enterprise SSD **Enterprise HDD:** 60x Seagate Enterprise Capacity 10TB HE 7200RPM 256MB SAS **Networking Options:** 1x Dual Port Gigabit Ethernet Module **OS:** 1x No Operating System. Include testing and customer OS preference in notes. **Warranty:** 1x Return to Depot Warranty (3 Year Hardware Warranty with Standard Advance Parts Replacement)				close
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