Understanding the cost of Computing in the cloud

CS553 PROJECT

Chetan Gupta | Cloud Computing | 4/23/2018

Project

- Configuration 1: 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 (for pricing comparison, see S3)
- Configuration 2: Support 1 million virtual machines (VM) where each VM requires 2-core, 15GB RAM, 32GB SSD storage, and 1Gb/s Fat-Tree network (each VM should be 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 (for pricing comparison, see S3)
- Configuration 3: Support deep learning with 1 exaflop of mixed precision performance (hint: each VM should be equivalent to p3.16xlarge instances; you will want to use the 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 (for pricing comparison, see S3)
- Compare the costs of the 3 different configurations between the public cloud (Amazon AWS) and the private cloud o you may assume a 5 year amortization cost

o 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
1000 servers o 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)

o 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. 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?

- Need a heading? On the Home tab, in the Styles gallery, just click the heading style you want.

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CONFIGURATION 1

Configuration 1: 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 (for pricing comparison, see S3)

1.1 PUBLIC CLOUD (D28XLARGE INSTANCE):

Core needed- 32 k , therefore number of VM's =889
Memory needed 256 TB, therefore number of VM's = 978
HDD needed 50PB, therefore number of VM's needed= 1042
Therefore, we need 1042 instances
According to the AWS Calculator the monthly cost for 1042 d2.8x large instances will be (including AWS Support for Business): $ 4369852.29
So, the cost for the 5 years for d2.8xlarge instance will be:
$ 4369852.29*12 * 5 = $ 262191137.4

For Distributed Storage:
For 100PB the total cost for per month which will be charged by AWS is $ 2365247.99(including AWS Business Support)
Therefore, total cost for 5 years is: -
$2365247.99 *12*5 =$ 141914897.4

Therefore Total Public Cloud Cost for Configuration 1 is :
Cost of EC2 for 5 years + Cost of Storage for 5 years:
$ 260613437.4 + $ 136532999.4 = $ 404106016.8

1.2 PRIVATE CLOUD

Component		Description	Quantity	Price/Unit	Total Price	Power(Watts)/ Unit	Total Watt/hour	Links
Computer Servers	Processor	INTEL XEON E5-2676 V3 2.40GHZ SOCKET 2011-3 LGA2011-3 HASWELL SERVER OEM CPU SR1Y5 CM8064401613101	2668	$2,197	$5,861,596.00	120	320160	https://starmicroinc.net/intel-xeon-e5-2676-v3-2-40ghz-socket-2011-3-lga2011-3-haswell-server-oem-cpu-sr1y5-cm8064401613101/
	Rackmount	SUPERMICRO SYS-4028GR-TRT2 4U Rackmountable Server - Barebone Dual LGA 2011 Intel C612 2400 / 2133 / 1866 / 1600 MHz ECC DDR4 SDRAM 72-bit	1334	$4,520	$6,029,680.00	2000	2668000	https://www.newegg.com/Product/Product.aspx?Item=N82E16816139162&cm_re=SUPERMICRO_SYS-4028GR-TRT2_4U_Rackmountable_Server_-_Barebone_Dual_LGA_2011_Intel_C612_2400_%2f_2133_%2f_1866_%2f_1600_MHz_ECC_DDR4_SDRAM_72-bit-_-16-139-162-_-Product
	Internal Storage	Seagate IronWolf ST12000VN0007 12TB 7200 RPM 256MB Cache SATA 6.0Gb/s 3.5" Internal Hard Drive	4167	$411	$1,712,637.00			https://www.newegg.com/Product/Product.aspx?Item=N82E16822172025&ignorebbr=1
	Memory	Samsung M386A8K40BM1-CPB 64GB DDR4-2133 4Rx4 LP ECC LRDIMM Server Memory	4000	$852.99	$3,411,960.00			https://www.newegg.com/Product/Product.aspx?Item=9SIA5EM3G36302&cm_re=memory_server-_-1WK-002G-00022-_-Product
Network Switches		Lenovo RackSwitch G8272 Layer 3 Switch	34	$5,526	$187,884.00	230	7820	https://www.newegg.com/Product/Product.aspx?Item=9SIA91N5SB8508&ignorebbr=1&nm_mc=KNC-GoogleMKP-PC&cm_mmc=KNC-GoogleMKP-PC-_-pla-_-Network++Switches-_-9SIA91N5SB8508&gclid=Cj0KCQiA6enQBRDUARIsAGs1YQhh12T-dkPpmJV30MuxP88R2FEp-uX4OuchW_H5IICTWfkZ-IhFOZ4aAu-BEALw_wcB&gclsrc=aw.ds

Rack & Shelf	Shelf	4U 7" Vented Rack Shelf	1507	$73	$110,011.00			https://www.newegg.com/Product/Product.aspx?Item=9SIA00Y1Y94194&cm_re=4u_rack_shelf-_-9SIA00Y1Y94194-_-Product
	Rack	45U Open Frame aluminium Server Network Rack 1000MM Deep 4 Post With 3 Pairs of L-Rails	170	$238	$40,460.00			https://www.newegg.com/Product/Product.aspx?Item=9SIAA054SF5010&cm_re=rack_45u-_-9SIAA054SF5010-_-Product
Network Cable		Dell Networking, Cable, SFP+ to SFP+, 10GbE, Active Optical (Optics included) Cable,3 Meter, Customer Kit	2494	$170	$423,980.00			http://www.dell.com/en-us/shop/accessories/apd/470-ablz?ref=p13n_ena_pdp_vv&c=us&cs=04&l=en&s=bsd
Storage Servers		J4601S-Storage Options: 1x HGST 4U 60 Bay JBOD with 60 x 12TB Helium SAS HDD (Kepler +) 3 Meter SAS Cable: 4x Patch Cable SFF-8644 to SFF-8644 External JBOD 3M Warranty and Support: 1x Return to Depot Warranty (5 Year Hardware Warranty with Standard Advance Parts Replacement)	139	$44,475.85	$6,182,143.15	3300	46200	
Electric Power					$17,737,598.40			
Cooling		Tripp Lite SRCOOL24K SmartRack 24,000 BTU 208 / 240V Portable Air Conditioning Unit	85	2,582	$219,470.00	7000	595000	https://www.newegg.com/Product/Product.aspx?Item=N82E16816228213&cm_re=SRCOOL24K-_-16-228-213-_-Product&nm_mc=AFC-C8Junction&cm_mmc=AFC-C8Junction-_-na-_-na-_-na&cm_sp=&AID=11552995&PID=1796839&SID=285945163
Administration			2	$1,000,000	$2,000,000.00			
Total					$43,917,419.55			

	Watt/hr	power for 5 years in watts	power for 5 years in Kwatts	Electricity cost(@$ 0.10)
Electricity:	4049680	177375984000.00	177375984	17737598.4

INTEL XEON E5-2676 V3 2.40GHZ SOCKET 2011-3 LGA2011-3 HASWELL SERVER OEM CPU SR1Y5 CM8064401613101

INTEL

$2,197.00

SKU:
E5-2676v3

Quantity
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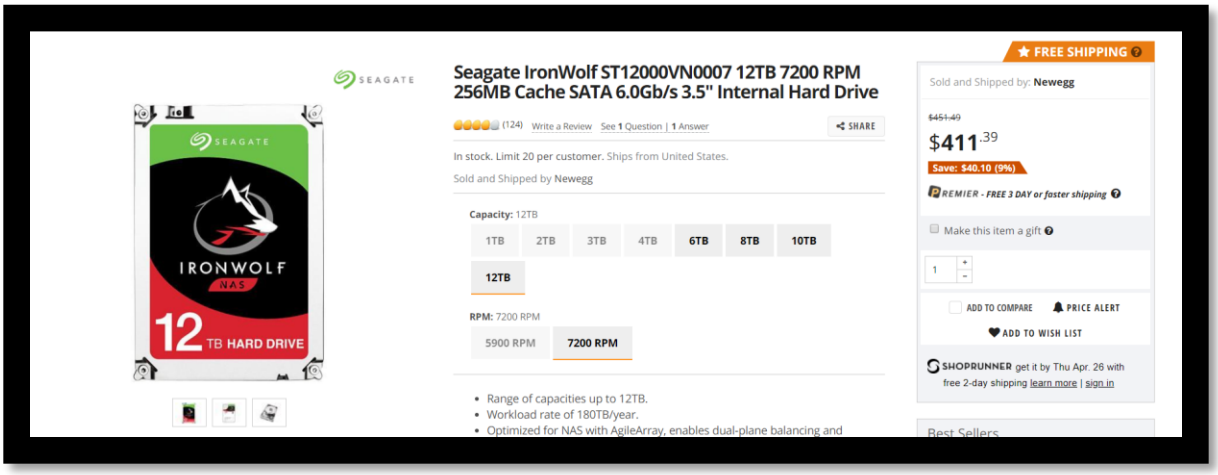
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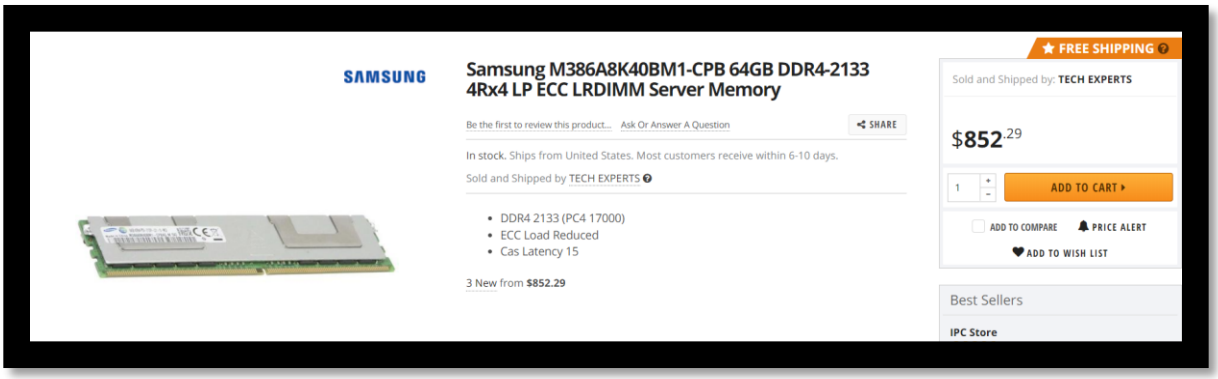
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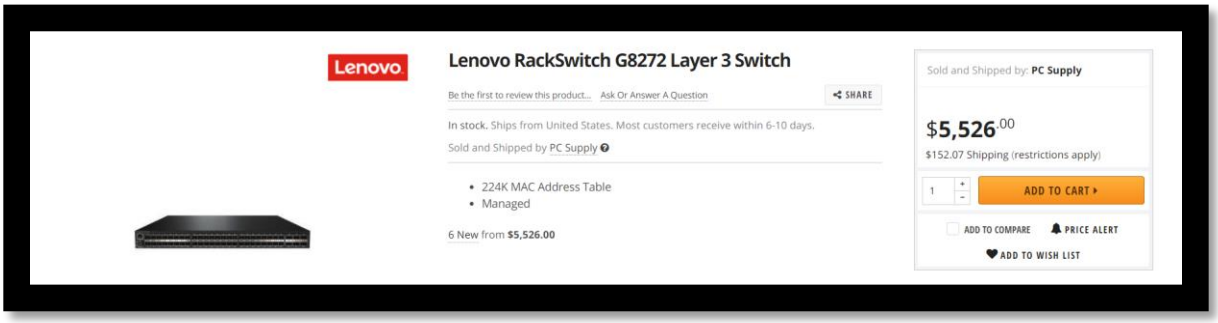
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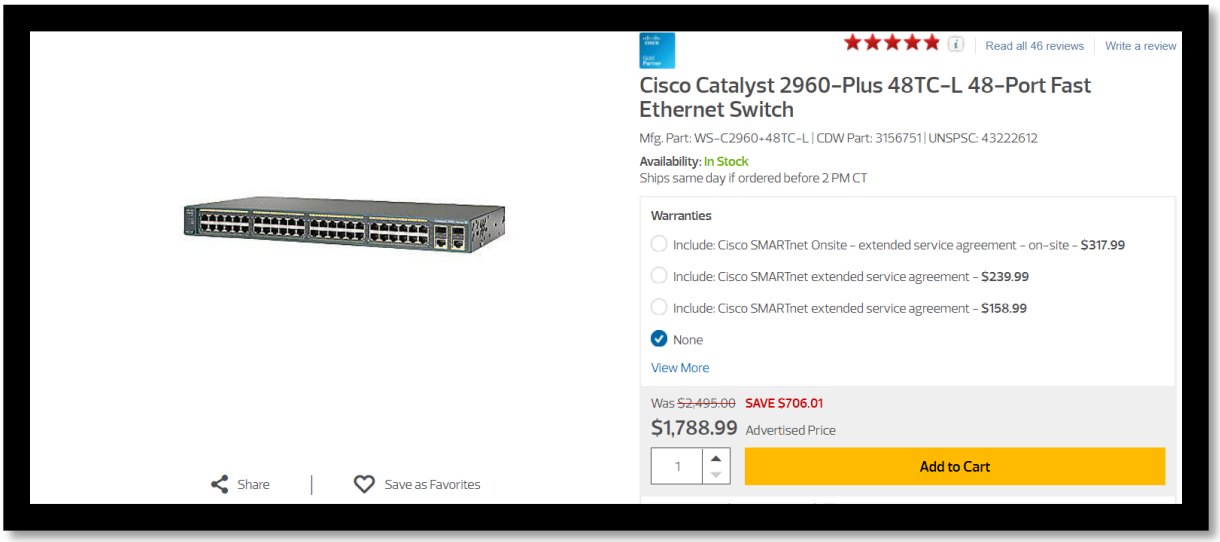
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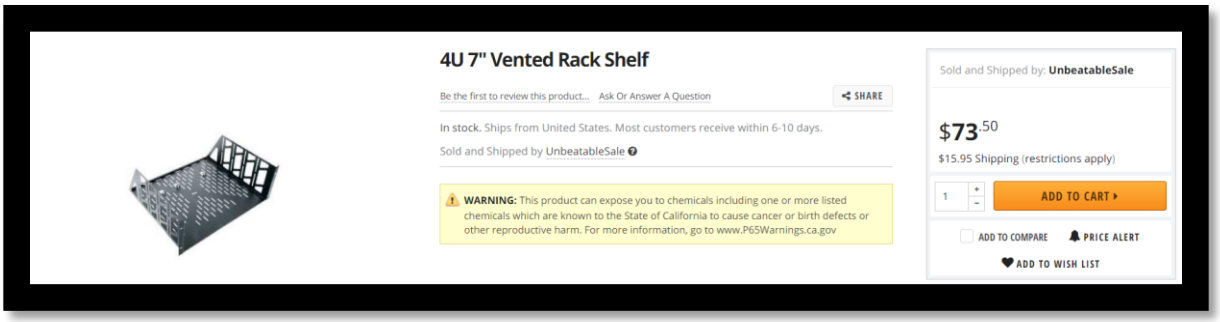
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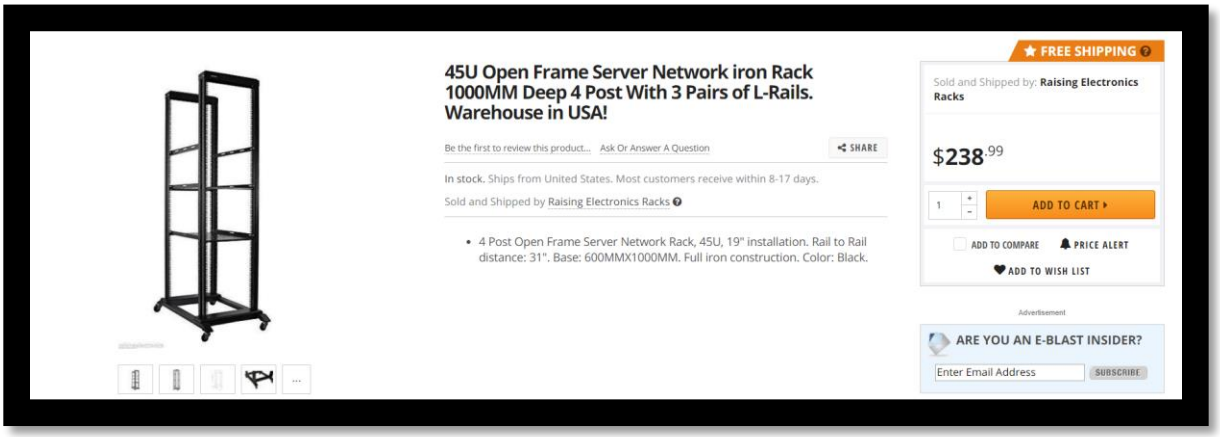
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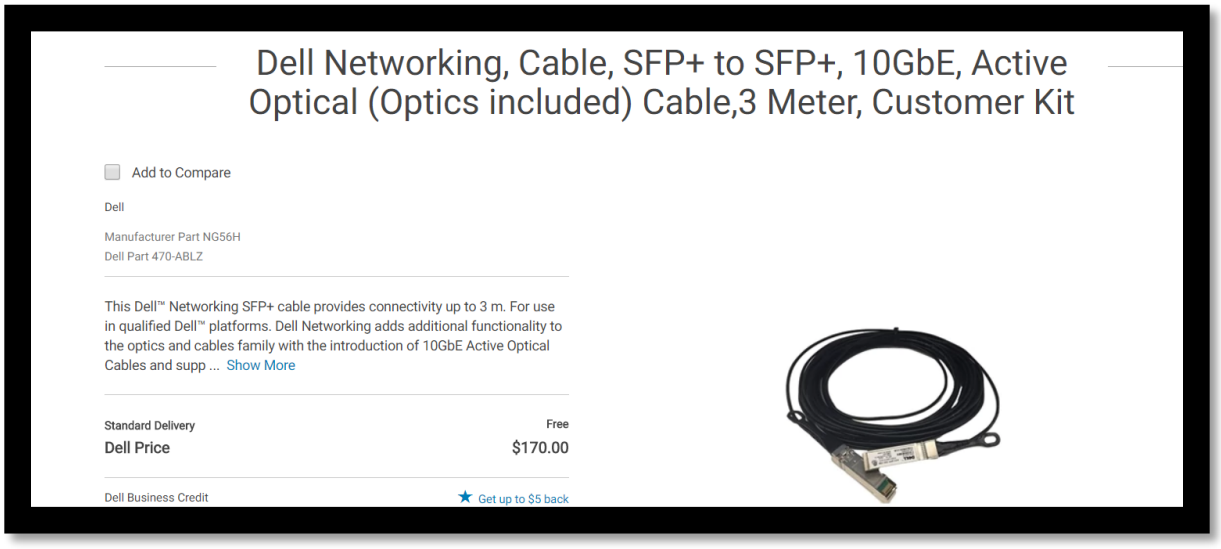
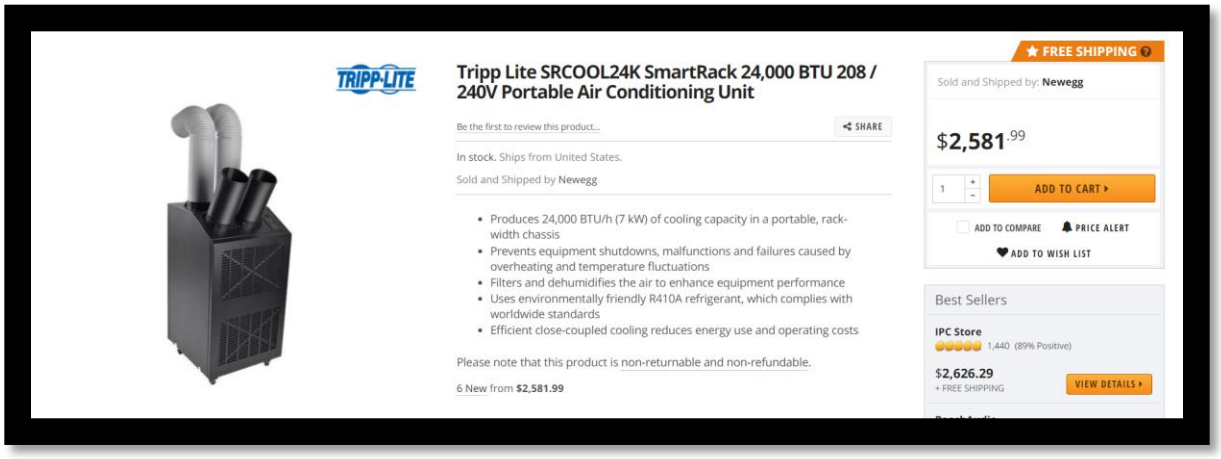




CONFIGURATION 2

Support deep learning with 1 exaflop of mixed precision performance (hint: each VM should be equivalent to p3.16xlarge instances; you will want to use the 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 (for pricing comparison, see S3)

VM needed 1 million
According to AWS Calculator 1 million VM of r3.large instance will cost up $ 125235800.00 (including cost AWS Business support)
SO, for 5 years the cost will be $ 125235800.00 *12*5 =$7514148000

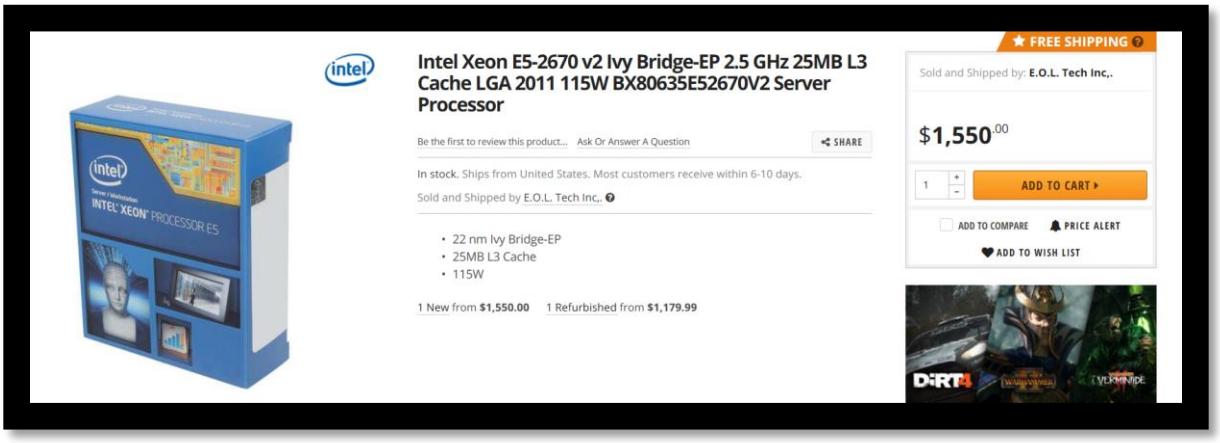
Distributed Storage:
For 10PB the total cost for per month which will be charged by AWS is $ 238962.37 (including AWS Business Support)
Therefore, total cost for 5 years is
$ 238962.37*12*5 =$ 14337742.2

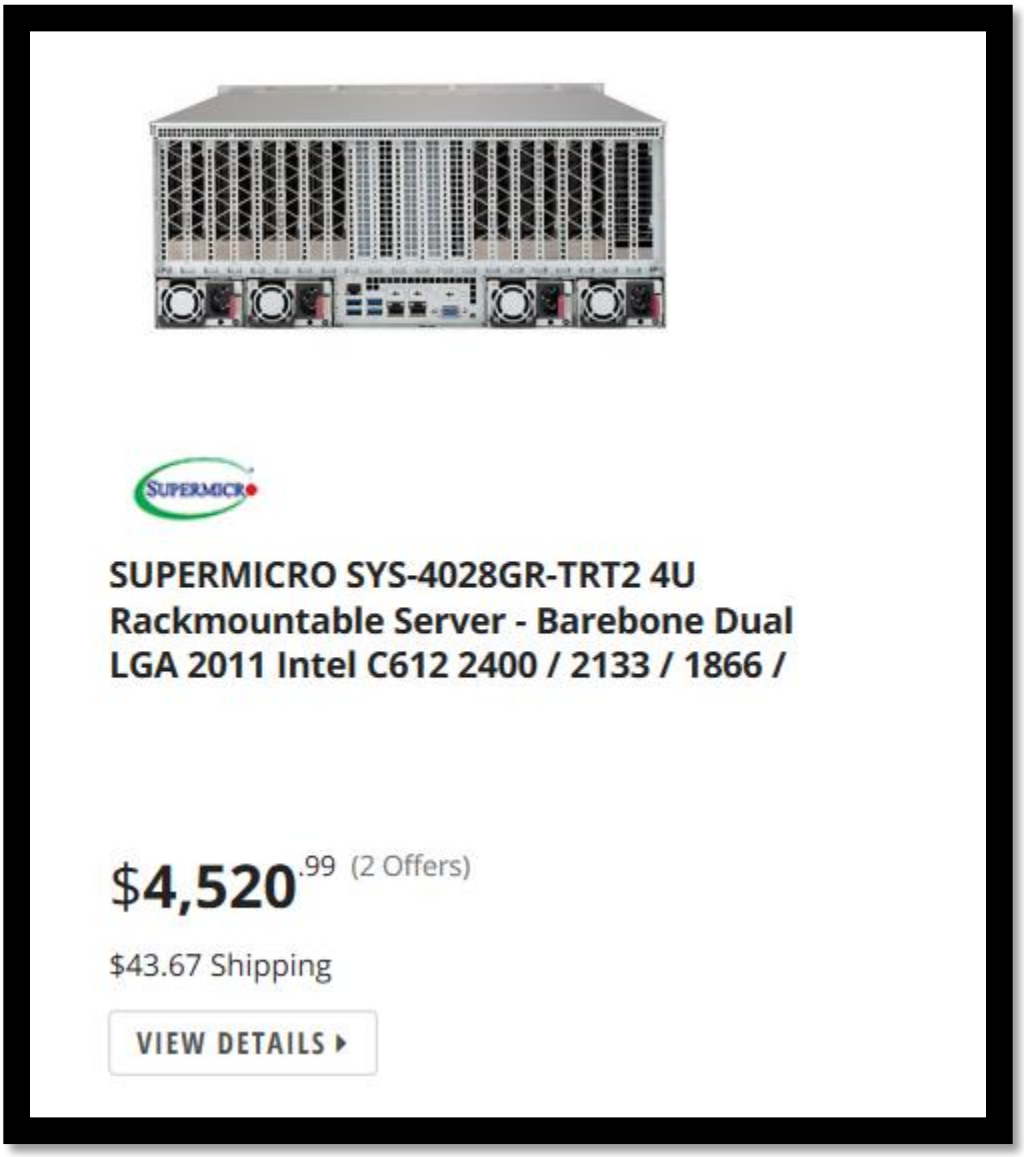
Therefore Total Public Cloud Cost for Configuration 2 is :
Cost of EC2 for 5 years + Cost of Storage for 5 years:
=$7514148000+ $ 14337742.2= $ 7528485742.2

Component		Description	Quantity	Price/Unit	Total Price	Power(Watts)/Unit	Total Power(watt)/hour	
Computer Servers	Processor	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	200000	$1,550	$310,000,000.00	115	23000000	https://www.newegg.com/Product/Product.aspx?Item=9SIAAEE5739794&ignorebbr=1
	Rackmount	SUPERMICRO SYS-4028GR-TRT2 4U Rackmountable Server - Barebone Dual LGA 2011 Intel C612 2400 / 2133 / 1866 / 1600 MHz ECC DDR4 SDRAM 72-bit	100000	$4,521	$452,099,000.00	2000	200000000	https://www.newegg.com/Product/Product.aspx?Item=N82E16816139162&cm_re=SUPERMICRO_SYS-4028GR-TRT2_4U_Rackmountable_Server_-_Barebone_Dual_LGA_2011_Intel_C612_2400_%2f_2133_%2f_1866_%2f_1600_MHz_ECC_DDR4_SDRAM_72-bit-_-16-139-162-_-Product
	Internal Storage	Intel 535 Series 2.5" 360GB SATA III MLC SSDSC2BW360H6R5	100000	$150	$15,000,000			https://www.newegg.com/Product/Product.aspx?Item=9SIA99455A0964&cm_re=ssd_storage-_-9SIA99455A0964-_-Product
	Memory	SAMSUNG 16GB 288-Pin DDR4 SDRAM Registered DDR4 2400 (PC4 19200) Memory (Server Memory) Model M393A2K40BB1-CRC	200000	$190	$38,000,000			https://www.newegg.com/Product/Product.aspx?Item=9SIAE9A6E64627&cm_re=SAMSUNG_16GB_288-Pin_DDR4_SDRAM_Registered_DDR4_2400_%28PC4_19200%29_Memory_%28Server_Memory%29_Model_M393A2K40BB1-CRC-_-20-147-575-_-Product
		Samsung M386A8K40BM1-CPB 64GB DDR4-2133 4Rx4 LP ECC LRDIMM Server Memory	200000	$852.29	$170,458,000			https://www.newegg.com/Product/Product.aspx?Item=9SIA5EM3G36302&cm_re=memory_server-_-1WK-002G-00022-_-Product
Network Switches		Cisco Catalyst 2960-Plus 48TC-L 48-Port Fast Ethernet Switch	2181	$1,789	$3,901,809	30.6	66738.6	https://www.cdw.com/product/Cisco-Catalyst-2960-Plus-48TC-L-48-Port-Fast-Ethernet-Switch/3156751

Rack& Shelf	Shelf	4U 7" Vented Rack Shelf	102174	$73	$7,458,702			https://www.newegg.com/Product/Product.aspx?Item=9SIA00Y1Y94194&cm_re=4u_rack_shelf-_-9SIA00Y1Y94194-_-Product
	Rack	45U Open Frame aluminium Server Network Rack 1000MM Deep 4 Post With 3 Pairs of L-Rails	10221	$238	$2,432,598			https://www.newegg.com/Product/Product.aspx?Item=9SIAA054SF5010&cm_re=rack_45u-_-9SIAA054SF5010-_-Product
Network Cable		Dell Networking, Cable, SFP+ to SFP+, 10GbE, Active Optical (Optics included) Cable,3 Meter, Customer Kit	104688	$170	$17,796,960			http://www.dell.com/en-us/shop/accessories/apd/470-ablz?ref=p13n_ena_pdp_vv&c=us&cs=04&l=en&s=bsd
Storage Servers		J4601S-Storage Options: 1x HGST 4U 60 Bay JBOD with 60 x 12TB Helium SAS HDD (Kepler +) 3 Meter SAS Cable: 4x Patch Cable SFF-8644 to SFF-8644 External JBOD 3M Warranty and Support: 1x Return to Depot Warranty (5 Year Hardware Warranty with Standard Advance Parts Replacement)	14	$44,475.85	$622,661.90	3300	46200	
Electric Power					$1,133,937,931			
Cooling		Tripp Lite SRCOOL24K SmartRack 24,000 BTU 208 / 240V Portable Air Conditioning Unit	5111	$2,582	$13,196,602	7000	35777000	https://www.newegg.com/Product/Product.aspx?Item=N82E16816228213&cm_re=SRCOOL24K-_-16-228-213-_-Product&nm_mc=AFC-C8Junction&cm_mmc=AFC-C8Junction-_-na-_-na-_-na&cm_sp=&AID=11552995&PID=1796839&SID=285950899
Administration			100	$1,000,000	$100,000,000			
Total					$2,264,904,264			

	Watt/hr	power for 5 years in watts	power for 5 years in Kwatts	Electricity cost(@$ 0.10)
Electricity:	258889939	11339379310680.00	11339379311	$1,133,937,931.07




SUPERMICR
SUPERMICRO SYS-4028GR-TRT2 4U Rackmountable Server - Barebone Dual LGA 2011 Intel C612 2400 / 2133 / 1866 /
$4,520.99 (2 Offers)
$43.67 Shipping
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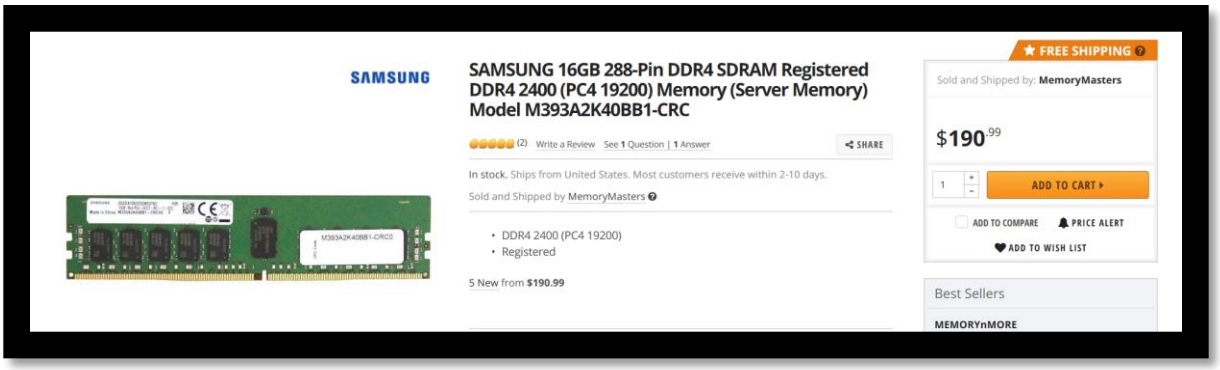
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SAMSUNG 16GB 288-Pin DDR4 SDRAM Registered DDR4 2400 (PC4 19200) Memory (Server Memory) Model M393A2K40BB1-CRC
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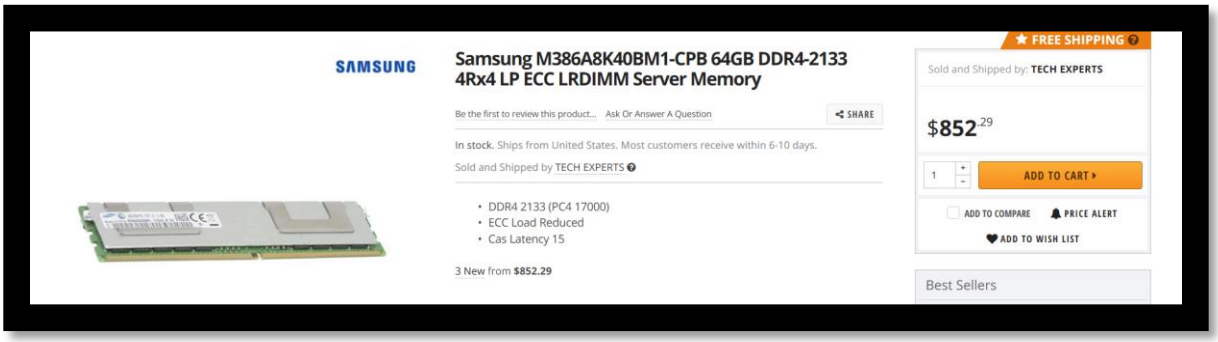
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Samsung M386A8K40BM1-CPB 64GB DDR4-2133 4Rx4 LP ECC LRDIMM Server Memory
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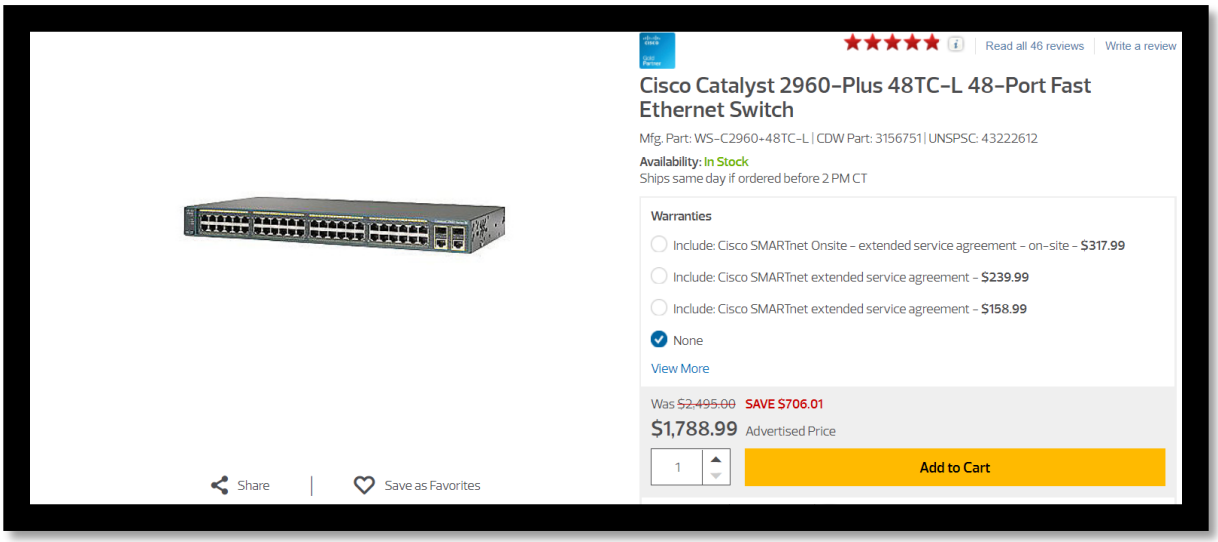
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Mfg. Part: WS-C2960+48TC-L | CDW Part: 3156751 | UNSPSC: 43222612
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Warranties
Include: Cisco SMARTnet Onsite - extended service agreement - on-site - $317.99
Include: Cisco SMARTnet extended service agreement - $239.99
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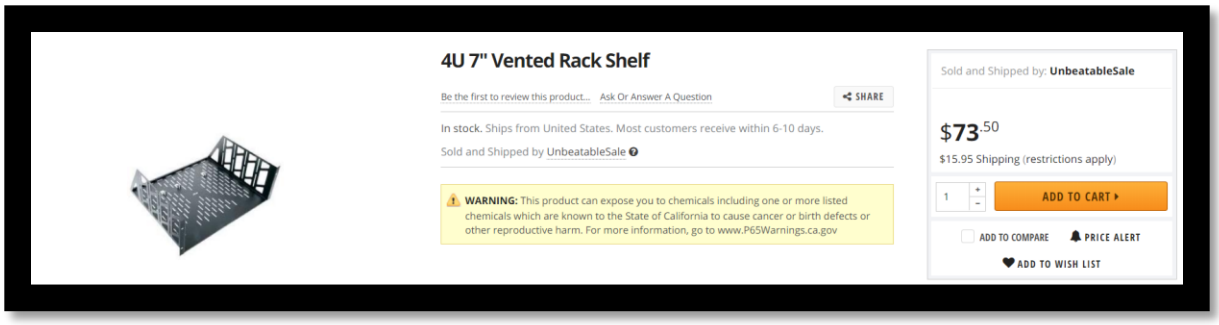
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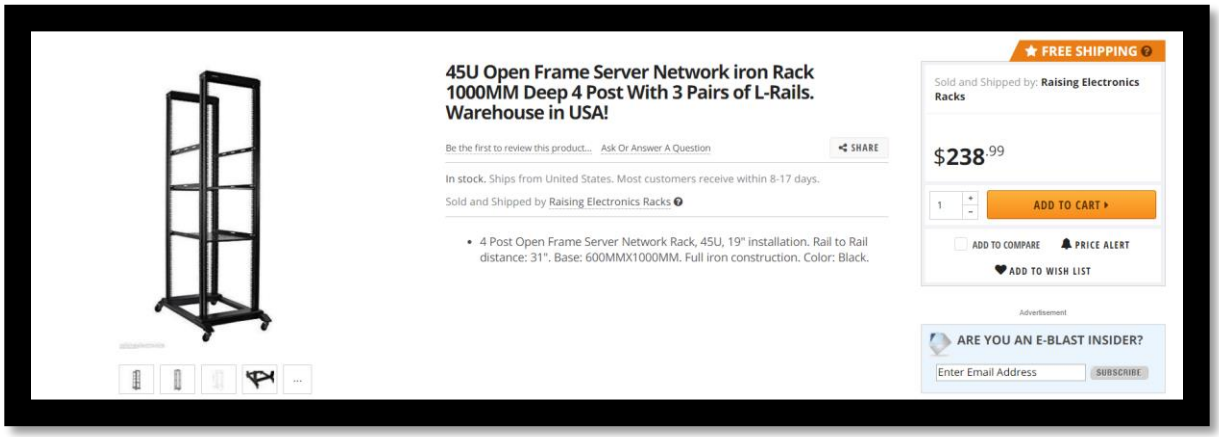
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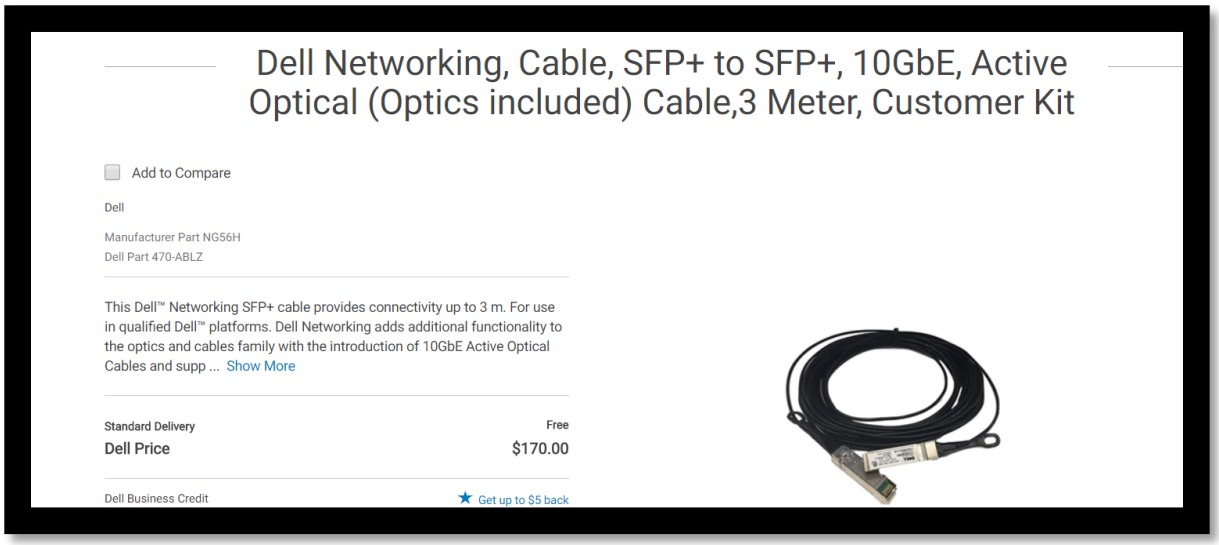
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This Dell™ Networking SFP+ cable provides connectivity up to 3 m. For use in qualified Dell™ platforms. Dell Networking adds additional functionality to the optics and cables family with the introduction of 10GbE Active Optical Cables and supp ... Show More
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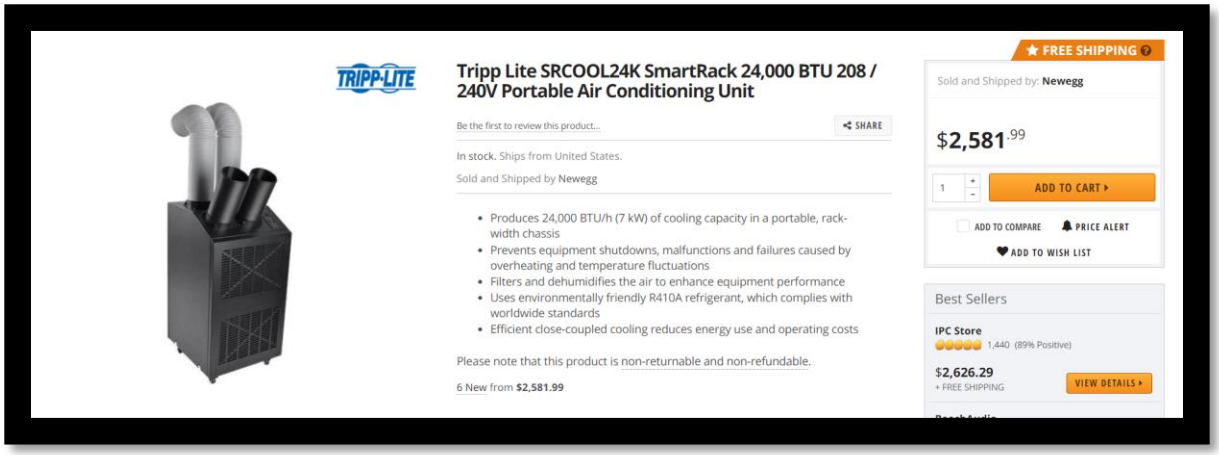
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CONFIGURATION 3

Support deep learning with 1 exaflop of mixed precision performance (hint: each VM should be equivalent to p3.16xlarge instances; you will want to use the 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 (for pricing comparison, see S3) EC2 per hour cost:$24.48 per Hour

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

Component		Description	Quantity	Price/Unit	Total Price	Power(Watts)/Unit	Total Watt/hour	
Computer Servers	GPU	NVIDIA CORP 8-GPU/512GB DGX-1 DL WITH V100	1000	$164,986	$164,986,460.00	120	120000	http://www.nextwarehouse.com/item/?2707240_g10e
Network Switches		Lenovo RackSwitch G8272 Layer 3 Switch	23	$5,526	$127,098.00	230	5290	https://www.newegg.com/Product/Product.aspx?Item=9SIA91N5SB8508&ignorebbr=1&nm_mc=KNC-GoogleMKP-PC&cm_mmc=KNC-GoogleMKP-PC-_-pla-_-Network++Switches-_-9SIA91N5SB8508&gclid=Cj0KCQiA6enQBRDUARIsAGs1YQhh12T-dkPpmJV30MuxP88R2FEp-uX4OuchW_H5IlCTWfkZ-IhFOZ4aAu-BEALw_wcB&gclsrc=aw.ds
Rack & Shelf	shelf	4U 7" Vented Rack Shelf	1025	$73	$74,825.00			https://www.newegg.com/Product/Product.aspx?Item=9SIA00Y1Y94194&cm_re=4u_rack_shelf-_-9SIA00Y1Y94194-_-Product
	Rack	42U 4 Post Open Frame Server Rack 19" Adjustable Depth 25"-37" Aluminum.	102	$238	$24,276.00			https://www.newegg.com/Product/Product.aspx?Item=9SIAA054SF5010&cm_re=rack_45u-_-9SIAA054SF5010-_-Product
Network Cable		Dell Networking, Cable, SFP+ to SFP+, 10GbE, Active Optical (Optics included) Cable,3 Meter, Customer Kit	1039	$170	$176,630.00			http://www.dell.com/en-us/shop/accessories/apd/470-ablz?ref=p13n_ena_pdp_vv&c=us&cs=04&l=en&s=bsd
Storage Servers		J4601S-Storage Options: 1x HGST 4U 60 Bay JBOD with 60 x 12TB Helium SAS HDD (Kepler +) 3 Meter SAS Cable: 4x Patch Cable SFF-8644 to SFF-8644 External JBOD 3M Warranty and Support: 1x Return to Depot Warranty (5 Year Hardware Warranty with Standard Advance Parts Replacement)	2	$44,475.85	$88,951.70	3300	6600	
Electric Power					$2,141,338.20			
Cooling		Tripp Lite SRCOOL24K SmartRack 24,000 BTU 208 / 240V Portable Air Conditioning Unit	51	2,582	$131,682.00	7000	357000	https://www.newegg.com/Product/Product.aspx?Item=N82E16816228213&cm_re=SRCOOL24K-_-16-228-213-_-Product&nm_mc=AFC-C8Junction&cm_mmc=AFC-C8Junction-_-na-_-na-_-na&cm_sp=&AID=11552995&PID=1796839&SID=285950899
Administration			1	$1,000,000	$1,000,000.00			
Total					$168,751,260.90			

	Watt/hr	power for 5 years in watts	power for 5 years in Kwatts	Electricity cost(@$ 0.10)
Electricity:	488890	21413382000.00	21413382	$2,141,338.20

NVIDIA CORP

8-GPU/512GB DGX-1 DL WITH V100

Mfg Part Number: **920-22787-2510-000** , Item #: 2707240

Price: **$164,986.46** + Free Shipping

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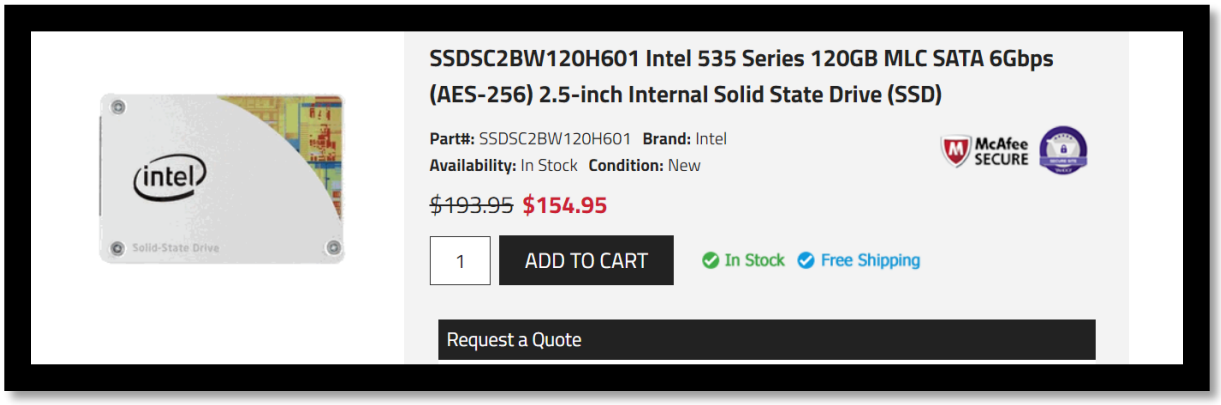
SSDSC2BW120H601 Intel 535 Series 120GB MLC SATA 6Gbps (AES-256) 2.5-inch Internal Solid State Drive (SSD)
Part#: SSDSC2BW120H601 Brand: Intel
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McAfee SECURE
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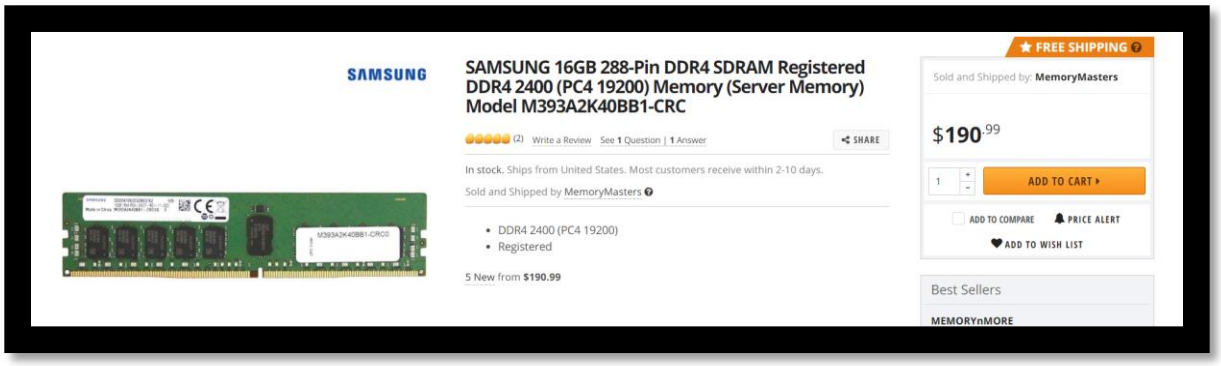
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SAMSUNG 16GB 288-Pin DDR4 SDRAM Registered DDR4 2400 (PC4 19200) Memory (Server Memory) Model M393A2K40BB1-CRC
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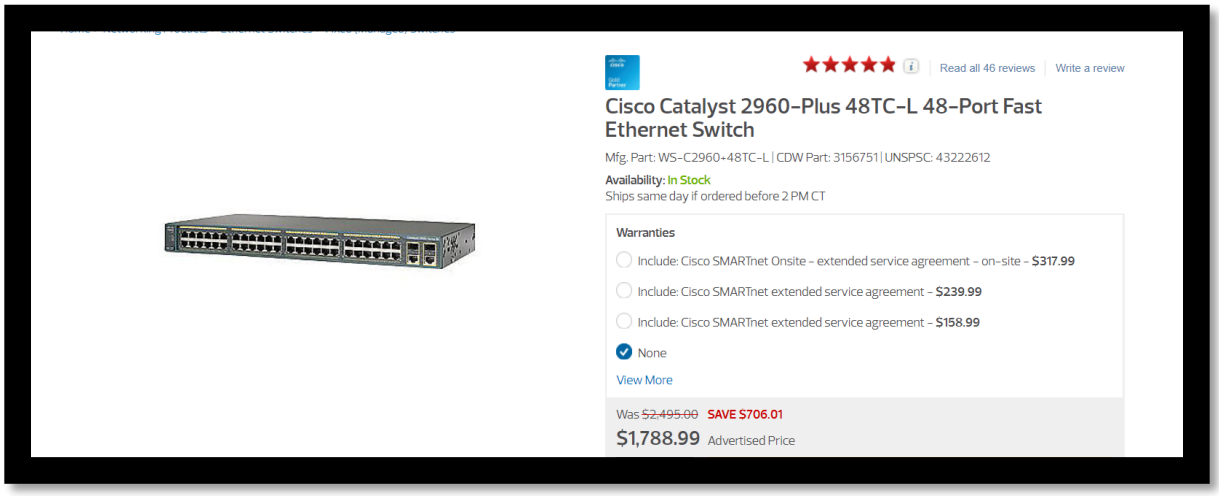
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Cisco Catalyst 2960-Plus 48TC-L 48-Port Fast Ethernet Switch
Mfg. Part: WS-C2960+48TC-L | CDW Part: 3156751 | UNSPSC: 43222612
Availability: In Stock
Ships same day if ordered before 2 PM CT
Warranties
Include: Cisco SMARTnet Onsite - extended service agreement - on-site - $317.99
Include: Cisco SMARTnet extended service agreement - $239.99
Include: Cisco SMARTnet extended service agreement - $158.99
None
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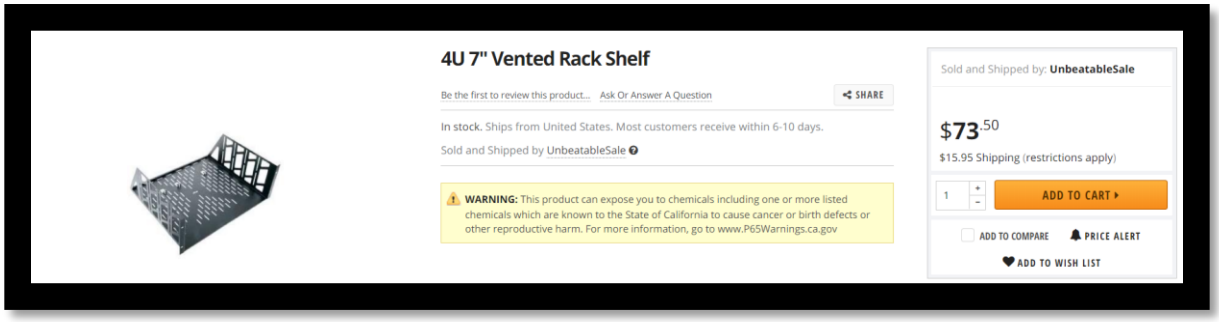
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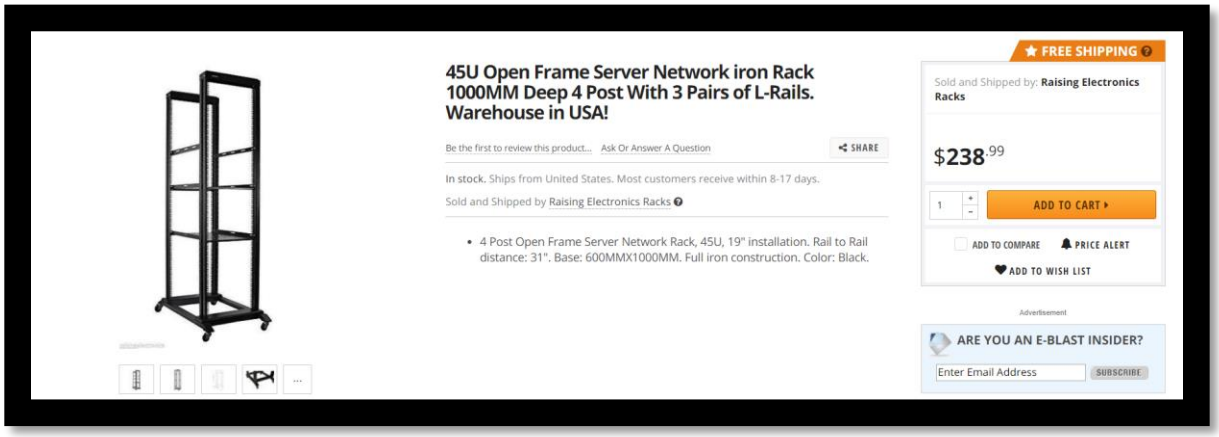
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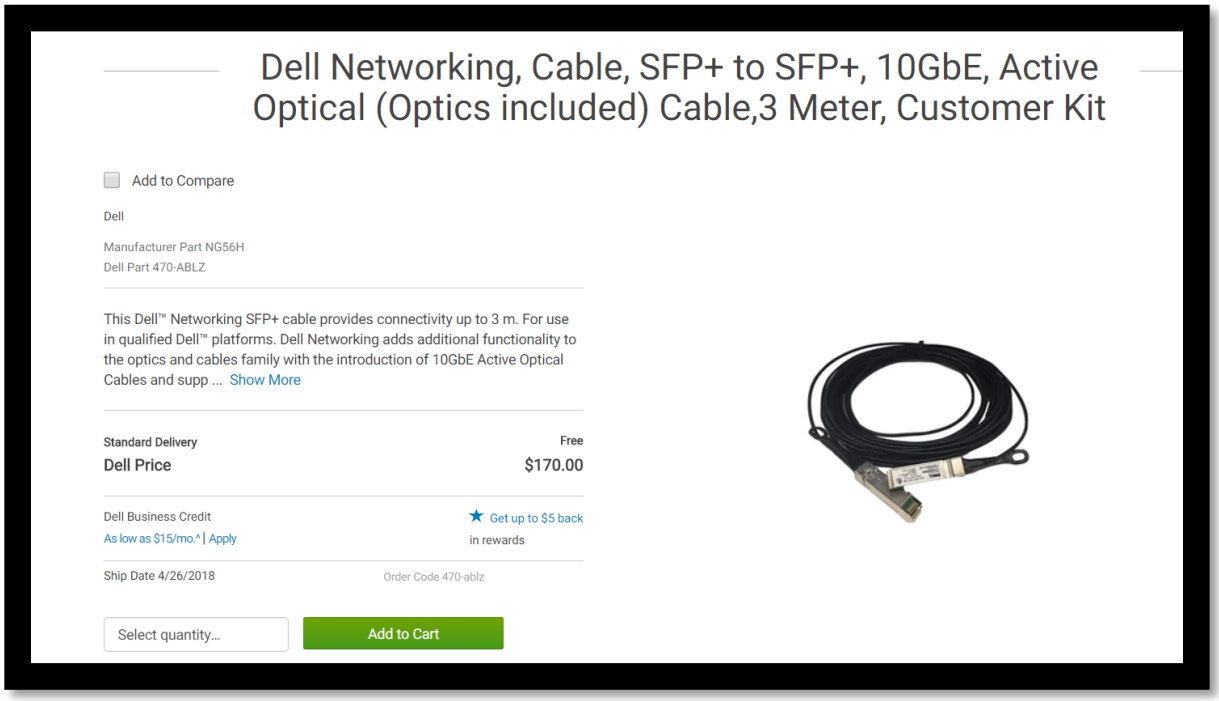

Conclusion: -

	Configuration 1	Configuration 2	Configuration 3
Public Cloud (including EC2 and S3) Cost over 5 years, 24/7 operation, with 100% usage	$404,106,016.80	$7,528,485,742.20	$1,073,484,000.00
Private Cloud cost over 5 years, 24/7 operation, with 100% usage	$43,917,419.55	$2,264,904,263.90	$168,751,260.90
What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud?	10.87%	30.08%	15.72%

In the above observations, if we decrease the utilization rates than above utilization rates then it will make the private cloud more expensive than that of the public cost. Because only the cost for electricity for the private cloud will get decrease, but for the public cloud it's not the same.