CS553 Project:

Understanding the Cost of Computing in the Cloud

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Introduction :

The notion of cloud computing being used in small and large scale applications which require different parameters for specification (such as computing capability , through put capability and storage capability) has been debatable. The different applications based upon the need of the business requiremenst have different capabilities. Some applications require computing capability and not focused on I/O of the data. Some aplications require storage capability but are not focused on the computing capability. In short , based on the above requirements and interests , the cloud providers tend to use various methods and ways to fullfill them.

In this project we are going to do the comaprison of cost based on teh computing capability of Amazon's AWS and a private cloud. Here we are focused on the computing power of the various resources that Amazon provides in terms of cost required to attain it VS the private cloud which we have developed using some basic approaches.

In the following pages , we will discuss the various amazon instances and their computing capability with respect to our private cloud in terms of cost behing per Gflops. We have made some assumptions below which have been used as in the project.

1. The Gflops measure of any hardware has been made using double precision floating point operations.
2. The costs of the hardware for the private cloud has been taken from well known websites. The list has been given at the end of project.

At first we calculate the cost per flop per hour for the amazon's aws (public cloud) then we do the same for the private cloud. Here we are considering 7 instances of amazon AWS listed as : t2.small , m3.large , c3.8xlarge , g2.2xlarge ,r3.4xlarge ,i2.8xlarge and hs1.8xlarge. We also have the private instances of above with Priavte as prefix.

A. Public cloud Instance cost for Gflops :

Below is the table for the instances for amazon where cost to achieve ceratin Gflops/ sec capability has been tabled in $.

Public Cloud Amazon EC2									
Instance Types	ECUs	GFOLPS	1GFlop cost	10 Gflop Cost	100 Gflop cost	1TFlop Cost	10TFlop cost	100TFlop cost	1PTFlops
t2.small	0.4	1.76	1.48E-002	0.15	1.48	14.77	147.73	1477.27	14772.73
m3.large	6.5	28.6	4.90E-003	0.05	0.49	4.9	49	490	4900
c3.8xlarge	108	475.2	3.54E-003	0.04	0.4	4	40	400	4000
g2.2xlarge	26+GK104	614.4	1.06E-003	0.01	0.11	1.06	10.58	105.79	1057.94
r3.4xlarge	52	228.8	6.12E-003	0.06	0.6	6	60	600	6000
i2.8xlarge	104	457.6	1.49E-002	0.15	1.5	15	150	1500	15000
hs1.8xlarge	35	154	2.99E-002	0.3	3	30	300	3000	30000

Table 1.1

In this plot , we have calculated the Gflop/sec cost for each of the instance in order to gain certain **Gflop/sec** capability for **an hour** using amazon defined ECU and pricing for the corresspoing instances. In the table below we have noted the number of instances required to attain the computing capability i.e 1GFlop to 1PFlop.

Instance Types/no. Of instances	1GFlop	10GFlop	100GFlop	1TFlop	10TFlop	100TFlop	1PFlop
t2.small	1	2	23	227	2272	22727.27	227272.73
m3.large	1	1	3	35	350	3496.5	34965
c3.8xlarge	1	1	1	2	21	210.44	2104.4
g2.2xlarge	1	1	1	9	87	874.13	8741.3
r3.4xlarge	1	1	1	4	44	437.06	4370.6
i2.8xlarge	1	1	1	2	22	218.53	2185.3
hs1.8xlarge	1	1	1	6	65	649.35	6493.5

Table 1.2

In the above 1.2 Table , we have calculated the number of instances required to go from 1GFlop to 1PFlop **per sec per hour**.

B. Private cloud instance cost per Gflop/sec per hour calculation.

In order to calculate the cost we have created the data in the tabluar format for each of the priavte instances as given below :

a. Private.t2.small table of cost broken down to compenent level :

Private.t2.small	40GFlops/sec		
category	description	cost(in $ for 1 year)	cost (in $ for 5 Year)
cpu	Intel Xeon E5-2609 v2 Ivy Bridge-EP 2.5GHz 10MB L3 Cache LGA 2011 80W Server Processor BX80635E52609V2	300	300
motherboard	intel c602 chipset	275	275
memory	240 -pin DDR3 SDRAM 4GB	55	55
disk	TCELL XS Mini Hard Disk	20	20
switches	24 port Gigabit port	170	170
case	SILVERSTONE Black Aluminum / Plastic Grandia GD09B ATX / SSI-CEB Media Center / HTPC Case	170	170
power	180Watt	145.08	725.4
cooling	1/3 of power	48.36	241.8
		Total cost without including (system administrator)	1957.2
Administration	average system admin salary	100000	500000

Table 2.1

In the above table , we have represented the cost of the components for 5 year period. The priavte instance has 40GFlops capabilty assuming the Amazon's t2 instances have burstable performance at the regular interval. Based on the above table we have calculated the cost per hour per Gflops for above instance shown in the below table :

Flops	Instance	5 year cost	1hour cost	cost 1hour per Gflop
1GFlop	1	501957	11.46	2.87E-001
10GFlop	1	501957	11.46	2.90E-001
100GFlop	3	505871.6	11.55	9.62E-002
1TFlop	25	548930	12.53	1.25E-002
10TFlop	250	989300	22.59	2.26E-003
100TFlop	2500	6393000	145.96	1.46E-003
1000TFlop	25000	61430000	1402.51	1.40E-003

Table 2.2

b. Private.m3.large :

Private.m3.large	100GFlops/sec			
category	Device	Details	Price($)	Cost for 5 years
Chassis	Rosewill RSV-L4000 Black Metal / Steel, 1.0 mm thickness, 4U Rackmount Server Chassis 8 Internal Bays, 7 Included Cooling Fans		84.99	84.99
motherboard	ASUS MAXIMUS VII HERO LGA 1150 Intel Z97 HDMI SATA 6Gb/s USB 3.0 ATX Intel Motherboard		221	221
cpu	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5GHz 25MB L3 Cache LGA 2011 115W Server Processor BX80635E52670V2		1534	1534
memory	HyperX Fury Series 8GB 240-Pin DDR3 SDRAM DDR3 1600 (PC3 12800) Desktop Memory Model HX316C10F/8		74	74
Storage	Delkin 32GB ExpressCard 34 Pro Solid State Drive #DDEXPSSD132GB		71	71
Cooling System	Cooler Master Sleeve Bearing 120mm Silent Fan for Computer Cases, CPU Coolers, and Radiators (Value 4-Pack)		21	21
Network Adapter	SYBA SY-PEX24028 Dual Port Gigabit Ethernet Network Adapter 10/ 100/ 1000Mbps PCI-Express 2 x RJ45		39	39
Network Switch	cisco WS-C3560-48TS-SSwitch(GradeA)		360	360
System Power			7247.05	36235.25
Cooling Power			2415.68	12078.4
		Total cost without including (system administrator)		50718.64
System Administrator			100000	500000

Table 3.1

Based on the above data we derived 100GFlops/sec capacity for this instance. The table below shows the cost per Gflop per Hour for private.m3.large.

Flops	Instance	5 year cost	cost per hour	cost 1hour per Gflop
1GFlop	1	550718.64	12.57	1.26E-001
10GFlop	1	550718.64	12.57	1.26E-001
100GFlop	1	550718.64	12.57	1.26E-001
1TFlop	10	1007186.4	23	2.30E-002
10TFlop	100	5571864	127.21	1.27E-002
100TFlop	1000	51218640	1169.38	1.17E-002
1000TFlop	10000	512186400	11693.75	1.17E-002

Table 3.2

c. Priavte.C3.8xlarge :

The table for component wise breakdown of cost is as shown below :

Private.c3.8xlarge	448GFlops			
category	Device	Details	Price($)	Cost for 5 years
Chassis	Rosewill RSV-L4000 Black Metal / Steel, 1.0 mm thickness, 4U Rackmount Server Chassis 8 Internal Bays, 7 Included Cooling Fans		85	85
motherboard	ASUS Z9PA-U8 ATX Server Motherboard LGA 2011 DDR3 1600/1333/1066		290	290
cpu	Intel Xeon E5-2680 v2 Ivy Bridge-EP 2.8GHz 25MB L3 Cache LGA 2011 115W Server Processor BX80635E52670V2	4x	6648	6648
memory	HyperX Fury Series 8GB 240-Pin DDR3 SDRAM DDR3 1600 (PC3 12800) Desktop Memory Model HX316C10F/8	8x	592	592
Storage	ADATA Premier Pro SP900 ASP900S3-128GM-C 2.5" 128GB SATA III MLC Internal Solid State Drive (SSD)	5x	350	350
Cooling System	Cooler Master Sleeve Bearing 120mm Silent Fan for Computer Cases, CPU Coolers, and Radiators (Value 4-Pack)	2x	60	60
Network Adapter	Intel X520-DA2 Dual Ports 10 Gigabit Ethernet Converged Network Adapter, PCI Express 2.0 x8, Low Profile - OEM		423	423
Network Switch	cisco WS-C3560-48TS-SSwitch(GradeA)		53	53
System Power			18811.55	94057.75
Cooling Power			6270.51	31352.55
		Total cost without including (system administrator)		133911.3
System Administrator			100000	500000

Table 4.1

The cost/ Gflop/sec per hour is calculated as below (having 448 Gflops/sec compute capacity of one instance).

Flops	Instance	5 year cost	cost per hour	cost 1hour per Gflop
1GFlop	1	633911.3	14.47	3.23E-002
10GFlop	1	633911.3	14.47	3.23E-002
100GFlop	1	633911.3	14.47	3.23E-002
1TFlop	2	767822.6	17.53	1.96E-002
10TFlop	20	3178226	72.56	8.10E-003
100TFlop	200	27282260	622.88	6.95E-003
1000TFlop	2000	268322600	6126.09	6.95E-004

Table 4.2

d. Private.g2.2xlarge :

Private.g2.2xlarge	694.8GFlops/sec			
category	Device	Details	Price($)	Cost for 5 years
Chassis	Rosewill RSV-L4000 Black Metal / Steel, 1.0 mm thickness, 4U Rackmount Server Chassis 8 Internal Bays, 7 Included Cooling Fans		85	85
motherboard	ASUS Z9PE-D8 WS Dual LGA 2011 Intel C602 SATA 6Gb/s USB 3.0 SSI EEB Intel Motherboard		535	535
cpu	Intel Xeon E5-2630 v2 Ivy Bridge-EP 2.6GHz 15MB L3 Cache LGA 2011 80W Server Processor BX80635E52630V2	2x	1220	1220
GPU	nVidia Tesla K10 8GB GDDR5 Computing Processing Unit Module GK104 Kepler GPUs. P/N: 900-22055-0020-000	3x	6960	6960
memory	Kingston 16GB (2 x 8GB) 240-Pin DDR3 SDRAM ECC Unbuffered DDR3 1333 Server Memory Model KVR1333D3E9SK2/16G		202	202
Storage	Corsair Force LS Series CSSD-F60GBLS 2.5" 60GB SATA III MLC Internal Solid State Drive (SSD)		50	50
Cooling System	Cooler Master Sleeve Bearing 120mm Silent Fan for Computer Cases, CPU Coolers, and Radiators (Value 4-Pack)		30	30
Network Adapter	NETGEAR 5 Port Gigabit Business-Class Desktop Switch - Lifetime Warranty (GS105)		35	35
Network Switch	cisco WS-C3560-48TS-SSwitch(GradeA)		300	300
System Power			1640	8200
Cooling Power			550	2750
			cost without system administrator	20367
system administrator cost			100000	500000

Table 5.1

The cost per Gflops/sec per hour is calculated as below(having 694.8 Gflops/sec compute capacity for per instance) :

Flops	Instance	5 year cost	cost per hour	cost 1hour per Gflop
1GFlop	1	520367	11.88	1.71E-002
10GFlops	1	520367	11.88	1.71E-002
100GFlops	1	520367	11.88	1.71E-002
1TFlop	2	540734	12.35	8.88E-003
10TFlops	15	805505	18.39	1.77E-003
100TFlops	144	3432848	78.38	7.83E-004
1PFlops	1440	30328480	692.43	6.92E-004

Table 5.2

e. Private.r3.4xlarge :

Private.r3.4xlarge	240GFlops/sec			
category	Device	Details	Price($)	Cost for 5 years
Chassis	iStarUSA D-313SE-MATX Black Aluminum / Steel 3U Rackmount Compact Industrial Chassis - Black Bezel 2 External 5.25" Drive Bays		86	86
motherboard	ASUS Z9PE-D8 WS Dual LGA 2011 Intel C602 SATA 6Gb/s USB 3.0 SSI EEB Intel Motherboard		535	535
cpu	Intel Xeon E5-2680 v3 Haswell 2.5GHz 12 x 256KB L2 Cache 30 MB L3 Cache LGA 2011-3 120W Server Processor BX80644E52680V3	2x	3644	3644
memory	Kingston 32GB (4 x 8GB) 240-Pin DDR3 SDRAM ECC Unbuffered DDR3 1600 Server Memory w/TS Model KVR16E11K4/32	4x	1520	1520
Storage	Intel DC S3500 Series SSDSC2BB160G401 2.5" 160GB SATA III MLC Internal Solid State Drive (SSD) - OEM	2x	320	320
Cooling System	Cooler Master Sleeve Bearing 120mm Silent Fan for Computer Cases, CPU Coolers, and Radiators (Value 4-Pack)		30	30
Network Adapter	SYBA SY-PEX24028 Dual Port Gigabit Ethernet Network Adapter 10/ 100/ 1000Mbps PCI-Express 2 x RJ45		39	39
Network Switch	cisco WS-C3560-48TS-SSwitch(GradeA)		300	300
System Power			1345	6725
Cooling Power			450	2250
			Total cost without including (system administrator)	15449
			system administrator cost	100000	500000

Table 6.1

The cost per Gflops/sec per hour is calculated as below (having 240GFlops/sec compute capacity per instance) :

Flops	Instance	5 year cost	costper hour	cost 1hour per Gflop
1GFlop	1	515449	11.77	4.90E-002
10GFlops	1	515449	11.77	4.90E-002
100GFlops	1	515449	11.77	4.90E-002
1TFlop	4	561796	12.83	1.34E-002
10TFlops	42	1148858	26.23	2.60E-003
100TFlops	417	6942233	158.5	1.58E-003
1PFlops	4167	66375983	1515.43	1.52E-003

Table 6.2

f . Private.i2.8xlarge :

Private.i2.8xlarge	480GFlops/sec			
category	Device	Details	Price($)	Cost for 5 years
Chassis	4U Rackmount server chasis	2x	170	170
motherboard	LGA 2011 intel Sata 6gb/s	2x	1000	1000
cpu	intel xeon E5-2690 3.00gz	4x	8040	8040
memory	Kingston 32GB memory DDR3	8x	4430	4430
Storage	intel 800GB SATA	8x	5920	5920
Cooling System	cool master coolingpack	4x	80	80
Network Adapter	intel Dual port 10Gigabit		423	423
Network Switch	cisco switch		420	420
System Power			2448	12240
Cooling Power			816	4080
		Total cost without including (system administrator)		36803
		system administrator cost	100000	500000

Table 7.1

The cost per Gflops/sec per hour is calculated as below :(having 480Gflops compute capacity per instance).

Flops	Instance	5 year cost	cost per hour	cost 1hour per Gflop
1GFlop	1	536803	12.26	2.55E-002
10GFlops	1	536803	12.26	2.55E-002
100GFlops	1	536803	12.26	2.55E-002
1TFlop	2	573606	13.1	1.36E-002
10TFlops	21	1272863	29.06	2.88E-003
100TFlops	208	8155024	186.19	1.86E-003
1PFlops	2083	76660649	1750.24	1.86E-004

Table 7.2

g. Private.h1.8xlarge :

Private.hs1.8xlarge	154GFlops			
category	Device	Details	Price($)	Cost for 5 years
Chassis	4U Rackmount server chasis		75	75
motherboard	intel SATA C602 chipset		500	500
cpu	Intel Xeon E5-2695 v2 Ivy Bridge-EP 2.4GHz 30 MB L3 Cache LGA 2011 115W Server Processor BX80635E52695V2	2x	4620	4620
memory	Kingston 32GB memory DDR3	4x	2215	2215
Storage	Samsung Electronics 840 EVO-Series 1TB 2.5-Inch SATA III Single Unit Version Internal Solid State Drive MZ-7TE1T0BW	48x	22320	22320
Cooling System	Cooling machine Master SIleve	4x	80	80
Network Adapter	inetl 10Gigabit Ethenert		430	430
Network Switch	cisco switch-S Swicth Ts		360	360
System Power			1091	5455
Cooling Power			365	1825
		Total cost without including (system administrator)		37880
		System Administrator	100k	500000

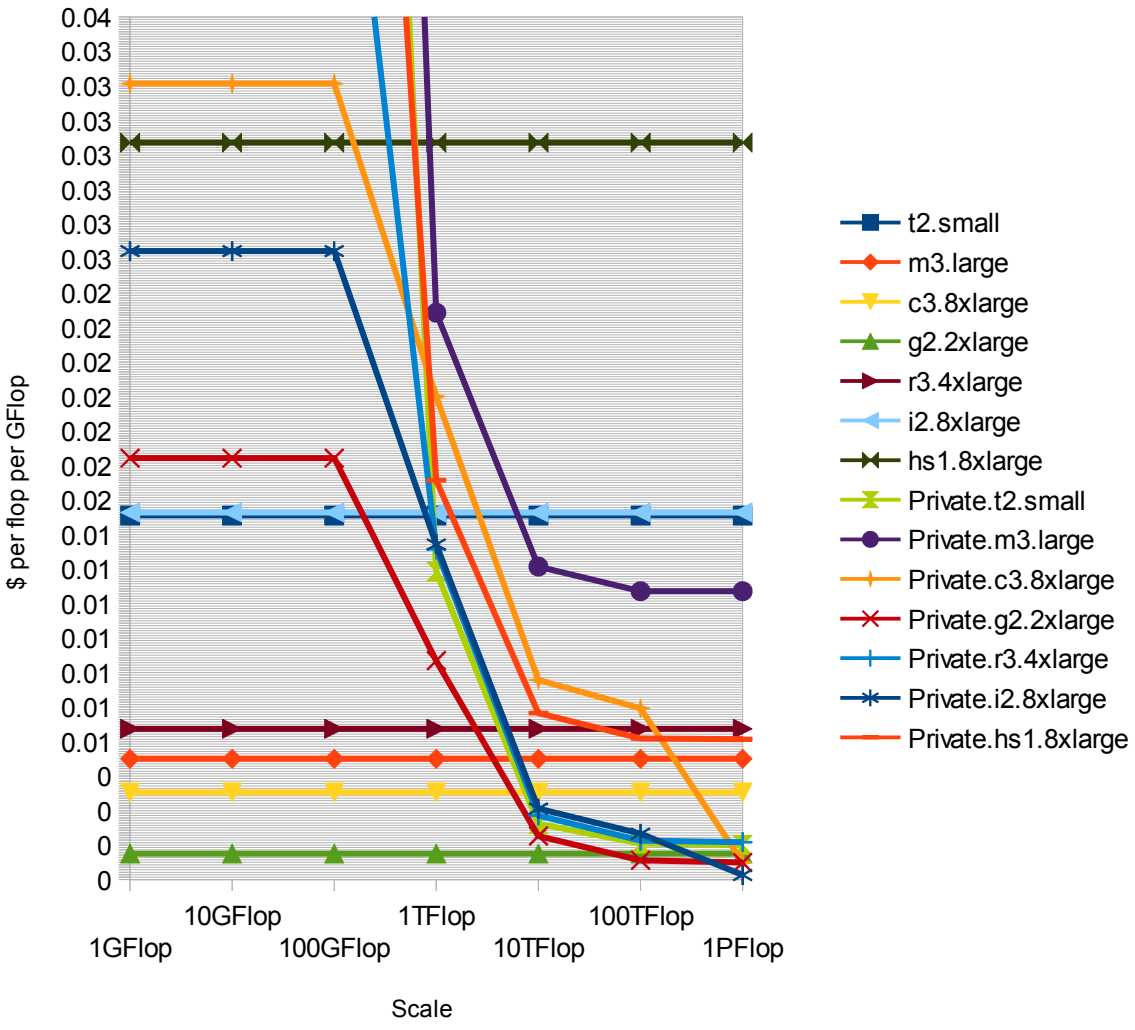
Table 8.1

The cost per Gflops/sec per hour is calculated as below :(having 154Gflops compute capacity per instance):

Flops	Instance	5 year cost	cost per hour	cost 1hour per Gflop
1GFlop	1	537880	12.28	7.97E-002
10GFlops	1	537880	12.28	7.97E-002
100GFlops	1	537880	12.28	7.97E-002
1TFlop	7	765160	17.47	1.62E-002
10TFlops	65	2962200	67.63	6.76E-003
100TFlops	651	25159880	574.43	5.73E-003
1PFlops	6511	250136680	5710.88	5.70E-003

Table 8.2

Based on the above data of the cost per Gflop/sec per hour we have plotted the graph (Plot #1) which will give cost ($) per Gflop/sec per hour for Amazon instances vs private instacnes. The Graph is as below :



Plot # 1

- Based on the above plot we can see that the M3.large private instance never breaks even with amazon instance within given Gflops range. The reason can be explained on the basis of the cost of the materials and the system administration cost . Hence the m3.large private instacne is expensive.
- Next , the private instances break even with the amazon instances because the cost of administration is proportionally reduced for higher Gflops capacity. The private instances for the small scale are far expensive than the amazon instances.
- As the scale increases , the private instances get cheaper as compared to amazon instances. This situation is preferrable for very large oragnizations where as Amazon does a lot of business with small to mid businesses which would prefer the amazon instances as compared to the private cloud.

Conclusion : The amazon vs priavte cloud can be selected upon the business needs. The small to mid rangeorganization should go for amazon and very large organization where computing is the prime task can customize a private cloud.

Refernces :

1. http://www.newegg.com/
2. http://www.intel.com/content/www/us/en/homepage.html
3. http://aws.amazon.com/ec2/instance-types/
4. http://www.amazon.com/