

Project Report on:

Understanding the Cost of Computing in the Cloud

The report is about cost of cloud computing while designing the private data centres, here the comparison have been made between public cloud Amazon EC2 and the one designed by private companies when they have a huge demand of cloud services.

Whenever a company wants to switch to cloud or a new company wants to design their own Data Centre for the purpose of their customer base, Trade-offs will always be there whether to opt for a public cloud such as Amazon Ec2, Google App Engine, and Microsoft Azure or design your own Data Centre which is nothing but private cloud.

While making a choice, many factors are needed to be considered to come to the final conclusion between both.

Following are the factors needs to be considered while deciding between private or public cloud.

- 1) Cost of computing
- 2) Demand/ Usage
- 3) Security
- 4) Maintenance
- 5) Compliance
- 6) Future usage
- 7) Scalability
- 8) Reliability

Here in report Cost is considered as one of the driving factor to decide between public and private cloud, as we know that for start-ups cost is major criteria to discuss on. Here the comparisons of cost have been made of Amazon Ec2 instances namely m4.10xlarge, m3.large, m3.2xlarge, c3.8xlarge, g2.2xlarge, r3.4xlarge, i2.8xlarge, and d2.8xlarge and the corresponding private cloud instances namely m4.10xlarge.private, m3.large.private, m3.2xlarge.prinvate, c3.8xlarge.private, g2.2xlarge.private, r3.4xlarge.private, i2.8xlarge.private, and d2.8xlarge.private to decide on choice. The cost has been calculated of each of the hardware required to own a data centre like Processor cost, Memory Cost, Motherboard cost, Disk Cost, Power and Cooling cost, admin cost etc. Based on various criteria 5 years cost have been calculated with the usage of cloud scaling from 1GFLOP to 1PFLOP, to analyse the cost of computing in cloud.

The cost is been calculated on \$/FLOP/Hour basis to better compare with the public cloud cost which will remain constant even if the usage of service scales up from 1GFLOP to 1 PFLOP.

GFLOPS for Public Cloud Instance:

Assumption:

I have used the Double Point Floating Point operation to calculate the GFLOPS for CPU.

Instance Type	Processor	Number of Cores	Clock speed (GHZ)	Instructions per cycle (IPC) (DP: Double Point)	GFLOPS
m4.10xlarge	Intel Xeon E5-2676 v3 (Haswell)	40	2.4	16 DP	768
m3.large	Intel Xeon E5-2670 v2 (Ivy Bridge)	2	2.5	8 DP	20
m3.2xlarge	Intel Xeon E5-2670 v2 v2 (Ivy Bridge)	8	2.5	8 DP	80
c3.8xlarge	Intel Xeon E5-2680 v2 v2 (Sandy Bridge)	32	2.8	8 DP	359
g2.2xlarge	Intel Xeon E5-2670 v2 (Sandy Bridge)	8	2.6	8 DP	84
r3.4xlarge	Intel Xeon E5-2670 v2 v2 (Ivy Bridge)	16	2.5	8 DP	160
i2.8xlarge	Intel Xeon E5-2670 v2 v2 (Ivy Bridge)	32	2.5	8 DP	320
d2.8xlarge	Intel Xeon E5-2676 v3(Haswell)	36	2.4	16 DP	692

Private cloud cost equivalents to the 8 different Amazon EC2 Instance Types:

m4.10xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	INTEL XEON E5-2676 V3 2.40GHz SR1Y5 30Mb 12 Cores	2	1500
Memory	Crucial 128GB (4 x 32GB) 288-Pin DDR4 SDRAM ECC DDR4 2133 (PC4 17000) Server Memory Model CT4K32G4LFQ4213	2	2340
Disk (SSD)	Seagate Surveillance HDD ST2000VX003 2TB 64MB Cache SATA 6.0Gb/s Internal Hard Drive	1	90
MotherBoard	ASUS Z10PA-U8 ATX Server Motherboard LGA 2011-3 DDR4 2133 / 1866 / 1600 / 1333	1	321
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel Ethernet Converged Network Adapter X540-T2	1	529
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power(5 Years)	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power(5 Years)	Chicago's Avg. Rate 0.153(kWh)		1608.336
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			447665.369
Total Cost for 1 hour			10.22067053
Final Price	Cost Per FLOP per Hour		0.013308165

m3.large.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	1	750
Memory	Kingston 8GB 240-Pin DDR3 SDRAM ECC Unbuffered DDR3 1600 Server Memory w/TS Intel Model KVR16E11/8I	1	48.82
Disk (SSD)	SanDisk SSD PLUS 2.5" 120GB SATA III Internal Solid State Drive (SSD) SDSSDA-120G-G25	1	43
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE- 825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel EXPI9301CTBLK Network Adapter 10/ 100/ 1000Mbps PCI-Express 1 x RJ45	1	28
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power	Chicago's Avg. Rate 0.153(kWh)		770.661
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			444257.514
Total Cost for 1 hour			10.14286562
Final Price	Cost Per FLOP per Hour		0.507143281

m3.2xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	1	1600
Memory	Black Diamond Memory 32GB (2 x 16GB) 240-Pin DDR3 SDRAM ECC Registered DDR3 1600 (PC3 12800) Server Memory Model BD16GX21600MTR26	1	180
Disk (SSD)	Intel DC S3610 2.5" 200GB SATA III MLC Internal Solid State Drive (SSD) SSDSC2BX200G401 - OEM	1	190
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel EXPI9301CTBLK Network Adapter 10/ 100/ 1000Mbps PCI-Express 1 x RJ45	1	28
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power	Chicago's Avg. Rate 0.153(kWh)		770.661
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			444535.694
Total Cost for 1 hour			10.14921676
Final Price	Cost Per FLOP per Hour		0.126865209

c3.8xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2680 v2 Ivy Bridge-EP 2.8 GHz 25MB L3 Cache LGA 2011 115W BX80635E52680V2 Server Processor	2	3560
Memory	Kingston ValueRAM 64GB (4 x 16GB) 240-Pin DDR3 SDRAM ECC Registered DDR3 1600 Server Memory (Intel Validated) Model KVR16R11D4K4/64I	1	400
Disk (SSD)	SAMSUNG 850 EVO 2.5" 1TB SATA III 3-D Vertical Internal Solid State Drive (SSD) MZ-75E1T0B/AM	1	190
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel Ethernet Converged Network Adapter X540-T2	1	529
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power	Chicago's Avg. Rate 0.153(kWh)		770.661
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			444535.694
Total Cost for 1 hour			10.21275557
Final Price	Cost Per FLOP per Hour		0.261865527

g2.2xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2670 Sandy Bridge-EP 2.6GHz (3.3GHz Turbo Boost) 20MB L3 Cache LGA 2011 115W BX80621E52670 Server Processor	1	585
Memory	Kingston 24GB (3 x 8GB) 240-Pin DDR3 SDRAM ECC DDR3 1600 (PC3 12800) Server Memory Model KVR16LE11K3/24	1	150.86
Disk (SSD)	Intel DC S3500 Series 1.8" 80GB SATA III MLC Internal Solid State Drive (SSD) SSDSC1NB080G401 - OEM	1	105
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel EXPI9301CTBLK Network Adapter 10/ 100/ 1000Mbps PCI-Express 1 x RJ45	1	28
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power (5years)	Chicago's Avg. Rate 0.153(kWh)		10132.5168
Cooling Power(5years)	Chicago's Avg. Rate 0.153(kWh)		770.661
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			446201.0378
Total Cost for 1 hour			10.18723831
Final Price	Cost Per FLOP per Hour		0.121276646

r3.4xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	1	1600
Memory	Kingston 64GB (4 x 16GB) 240-Pin DDR3 SDRAM ECC Registered DDR3 1600 Server Memory DR x4 Model KVR16R11D4K4/64	2	740
Disk (SSD)	SAMSUNG 850 PRO 2.5" 512GB SATA III 3-D Vertical Internal Solid State Drive (SSD) MZ-7KE512BW	1	212.19
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel EXPI9301CTBLK Network Adapter 10/ 100/ 1000Mbps PCI-Express 1 x RJ45	1	28
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power (5years)	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power(5years)	Chicago's Avg. Rate 0.153(kWh)		770.661
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			445117.884
Total Cost for 1 hour			10.16250877
Final Price	Cost Per FLOP per Hour		0.06351568

i2.8xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	Intel Xeon E5-2670 v2 Ivy Bridge-EP 2.5 GHz 25MB L3 Cache LGA 2011 115W BX80635E52670V2 Server Processor	2	3200
Memory	Kingston 64GB (4 x 16GB) 240-Pin DDR3 SDRAM ECC Registered DDR3 1600 Server Memory DR x4 Model KVR16R11D4K4/64	4	1468
Disk (SSD)	SAMSUNG 850 PRO 2.5" 2 TB SATA III 3-D Vertical Internal Solid State Drive (SSD) MZ-7KE2T0BW	4	3600
MotherBoard	Intel DBS2600CP2 SSI EEB Server Motherboard Dual LGA 2011 DDR3 1600	1	490
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE-825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel Ethernet Converged Network Adapter X540-T2	1	529
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power (5years)	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power(5years)	Chicago's Avg. Rate 0.153(kWh)		3082.644
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			453646.677
Total Cost for 1 hour			10.35723007
Final Price	Cost Per FLOP per Hour		0.032366344

d2.8xlarge.private:

Parameters	Components Name	Quantity	Cost (\$)
CPU	INTEL XEON E5-2676 V3 2.40GHz SR1Y5 30Mb 12 Cores	2	1500
Memory	Kingston 64GB (4 x 16GB) 288-Pin DDR4 SDRAM ECC Registered DDR4 2133 (PC4 17000) Server Memory Model KVR21R15D4K4/64	5	1830
Disk (SSD)	Seagate Surveillance HDD ST2000VX003 2TB 64MB Cache SATA 6.0Gb/s Internal Hard Drive	24	2160
MotherBoard	ASUS Z10PA-U8 ATX Server Motherboard LGA 2011-3 DDR4 2133 / 1866 / 1600 / 1333	1	345
Rack	StarTech.com 42U Adjustable Depth Open Frame 4 Post Server Rack Cabinet - Flat Pack w/ Casters, Levelers and Cable Management Hooks	1	230
Chasis	SUPERMICRO CSE- 825TQ-R720LPB Black 2U Rackmount Server Case 720W Redundant	1	584
Network Adapter Card	Intel Ethernet Converged Network Adapter X540-T2	1	529
Network Switch	Cisco Small Business 500 Series SF500-48P-K9-NA Managed PoE Stackable Managed Ethernet Switch	1	1000
Administration Cost	Pay/Year		70000
System Power (5years)	Chicago's Avg. Rate 0.153(kWh)		7338.033
Cooling Power(5years)	Chicago's Avg. Rate 0.153(kWh)		1608.336
Network Service Provider	RCN (50MBPS)		82125
Total Cost for 5years			449249.369
Total Cost for 1 hour			10.25683491
Final Price	Cost Per FLOP per Hour		0.014822016

Cost per Flop per Hour for Private and Public Cloud Instances for 5 years amortized:

Instance Types	1GFLOP	10GFLOP	100 GFLOP	1000 GFLOP	10000 GFLOP	100000 GFLOP
m4.10xlarge.private	0.013308165	0.013308165	0.013308165	0.006850248	0.001227861	0.000409129
m3.large.private	0.507143281	0.507143281	0.105003947	0.011473004	0.001605121	0.000519104
m3.2xlarge.private	0.126865209	0.126865209	0.063827676	0.01062969	0.001989894	0.001090959
c3.8xlarge.private	0.028447787	0.028447787	0.028447787	0.008329497	0.001436957	0.000683017
g2.2xlarge.private	0.121276646	0.121276646	0.060861133	0.011784001	0.002955689	0.002075205
r3.4xlarge.private	0.06351568	0.063625649	0.063625649	0.009997943	0.002072175	0.00118159
i2.8xlarge.private	0.032366344	0.032366344	0.032680556	0.008877312	0.00211387	0.001965645
d2.8xlarge.private	0.014822016	0.014822016	0.014822016	0.007542523	0.001355602	0.000493781
m4.10xlarge	0.003117188	0.003117188	0.003117188	0.003117188	0.003117188	0.003117188
m3.large	0.00665	0.00665	0.00665	0.00665	0.00665	0.00665
m3.2xlarge	0.00665	0.00665	0.00665	0.00665	0.00665	0.00665
c3.8xlarge	0.0046875	0.0046875	0.0046875	0.0046875	0.0046875	0.0046875
g2.2xlarge	0.0078125	0.0078125	0.0078125	0.0078125	0.0078125	0.0078125
r3.4xlarge	0.0083125	0.0083125	0.0083125	0.0083125	0.0083125	0.0083125
i2.8xlarge	0.0213125	0.0213125	0.0213125	0.0213125	0.0213125	0.0213125
d2.8xlarge	0.007986111	0.007986111	0.007986111	0.007986111	0.007986111	0.007986111




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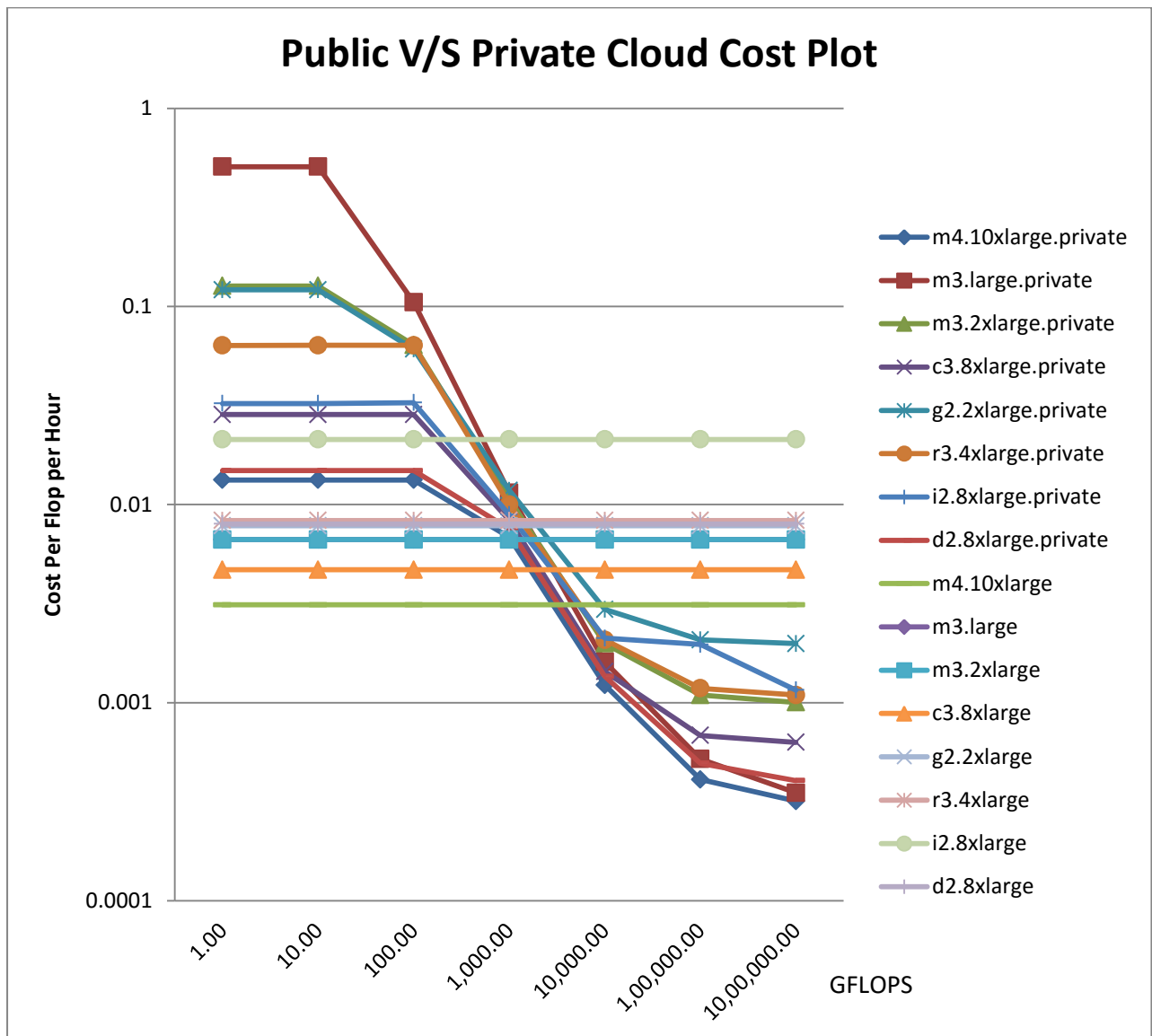
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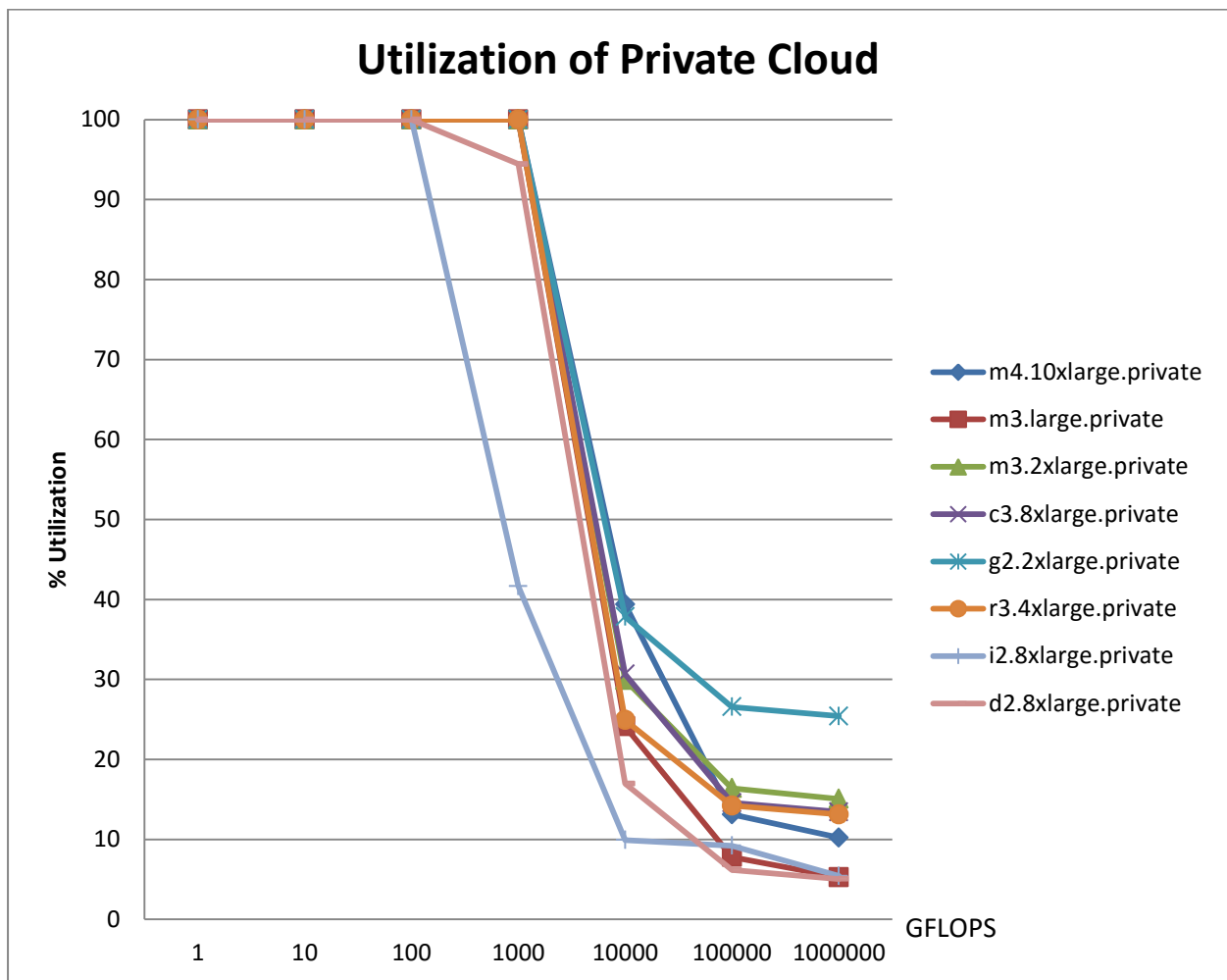
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Plot 1: The cost (in \$) per flop per hour, for the 8 Amazon EC2 instance types, vs. the 8 private cloud equivalent instance types, from 1GFlop to 1PFlop.



Through the analysis of cost for public and private cloud, from above graph we can see that initially when the utilization of cloud is low in number of GLOPS, we can see that it's always good to go for Public cloud than the Private one, but as we scale up from 1 GFLOPS to 1 PFLOPS, the cost/flop/hour of private cloud is going way economical than the private cloud as the resources owned by you will get utilized to its maximum so that the cost will get amortized in the period of 5 years if the number of required GFLOPS remains same, than it will be always better to have a private cloud than to opt for a public one, as we can see that the cost of amazon ec2 instances remains the same even after scaling up from 1 GFLOPS to 1 PFLOPS.

Plot 2: utilization of the private cloud from 1GFlop to 1PFlop for the different instance types.



Above graph is the cost based % utilization of Private Cloud compared to public cloud, which has been calculated using $(\text{Private Cloud Cost} / \text{Public Cloud Cost}) * 100$. Through analysis we can see that initially the utilization of private cloud is 100% which means that the cost of private cloud is higher than the public cloud for initial GFLOPS till 1000GFLOPS, but when the utilization in GFLOPS is scaled till 1 PFLOP, the cost of private cloud is going way cheaper than the public cloud cost, through this we can conclude that on higher GFLOP utilization the cost will get amortized in the span of 5 years for a private cloud, so that it's always good to own a Cloud than to opt for public cloud.

Conclusion:

Through this experiment, I learnt the various challenges came across while designing the cloud infrastructure, starting from choice of CPU to the various cost of different components. Now through analysis of designing the private cloud compared with amazon ec2 public cloud on a scale of 1 GFLOP to 1 PFLOP, we can make a conclusion that when the utilization of cloud service is low, it's always cheaper to go for a public cloud, but when the cloud service utilization increases, the cost of owning a cloud will get amortized such that it's better to own a cloud than go for a public one.