Understanding the Cost of Computing in the Cloud

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1. Hadoop/Spark Cluster
1.1 Private cloud

Hadoop/Spark Cluster with 32K-cores, 256TB memory, 50PB HDD
Use 5.4k X DELL PowerEdge R730xd Rack Servers to comprise the cluster

Node configuration

Node configuration	DELL PowerEdge R730xd Rack Server	
Equipment	Model	Quantity
Processor	Intel® Xeon® E5-2603 v4 1.7GHz,15M Cache,6.4GT/s QPI,6C/6T (85W) Max Mem 1866MHz	1
Memory	32+16GB RDIMM, 2400MT/s, Dual Rank, x4 Data Width	1
Disk	12TB 7.2K RPM NLSAS 12Gbps 512e 3.5in Hot-plug Hard Drive	1
Network Adapter	QLogic 57810 DP 10Gb DA/SFP+ Converged Network Adapter	1
Motherboard		1
Chassis	Chassis with up to 12, 3.5" Hard Drives	1
power supply		500w
	server unit price	$5,105.46

100PB distributed storage

Use 167 x Iris 428-60 storage servers, each includes 60 HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s, that is 167x60x10TB=100.2 PB

Equipment	Model	Quantity
Processor	Intel® Xeon® processor E5-2603 v4 6C 1.7G 15MB Cache	2
Memory	16GB DDR4 ECC Reg 2400MHz(2x8GB)	1
Disk	HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s	60

Network Adapter	Dual Port Gigabit Ethernet Module	1
Chassis	4U 60 Bay Storage Server	1
power supply		2000w
	server unit price	$37,351.05

10 Gb/s fat-tree network

use Dell Z9100-ON as leaf switch and spinning switch. Each switch can connect 128 10G node, Since we have 32k servers, totally we need 32000/64=500 leaf swtich and 250 spinning switch.
Price would be 750x$8,452.20=$6339150

Summarize of the private configure 1 cloud

	Description	Price per Item	Quantity	Total Price
Compute Servers	DELL PowerEdge R730xd Rack Server	$5105.46	5400	90463680
Network Switches	Dell Z9100-ON	$8,494.80	750	6371100
Racks	APC AR3307 NetShelter SX 48U Enclosure	$2,014.99	696.2083333	1402853
Storage Servers	Iris 428-60	$16,646.29	167	2779930
Electric Power		8c/kwh	5year	28032000
Cooling	Approximately same with IT devices	8c/kwh	5year	28032000
Administration		$150000/year	3	450000
power system construcion				3075776
HVAC construction				670487
TOTAL				**97,266,990**

1.2 AWS EC2

Hadoop/Spark Cluster with 32K-cores, 256TB memory, 50PB HDD, and 10Gb/s Ethernet Fat-Tree

Use 889 X d2.8xlarge

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
d2.8xlarge	36	116	244	24 x 2000 HDD	$5.52 per Hour

100PB distributed storage S3 Standard Storage

storage	period	unit price	Total
100PB	5x12month	$0.021 per GB/month	126000000

Summarize of the AWS configure 1 cloud

Description	Price per Item	Quantity	Total Price
d2.8xlarge	$5.52 per Hour	5 year	214938864
100PB storage	$0.021 per GB/month	5 year	126000000
		total	**340,938,864**

2. One Million VM cloud

Support 1 million virtual machines (VM) where each VM requires 2-core, 15GB RAM, 32GB SSD storage, and 1Gb/s Fat-Tree network

2.1 Private cloud

Use 334k X DELL PowerEdge R730xd Rack Servers to comprise the cluster

Node configuration

node configuration	DELL PowerEdge R730xd Rack Server	
Equipment	Model	Quantity

Processor	Intel® Xeon® E5-2603 v4 1.7GHz,15M Cache,6.4GT/s QPI,6C/6T (85W) Max Mem 1866MHz		1
Memory	16GB RDIMM, 2400MT/s, Dual Rank, x8 Data Width+32GB RDIMM, 2400MT/s, Dual Rank, x4 Data Width		1
Disk	400GB Solid State Drive SAS Mix Use 12Gbps 512e 2.5in Hot-plug Drive,3.5in HYB CARR, PM1635a		1
Network Adapter	Broadcom 5719 QP 1Gb Network Interface Card		1
Motherboard			1
Chassis	Chassis with up to 12, 3.5" Hard Drives		1
power supply			500w
		server unit price	**$4,166. 49**

10PB distributed storage

Use 17 x Iris 428-60 storage servers, each includes 60 HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s, that is 17x60x10TB=10 PB

Equipment	Model	Quantity
Processor	Intel® Xeon® processor E5-2603 v4 6C 1.7G 15MB Cache	2
Memory	16GB DDR4 ECC Reg 2400MHz(2x8GB)	1
Disk	HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s	60
Network Adapter	Dual Port Gigabit Ethernet Module	1
Chassis	4U 60 Bay Storage Server	1
power supply		2000w
	server unit price	$37,351.05

1 Gb/s fat-tree network

Use Dell S3124F as leaf switch and spinning switch. Each switch can connect 24 1G node, also have 2 10G port for up stream. Since we have 334k servers, totally we need 334000/24=13917 switches.
Price would be **13917**x$4829=$67,203,583

Summarize of the private configure 2 cloud

	Description	Price per Item	Quantity	Total Price
Compute Servers	DELL PowerEdge R730xd Rack Server	**$4,166.49**	334000	1391607660
Network Switches	Dell S3124F	4829	**13917**	67205193
Racks	APC AR3307 NetShelter SX 48U Enclosure	$2,014.99	7248.625	14605907
Storage Servers	Iris 428-60	$16,646.29	17	282987
Electric Power		8c/kwh	5year	419370634
Cooling	approximately same with IT devices	8c/kwh	5year	419370634
Administration		$150000/year	33	4950000
TOTAL				**2,317,393,014**

2.2 AWS EC2

Support 1 million virtual machines (VM) where each VM requires 2-core, 15GB RAM, 32GB SSD storage, and 1Gb/s Fat-Tree network

Use 1M X r4.large

	vCPU	ECU	Memory (GiB)	Instance Storage (GB)	Linux/UNIX Usage
r4.large	2	7	15.25	EBS only	$0.133 per Hour

10PB distributed storage S3 Standard Storage

storage	period	unit price	Total
10PB	5x12month	$0.021 per GB/month	12600000

Summarize of the AWS configure 2 cloud

Description	Price per Item	Quantity	Total Price
r4.large	$0.133 per Hour	5 year	58254000000
10PB storage	$0.021 per GB/month	5 year	12600000
		total	**58,266,600,000**

3. One exaflop of mixed precision performance
Support deep learning with 1 exaflop of mixed precision performance

3.1 Private cloud

Use 1k X SuperServer 4027GR-TR to comprise the cluster

SuperServer 4027GR-TR configuration

Equipment	Model	Quantity
CPU	Intel Xeon E5-2643 Processor	1
GPU	NVIDIA® Tesla® V100 GPU	8
Memory	16GB PC3-14900 DIMM DDR3-1866	32
Disk	1TB HGST 0J22423 / HTS721010A9E630	1
Chassis	Chassis with up to 12, 3.5" Hard Drives	1
power supply		4 x 1600W Redundancy
	server unit price	**$16,375.65**

1PB distributed storage

Use 2 x Iris 428-60 storage servers, each includes 60 HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s, that is 2x60x10TB=1.2 PB

Equipment	Model	Quantity
Processor	Intel® Xeon® processor E5-2603 v4 6C 1.7G 15MB Cache	2
Memory	16GB DDR4 ECC Reg 2400MHz(2x8GB)	1
Disk	HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s	60
Network Adapter	Dual Port Gigabit Ethernet Module	1

Chassis	4U 60 Bay Storage Server	1
power supply		2000w
	server unit price	$37,351.05

100 Gb/s fat-tree network

Use Dell Z9100-ON as leaf switch and spinning switch. Each switch can connect 32 port 100GbE, Since we have 1k servers, totally we need 1000/16=63 leaf switch and 32 spinning switch.

Price would be 95x$8,452.20=$802940

Summarize of the private configure 3 cloud

	Description	Price per Item	Quantity	Total Price
Compute Servers	SuperServer 4027GR-TR	**$16,375.65**	1000	16375650
Network Switches	Dell Z9100-ON	$8,494.80	95	807006
Racks	APC AR3307 NetShelter SX 48U Enclosure	$2,014.99	65	130974
Storage Servers	Iris 428-60	$16,646.29	2	33293
Electric Power		8c/kwh	5year	14082576
Cooling	approximately same with IT devices	8c/kwh	5year	14082576
Administration		$150000/year	1	150000
TOTAL				**45,662,075**

3.2   AWS EC2

Use 1000 x p3.16xlarge

Instance Size	GPUs - Tesla V100	GPU Peer to Peer	GPU Memory (GB)	vCPUs	Memory (GB)	On-Demand Price/hr*
p3.16xlarge	8	NVLink	128	64	488	$24.48

1PB distributed storage S3 Standard Storage

storage	period	unit price	Total
1PB	5x12month	$0.021 per GB/month	1260000

Summarize of the AWS configure 3 cloud

Description	Price per Item	Quantity	Total Price
p3.16xlarge	$24.48 Per hour	5 year	**1,073,484,000**

4. Summary

3 configurations comparing

	Configuration 1	Configuration 2	Configuration 3
Public Cloud (including EC2 and S3) Cost over 5 years, 24/7 operation, with 100% usage	**340,938,864**	**58,266,600,000**	**1,073,484,000**
Private Cloud cost over 5 years, 24/7 operation, with 100% usage	**97,266,990**	**2,317,393,014**	**45,662,075**
What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud?	Minimum the idle rate and maximum the workload full	Minimum the idle rate and maximum the workload full	Minimum the idle rate and maximum the workload full

PowerEdge R730xd Rack Server Summary

Dell Price **$2,826.99**

Starting at Price	~~$4,489.00~~
Total Savings	$1,662.01
Standard Delivery	**Free**

Dell Business Credit
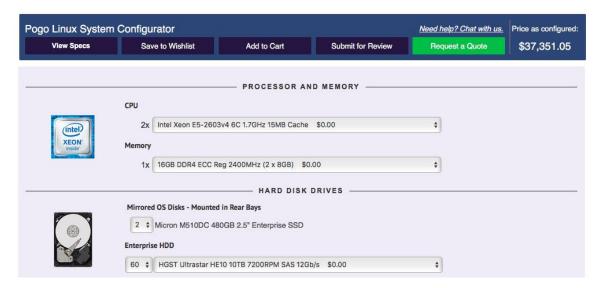As low as $85/mo.^ | Apply
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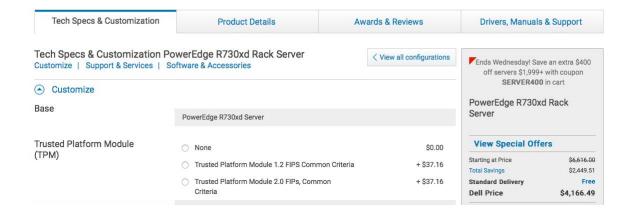
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4U 60 Bay Storage Server
Dual Xeon E5-2600v4 Series CPU
Up to 600TB Storage Capacity
Flexible Networking Options
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Iris 428-60

Pogo Linux System Configurator

Need help? Chat with us.

Price as configured:

| View Specs | Save to Wishlist | Add to Cart | Submit for Review | Request a Quote | $37,351.05 |

PROCESSOR AND MEMORY

CPU

2x | Intel Xeon E5-2603v4 6C 1.7GHz 15MB Cache $0.00

Memory

1x | 16GB DDR4 ECC Reg 2400MHz (2 x 8GB) $0.00

HARD DISK DRIVES

Mirrored OS Disks - Mounted in Rear Bays

2 | Micron M510DC 480GB 2.5" Enterprise SSD

Enterprise HDD

60 | HGST Ultrastar HE10 10TB 7200RPM SAS 12Gb/s $0.00

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Tech Specs & Customization PowerEdge R730xd Rack Server

Customize | Support & Services | Software & Accessories

⌃ Customize

Base

PowerEdge R730xd Server

Trusted Platform Module (TPM)

○ None $0.00

○ Trusted Platform Module 1.2 FIPS Common Criteria   + $37.16

○ Trusted Platform Module 2.0 FIPs, Common Criteria   + $37.16

⟨ View all configurations

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PowerEdge R730xd Rack Server

View Special Offers

Starting at Price	$6,616.00
Total Savings	$2,449.51
Standard Delivery	Free
Dell Price	**$4,166.49**

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Tech Specs & Customization PowerEdge R730xd Rack Server
Customize | Support & Services | Software & Accessories

‹ View all configurations

PowerEdge R730xd Rack Server

⌃ Customize

Base

PowerEdge R730xd Server

Trusted Platform Module (TPM)

○ None	$0.00
○ Trusted Platform Module 1.2 FIPS Common Criteria	+ $37.16
○ Trusted Platform Module 2.0 FIPs, Common Criteria	+ $37.16
○ No Trusted Platform Module	Included in price

View Special Offers

Starting at Price	~~$8,107.00~~
Total Savings	$3,001.54
Standard Delivery	Free
Dell Price	**$5,105.46**

Supermicro SuperServer 4027GR-TR 4U DP Xeon E5-2600 LGA2011 24xDDR3 8xGPU 11xPCIe R1600W SYS-4027GR-TR

− Click to view description
Supermicro Intel Products
SuperServer 4027GR-TR for GPU-Optimized Supercomputing Server Solutions

Mfg. Model Number:
Supermicro SYS-4027GR-TR
RoHS Compliant

Features & Benefits:
Based on the new generation Intel® Xeon® Processor E5-2600/E5-1600 series, Supermicro new GPU Computing Servers are targeted for the Mission-critical app, enterprise server, oil & gas, financial, 3D rendering, chemistry, Astrophysics ... at HPC environments with 24/7 Mission Critical requirements.

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Price Per System: $16375.65

Quantity: [1 ‡]

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⌃ **Customize**

Dell Networking S3100 Series Switches

> S3124F, L3, 24x 1GbE SFP, 2xCombo, 2x 10GbE SFP+ fixed ports, Stacking, IO to PSU air, 1x AC PSU

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Stacks
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Review Summary

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Dell Z9100-ON Layer 2 or 3 Switch Reverse Airflow Switch

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Incl. Tax: $10,193.76

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- 2 x 10Gb SFP+ Fixed Ports
- 2 x Power Supplies
- Dell Networking OS9

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