Project Report

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1. Introduction

This report is regarding cost estimations of public cloud as well as private cloud (build up a cloud) for the 3 different configurations and provide the better solution. The various configurations are as given –

Configuration 1: Hadoop/Spark Cluster

The cluster should have 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: VMs Cluster

The cluster supports 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: Deep learning Cluster

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)

2. Assumptions

- The calculated total cost for 5 years is based on the current market price.
- The administration cost (an admin handles 1000 compute servers) is $100,000.00 for 1st year and a hike of 10% per year.
- For the estimations of various components for private cloud, I have explored mainly Pogolinux, AcmeMicro and Thinkmate. However, I have checked other websites for getting the cheaper products. (links are given in Appendix a)
- For the estimations of various components for public cloud, I have used AWS monthly price calculator and used the same value for 5 years estimation.
- The electricity rate has been considered of the city Cleveland, Ohio and the cost is 7.73¢/kWh.
- The cooling cost has been assumed to be 1/4th of the total power consumption.
- The hardware used for estimation of private cloud is similar or higher than the hardware mentioned for public cloud.

3. Public cloud cost Estimation

Configuration 1:

Service Type	Components	Region	Component Price	Service Price
Amazon EC2 Service (US East (Ohio))				$4,242,672
	Compute:	US East (Ohio)	$4,242,672	
Amazon S3 Service (US East (Ohio))				$2,202,572.80
	Standard Storage:	US East (Ohio)	$2,202,572.80	
AWS Support (Business)				$200,257.35
	Support for all AWS services:		$200,257.35	
		Free Tier Discount:		($0.12)
		Total Monthly Payment:		$6,645,502.03
		Total Payment for 5 Years	5x12	$398,730,121.80

Configuration 2:

Service Type	Components	Region	Component Price	Service Price
Amazon EC2 Service (US East (Ohio))				$121,520,000
	Compute:	US East (Ohio)	$121,520,000	
Amazon S3 Service (US East (Ohio))				$220,764.16
	Standard Storage:	US East (Ohio)	$220,764.16	
AWS Support (Business)				$3,659,122.93
	Support for all AWS services:		$3,659,122.93	

		Free Tier Discount:		($0.12)
		Total Monthly Payment:		$125,399,886.97
		Total Payment for 5 Years	5x12	$7,523,993,218.20

Configuration 3:

Service Type	Components	Region	Component Price	Service Price
Amazon EC2 Service (US East (Ohio))				$17,919,360
	Compute:	US East (Ohio)	$17,919,360	
Amazon S3 Service (US East (Ohio))				$22,583.30
	Standard Storage:	US East (Ohio)	$22,583.30	
AWS Support (Business)				$545,158.30
	Support for all AWS services:		$545,158.30	
		Free Tier Discount:		($0.12)
		Total Monthly Payment:		$18,487,101.48
		Total Payment for 5 Years	5x12	$1,109,226,088.80

4. Private cloud cost Estimation

Configuration 1:

Components	Details	Year	Quantity	Unit Price	Total Cost
Compute Servers	Iris 428-60: **CPU:** 2x Intel Xeon E5-2683v4 16C 2.1GHz 40MB Cache **Memory:** 1x 256GB DDR4 ECC Reg 2400MHz (8 x 32GB) **Mirrored OS Disks**- Mounted in Rear Bays: 2x Micron M510DC 480GB 2.5" Enterprise SSD **Enterprise HDD:** 50x Seagate Enterprise Capacity 1TB 12Gb/s 7200rpm 128MB SAS **Networking Options:**1xDual Port Gigabit Ethernet Module		1000	$29,224.93	$29,224,930.00
Network Switches (Level 1 & 2)	Mellanox MSX1012X-2BFS SwitchX-2 Based 10GbE 1U Open Ethernet Switch with Mellanox Onyx 12 QSFP+ Ports 2 Power Supplies (AC) Short Depth PPC460 Connector Airflow Out		167	$3,095.00	$516,865.00
	Mellanox MCS7520 43Tb/s 216-port EDR chassis switch includes 8 fans and 4 power supplies (N+N) RoHS R6		6	$58,335.00	$350,010.00
Network Cables	Cables		2002	$3.67	$7,347.34
Racks	36U Adjustable Rack		170	$399.99	$67,998.30
Storage Servers	Thinkmate®STX-3316 3U		640	$8,629.00	$5,522,560.00
Electric Power (per hour)	6.24¢/kWh	5	365x24	$166.19	$7,279,209.51
Cooling (per hour)		5	365x24	$41.55	$1,819,802.38
Administration (for 5 years)	IT admin	1	1	$671,561.00	$671,561.00
Total		N/A	N/A	N/A	$45,460,283.53

Following is the table for the calculation of the electricity consumed-

Components	Total Devices	Power(W)	Total Power(kW)	Electricity Consumption(kWh)
Compute Server	1000	2000	2000000	2000
Network level-1	167	49.9	8333.3	8.3333
Network level-2	6	2500	15000	15
Storage Server	640	1000	640000	640
Total			2663333	2663.333

Cost of electricity per hour *= Total electricity consume (in kWh) x electricity rate*

Cost of electricity per hour = 2663.333 x 0.0624 = **$166.19**

Configuration 2:

Components	Details	Year	Quantity	Unit Price	Total Cost
Compute Servers	Iris 2482: **CPU:** 2x Intel Xeon E5-2683v4 16C 2.1GHz 40MB Cache **Memory:** 1x 256GB DDR4 ECC Reg 2400MHz (8 x 32GB) **SATA HDD:**1x Intel S4500 Series 480GB 3D1 TLC SATA SSD 6Gb/s		15625	$19,582.40	$305,975,000.00
Network Switches (Level 1 & 2)	Mellanox MSB7780-ES2F Switch-IB Based EDR InfiniBand 1U Router 36 QSFP28 Ports 2 Power Supplies (AC) x86 dual core Standard Depth P2C Airflow Rail Kit RoHS6		579	$18,000.00	$10,422,000.00
	Mellanox MCS7500 130Tb/s 648-port EDR InfiniBand chassis switch includes 20 fans and 10 power supplies (N+N) RoHS R6		9	$108,335.00	$975,015.00
Network Cables	Cables		20836	$3.67	$76,468.12
Racks	RS-4POSTRACK-42u		758	$424.99	$322,142.42
Storage Servers	Thinkmate®STX-3316 3U		64	$8,629.00	$552,256.00
Electric Power (per hour)	6.24¢/kWh	5	365x24	$1,960.31	$85,861,631.68
Cooling (per hour)		5	365x24	$490.08	$21,465,407.92
Administration (for 5 years)	IT admin		16	$671,561.00	$10,744,976.00
Total		N/A	N/A	N/A	$436,394,897.14

Following is the table for the calculation of the electricity consumed-

Components	Total Devices	Power(W)	Total Power(kW)	Electricity Consumption(kWh)
Compute Server	15625	2000	31250000	31250
Network level-1	579	136	78744	78.744
Network level-2	9	2500	22500	22.5
Storage Server	64	1000	64000	64
Total			31415244	31415.24

Cost of electricity per hour *= Total electricity consume (in kWh) x electricity rate*
Cost of electricity per hour = 31415.24 x 0.0624 = **$1,960.31**

Configuration 3:

Components	Details	Years	Quantity	Unit Price	Total Cost
Compute Servers	NVIDIA DGX-1 with Tesla V100		1024	$149,000.00	$152,576,000.00
	Sixteen-Core Intel® Xeon® Processor E5-2683 v4 2.10GHz 40MB Cache (120W)		1024	$7,996.00	$8,187,904.00
	Gigabyte MD30-RS0 Dual LGA 2011-3 ATX Motherboard		1024	$1,553.40	$1,590,681.60
	64GB PC4-21300 DDR4-2666Mhz Load Reduced ECC Quad Ranked 1.2V Major Brand		1024	$6,399.92	$6,553,518.08
Network Switches (Level 1 & 2)	Mellanox MSB7780-ES2F Switch-IB Based EDR InfiniBand 1U Router 36		57	$18,000.00	$1,026,000.00
	Mellanox MSX6506-NR 108 port FDR capable modular chassis includes 4 fans and 2 (N+N) power supplies ROHS6 Non-blocking configuration needs all spines		18	$21,435.00	$385,830.00
Network Cables	Cables		2050	$3.67	$7,523.50
Racks	42U-Rack		4	$424.99	$1,699.96
	12U-Rack		1	$349.99	$349.99
Storage Servers	Thinkmate®STX-3316 3U		8.00	$7,669.00	$61,352.00
Electric Power (per hour)	6.24¢/kWh	5	365x24	$195.48	$8,562,187.15
Cooling (per hour)		5	365x24	$48.87	$2,140,546.79
Administration (for 5 years)	IT admin	1	2	$671,561.00	$1,343,122.00
Total		N/A	N/A	N/A	$182,436,715.06

Following is the table for the calculation of the electricity consumed-

Components	Total Devices	Power(W)	Total Power(kW)	Electricity Consumption(kWh)
Compute Server	1024	3000	3072000	3072
Network level-1	57	136	7752	7.752
Network level-2	18	2500	45000	45
Storage Server	8	1000	8000	8
Total			3132752	3132.752

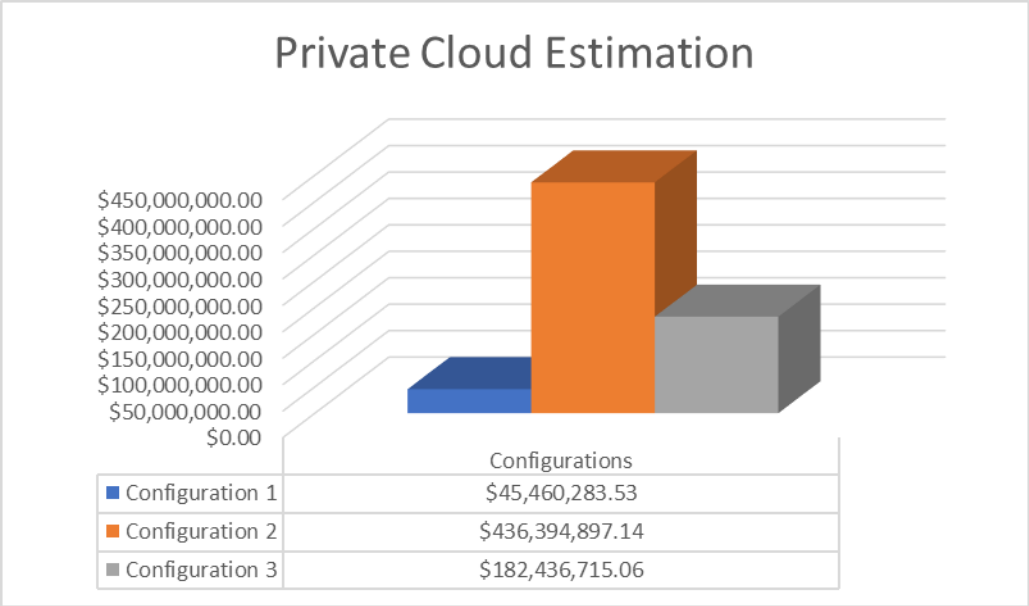
Cost of electricity per hour *= Total electricity consume (in kWh) x electricity rate*
Cost of electricity per hour = 3132.752 x 0.0624 = **$195.48**

5. Summary Table

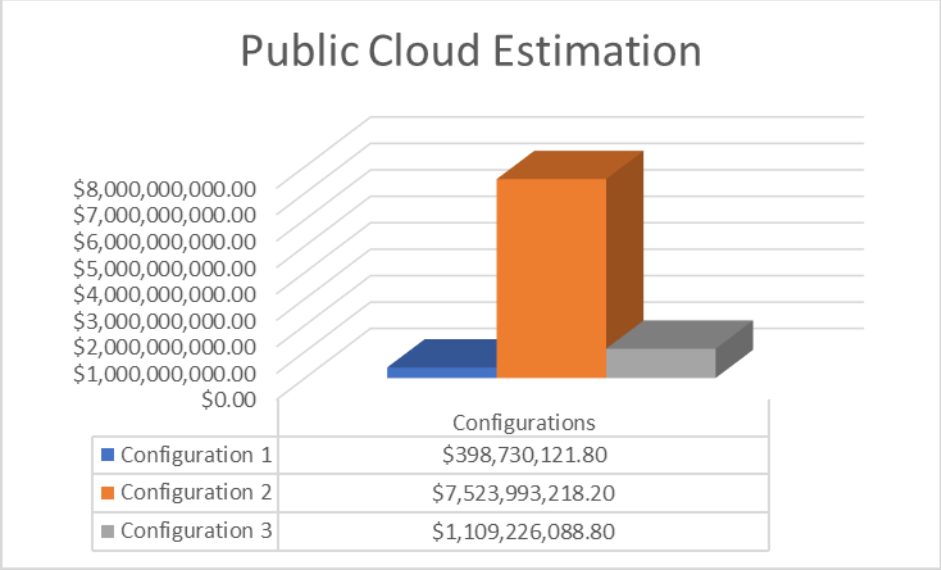
	Configuration 1	Configuration 2	Configuration 3
Public Cloud (including EC2 and S3) Cost over 5 years, 24/7 operation, with 100% usage	$398,730,121.80	$7,523,993,218.20	$1,109,226,088.80
Private Cloud cost over 5 years, 24/7 operation, with 100% usage	$45,460,283.53	$436,394,897.14	$182,436,715.06
What utilization must be achieved with the private cloud to make the private cloud option more attractive than the public cloud?	• From the estimation, private cloud is cheaper and attractive than the public cloud for the longer duration of time like 5 years. • To make the public cloud cheaper and beneficial for shorter time (e.g., 1year or less), we need to utilize it such that the total cost come down near to 25%. • A cheaper is to use rented hardware till the time the amortize cost for public cloud is lesser than the private cloud.		

6. Graphs and analysis

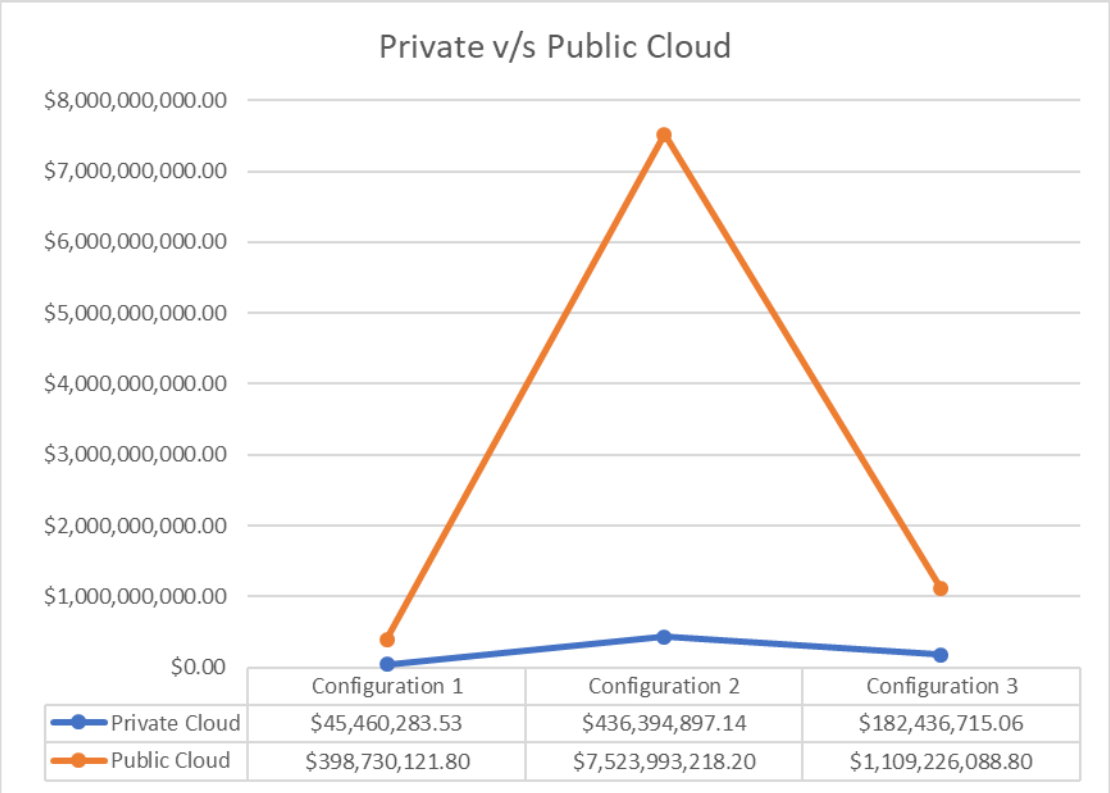
Below are the graphs based on the total cost for the 3 configurations:



[Fig. 1]



[Fig. 2]



[Fig. 3]

From the Fig. 1 to 3, we can see and conclude that

- For the long term like 5 years, it is better to develop the private cloud rather than going for public one.
- The rental cost for public cloud is much higher than the private cloud which we build.
- The “On-demand” instance in public cloud is costlier than other instances. Therefore, if we plan for public cloud than we need to think about the utilization so that it can be cheaper.
- The recovery time for the cost will be less for private cloud than the public cloud.

Appendix

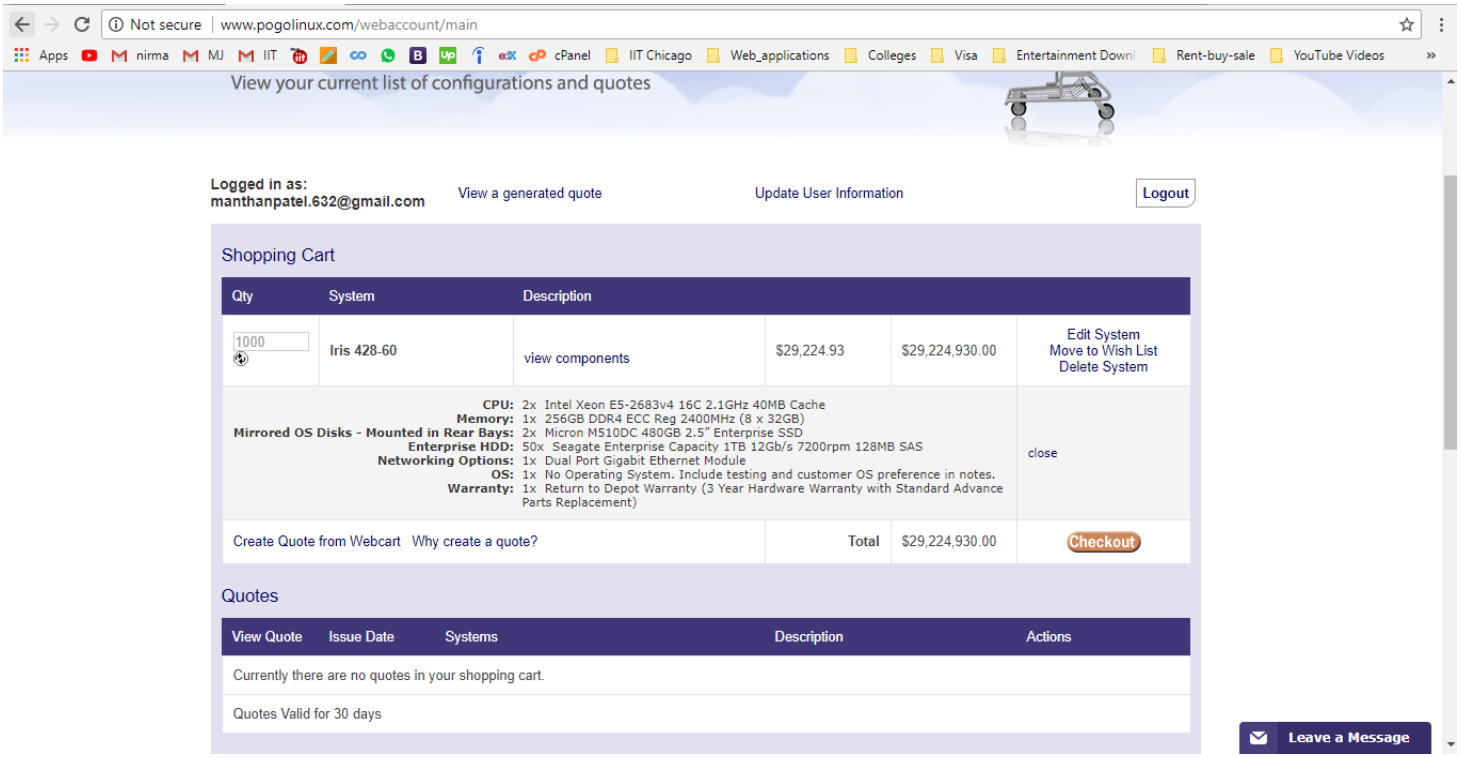
Referred links:

Following links have been used in the cost estimation of the hardware-

- http://www.pogolinux.com
- https://www.startech.com
- https://www.thinkmate.com
- https://www.bhphotovideo.com
- http://www.acmemicro.com
- https://store.mellanox.com
- https://www.cdw.com
- https://www.rackmountsolutions.net
- https://www.electricitylocal.com/states/ohio/cleveland/
- https://www.nvidia.com/en-us/data-center/dgx-1/
- http://aws.amazon.com/

Screenshots of cart items:

Configuration 1:



Secure | https://store.mellanox.com/products/mellanox-msx1012x-2bfs-switchx-2-based-10gbe-1u-open-ethernet-switch-with-mellanox-onyx-12-qsfp-ports-2-power-supplies-ac-sho...

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Mellanox MSX1012X-2BFS SwitchX-2 Based 10GbE 1U Open Ethernet Switch with Mellanox Onyx 12 QSFP+ Ports 2 Power Supplies (AC) Short Depth PPC460 Connector Airflow Out

Condition: New MPN: MSX1012X-2BFS

Availability:	Limited
List Price:	~~$5,076.00~~
Our Price:	$3,095.00
Savings:	(You save $1,981.00)
Switch Family:	SX1000
Condition:	New
Max Ports:	12x10GbE
Connector Type:	QSFP28/QSFP+
Max Speed:	10GbE
ECCN:	5A991
Operating System:	Mellanox Onyx

Quantity: 1

Add Mellanox Support?

-- None --

Add to Cart

Get a Quote?

Save the MSX1012X-2BFS

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Secure | https://store.mellanox.com/products/mellanox-mcs7520-43tb-s-216-port-edr-chassis-switch-includes-8-fans-and-4-power-supplies-n-n-rohs-r6.html

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Mellanox MCS7520 43Tb/s 216-port EDR chassis switch includes 8 fans and 4 power supplies (N+N) RoHS R6

Condition: New MPN: MCS7520

Availability:	Limited
List Price:	~~$95,667.00~~
Our Price:	$58,335.00
Savings:	(You save $37,332.00)
Switch Family:	CS7500
Condition:	New
Max Ports:	216
Max Speed:	EDR
ECCN:	5A991

Quantity: 1

Add Mellanox Support?

-- None --

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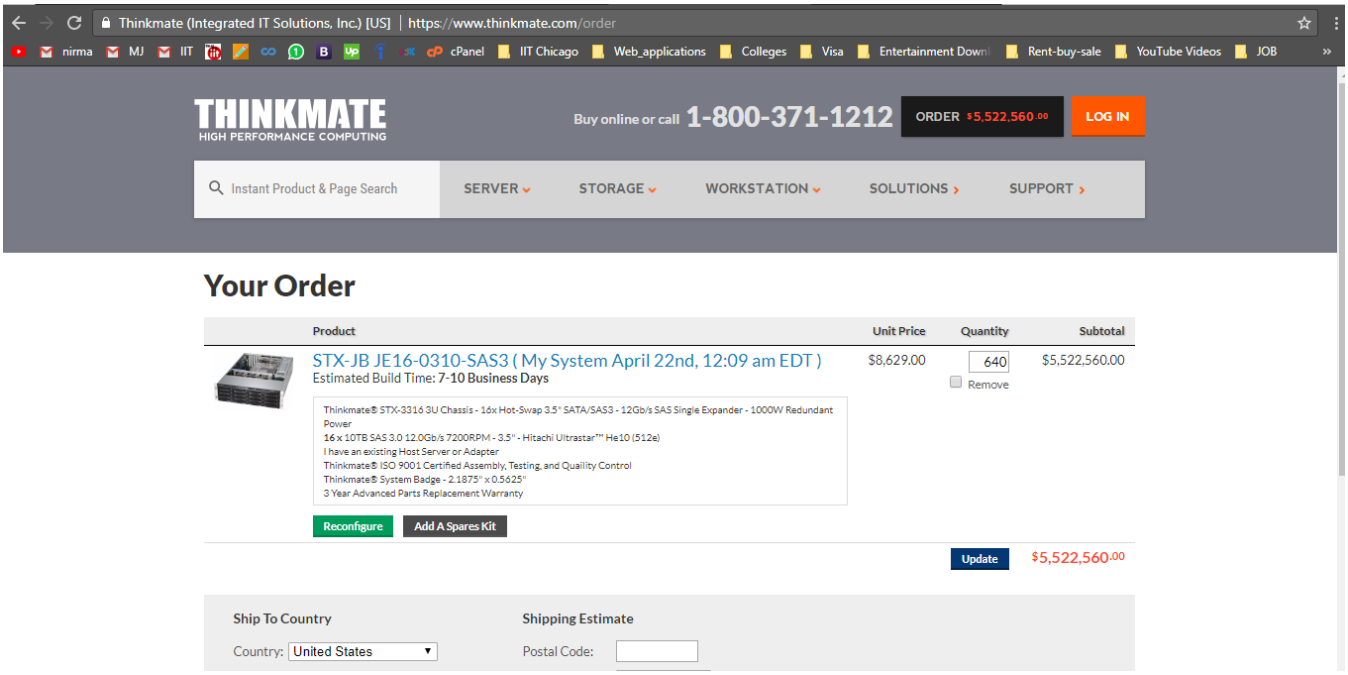
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Estimated Build Time: 7-10 Business Days
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Remove
$5,522,560.00
Thinkmate® STX-3316 3U Chassis - 16x Hot-Swap 3.5" SATA/SAS3 - 12Gb/s SAS Single Expander - 1000W Redundant Power
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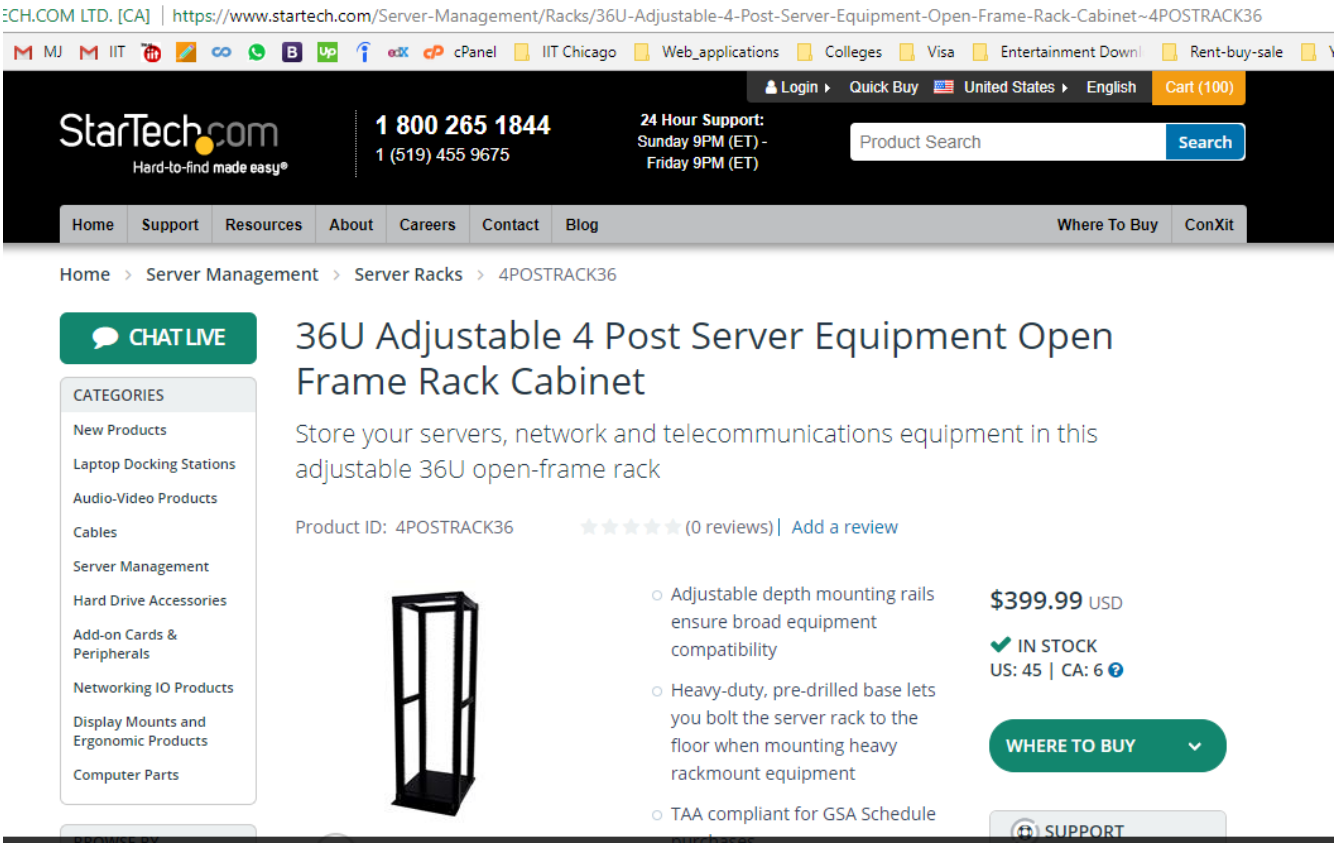
Postal Code: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Server Management
Hard Drive Accessories
Add-on Cards & Peripherals
Networking IO Products
Display Mounts and Ergonomic Products
Computer Parts
36U Adjustable 4 Post Server Equipment Open Frame Rack Cabinet
Store your servers, network and telecommunications equipment in this adjustable 36U open-frame rack
Product ID: 4POSTRACK36
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Adjustable depth mounting rails ensure broad equipment compatibility
Heavy-duty, pre-drilled base lets you bolt the server rack to the floor when mounting heavy rackmount equipment
TAA compliant for GSA Schedule
$399.99 USD
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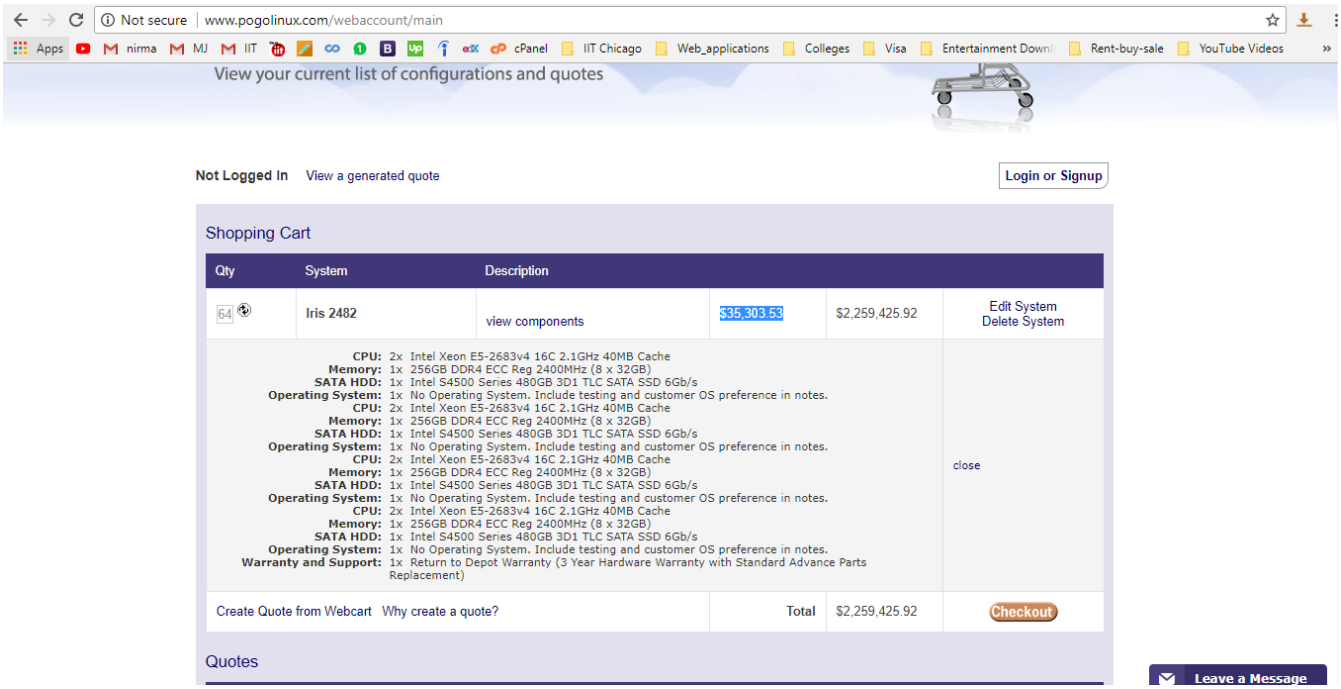
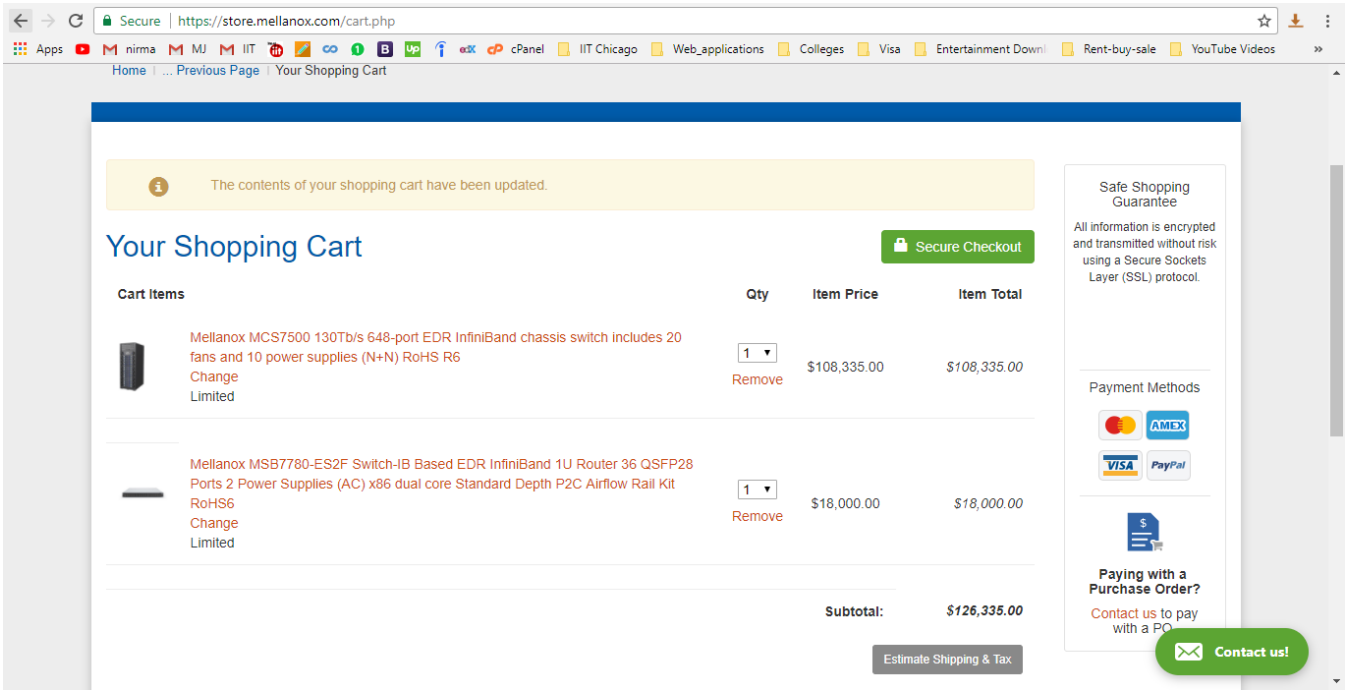
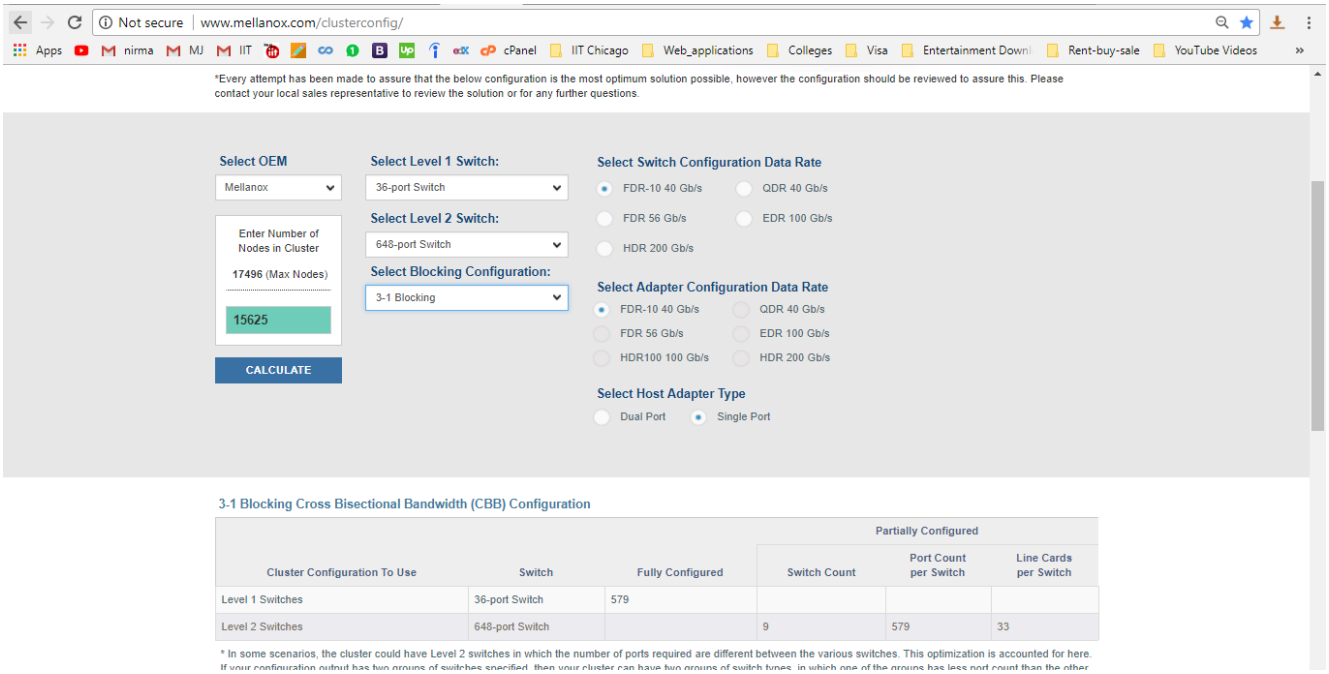
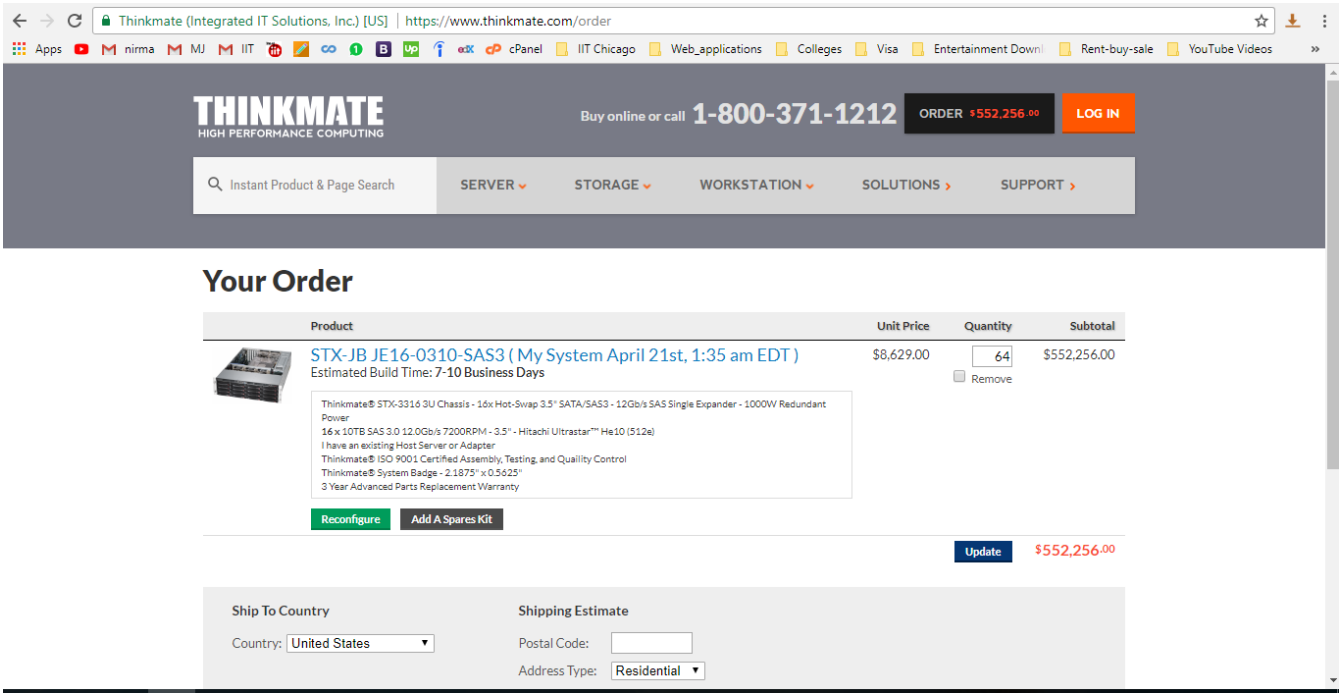
US: 45 | CA: 6
WHERE TO BUY
SUPPORT

Configuration 2:






Not secure | www.mellanox.com/clusterconfig/
*Every attempt has been made to assure that the below configuration is the most optimum solution possible, however the configuration should be reviewed to assure this. Please contact your local sales representative to review the solution or for any further questions.
Select OEM
Mellanox
Enter Number of Nodes in Cluster
17496 (Max Nodes)
15625
CALCULATE
Select Level 1 Switch:
36-port Switch
Select Level 2 Switch:
648-port Switch
Select Blocking Configuration:
3-1 Blocking
Select Switch Configuration Data Rate
FDR-10 40 Gb/s
QDR 40 Gb/s
FDR 56 Gb/s
EDR 100 Gb/s
HDR 200 Gb/s
Select Adapter Configuration Data Rate
FDR-10 40 Gb/s
QDR 40 Gb/s
FDR 56 Gb/s
EDR 100 Gb/s
HDR100 100 Gb/s
HDR 200 Gb/s
Select Host Adapter Type
Dual Port
Single Port
3-1 Blocking Cross Bisectional Bandwidth (CBB) Configuration
Cluster Configuration To Use
Switch
Fully Configured
Partially Configured
Switch Count
Port Count per Switch
Line Cards per Switch
Level 1 Switches
36-port Switch
579
Level 2 Switches
648-port Switch
9
579
33
* In some scenarios, the cluster could have Level 2 switches in which the number of ports required are different between the various switches. This optimization is accounted for here.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SUPPORT
Your Order
Product
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Quantity
Subtotal
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Estimated Build Time: 7-10 Business Days
$8,629.00
64
Remove
$552,256.00
Thinkmate® STX-3316 3U Chassis - 16x Hot-Swap 3.5" SATA/SAS3 - 12Gb/s SAS Single Expander - 1000W Redundant Power
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3 Year Advanced Parts Replacement Warranty
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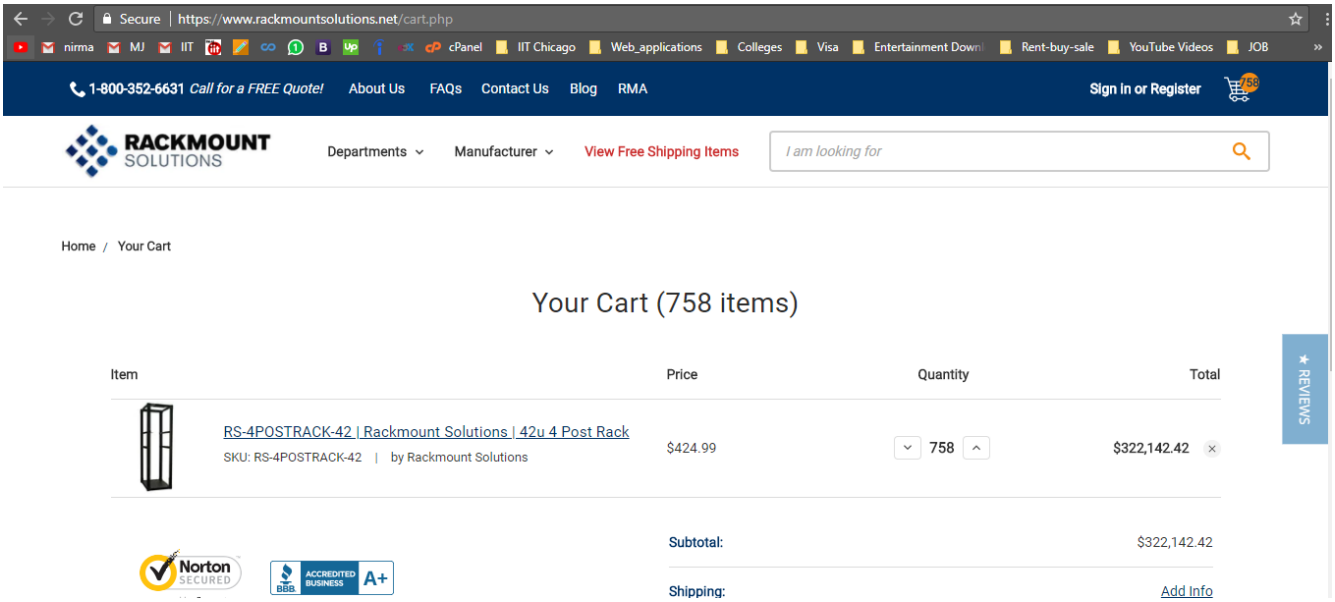
Add A Spares Kit
Update
$552,256.00
Ship To Country
Country: United States
Shipping Estimate
Postal Code:
Address Type: Residential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Price
Quantity
Total
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758
$322,142.42
Norton SECURED
ACCREDITED BUSINESS A+
Subtotal:
$322,142.42
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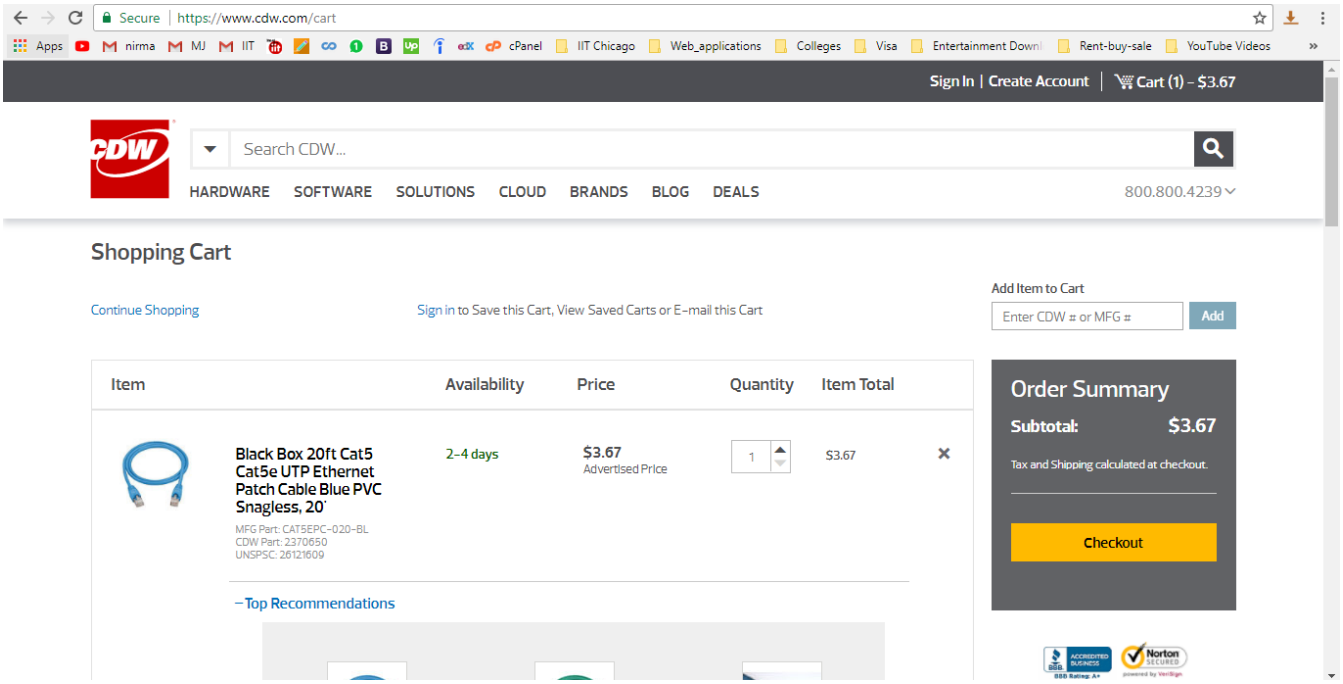
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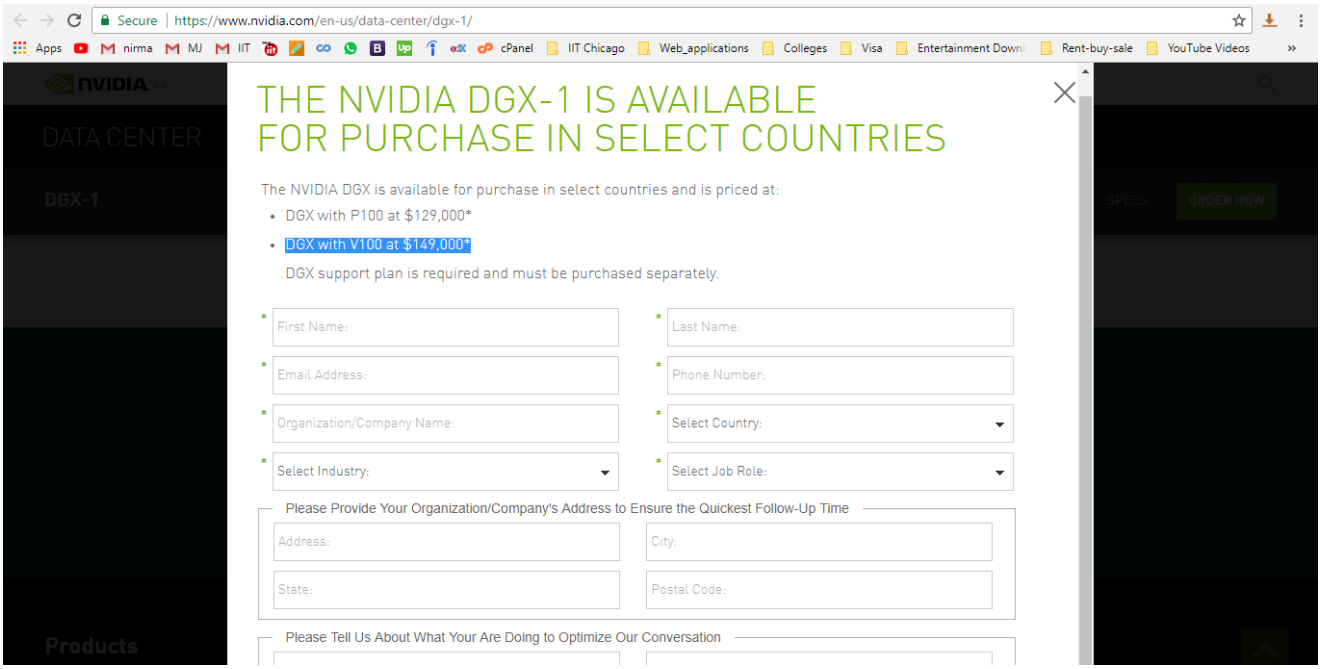

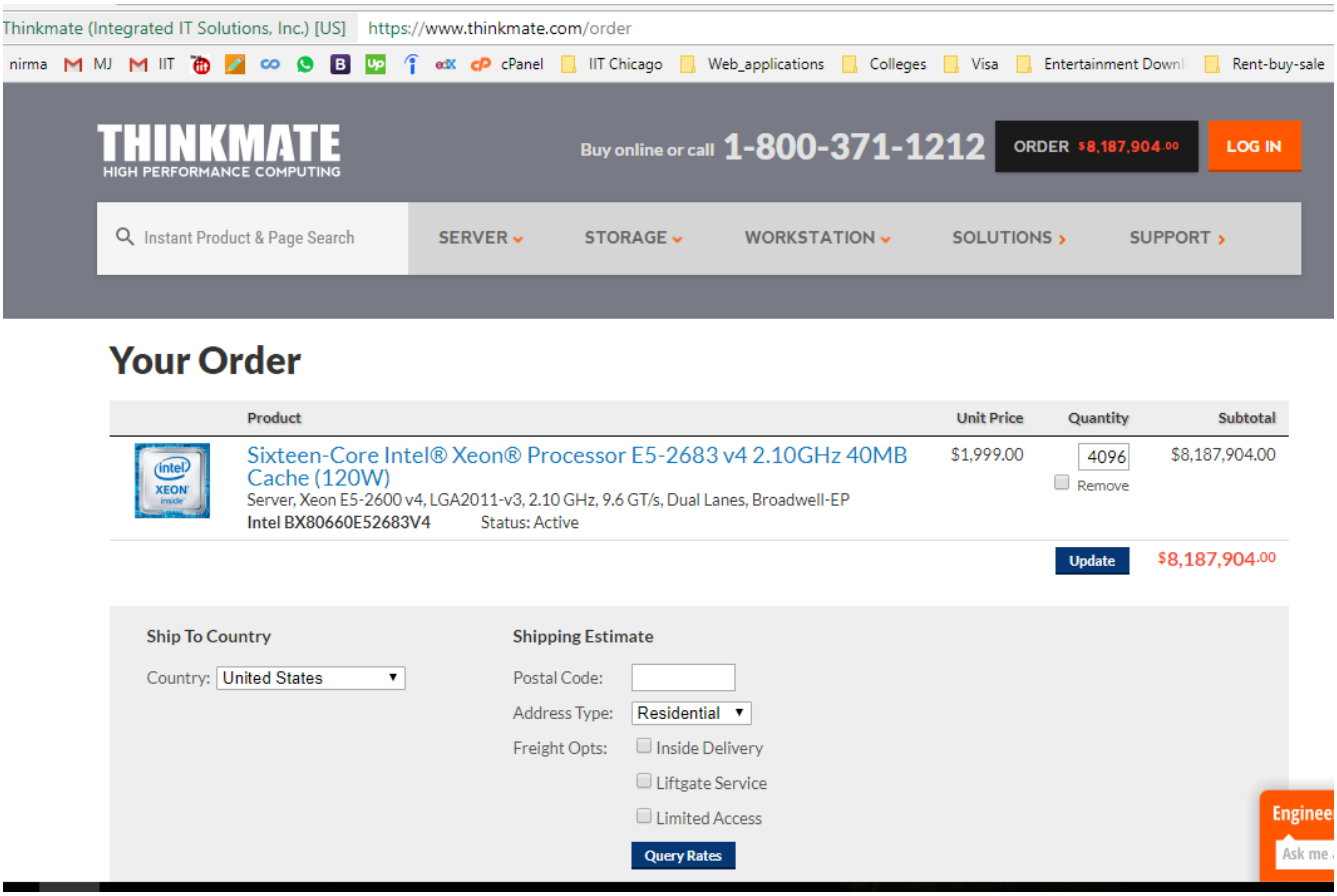

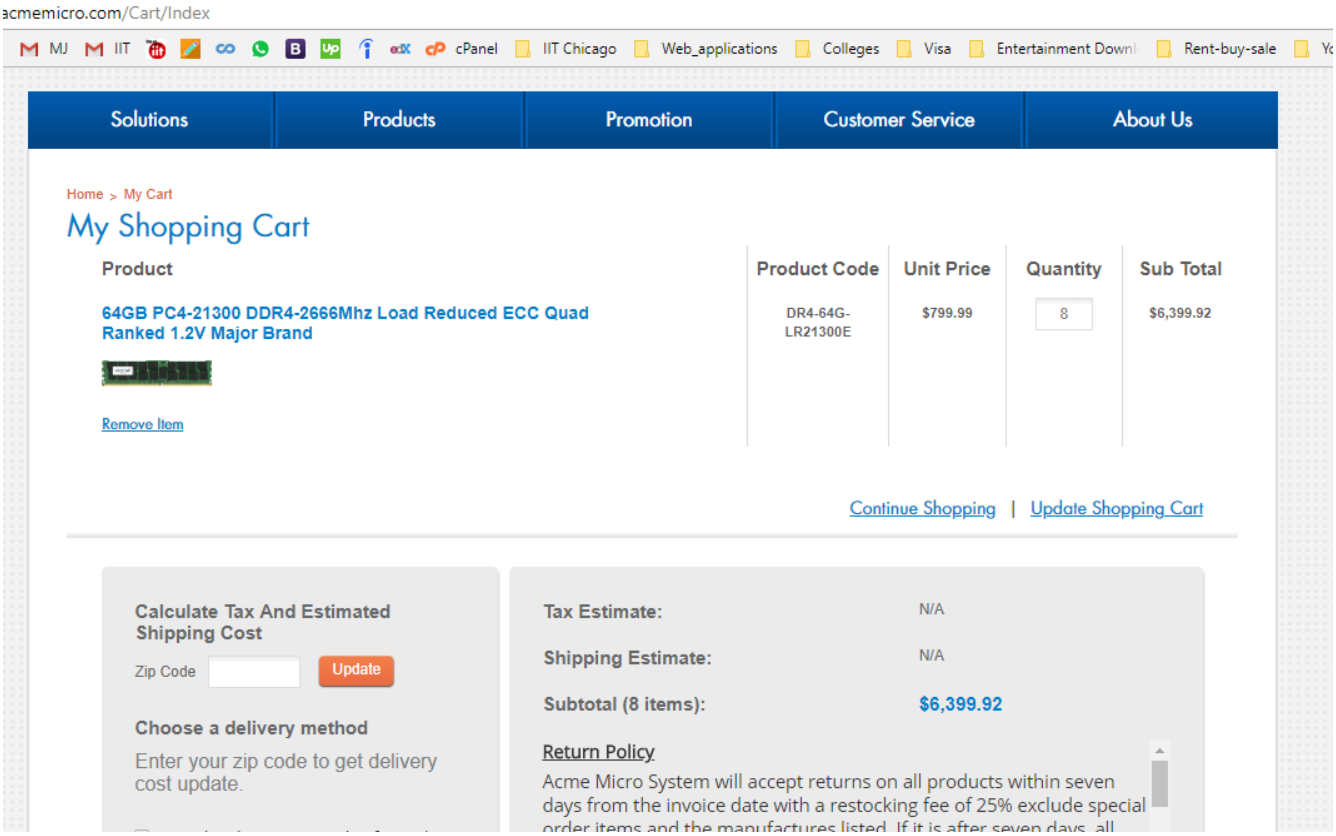
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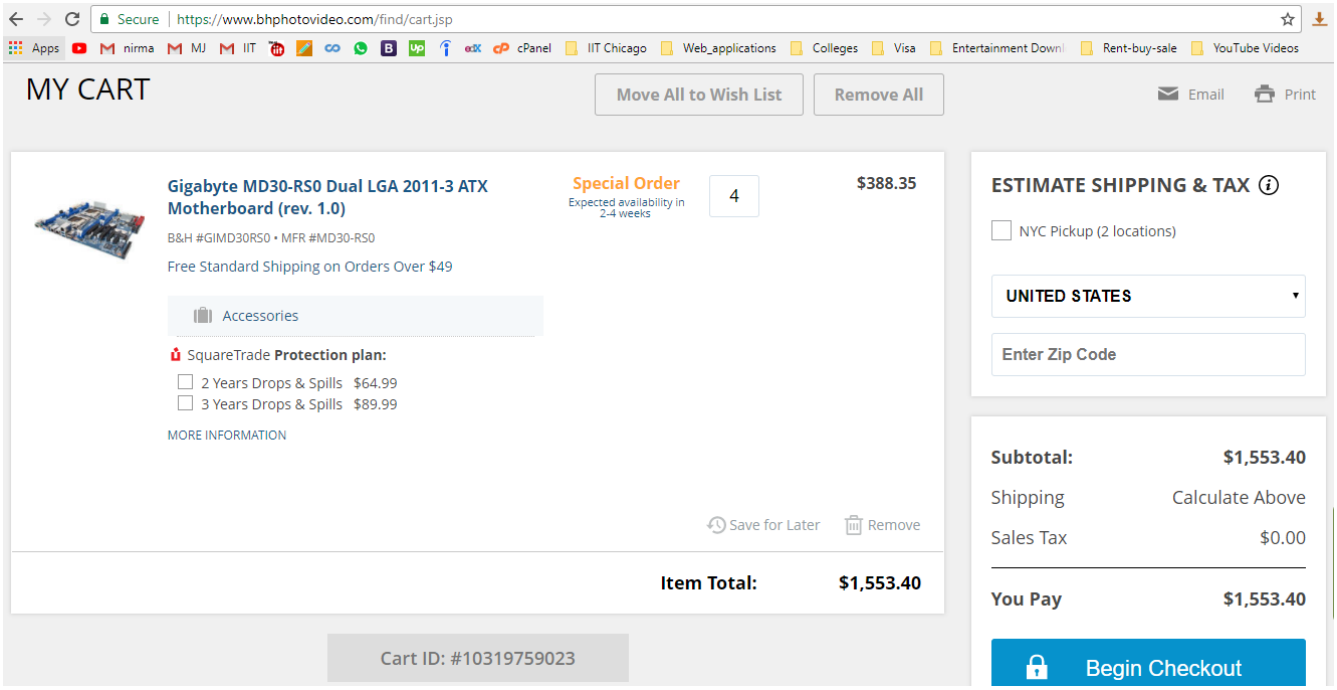
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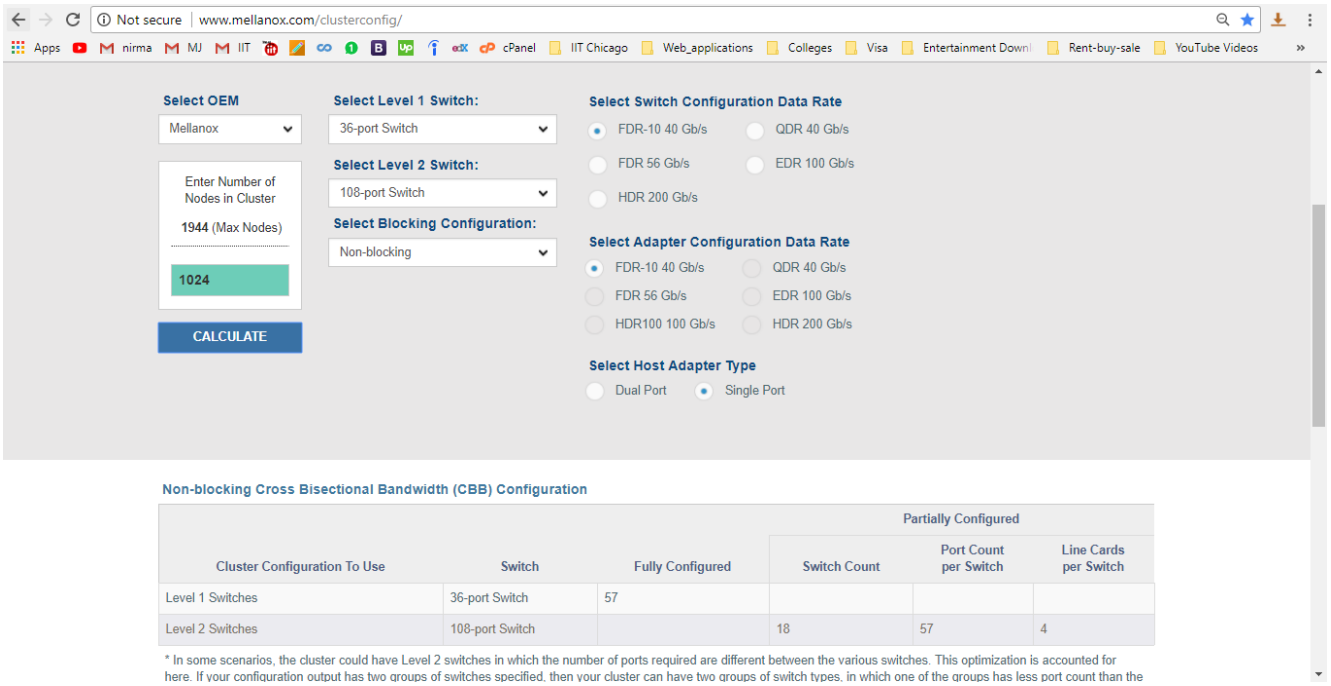
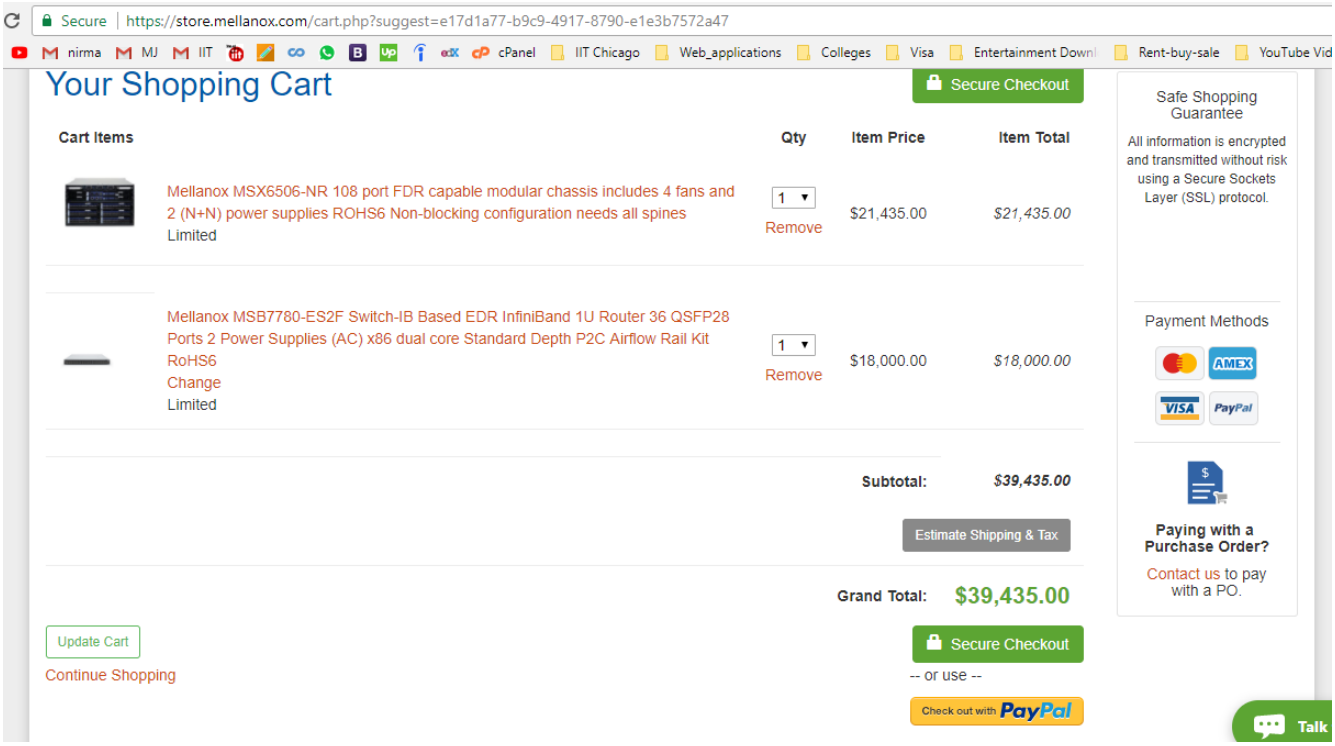
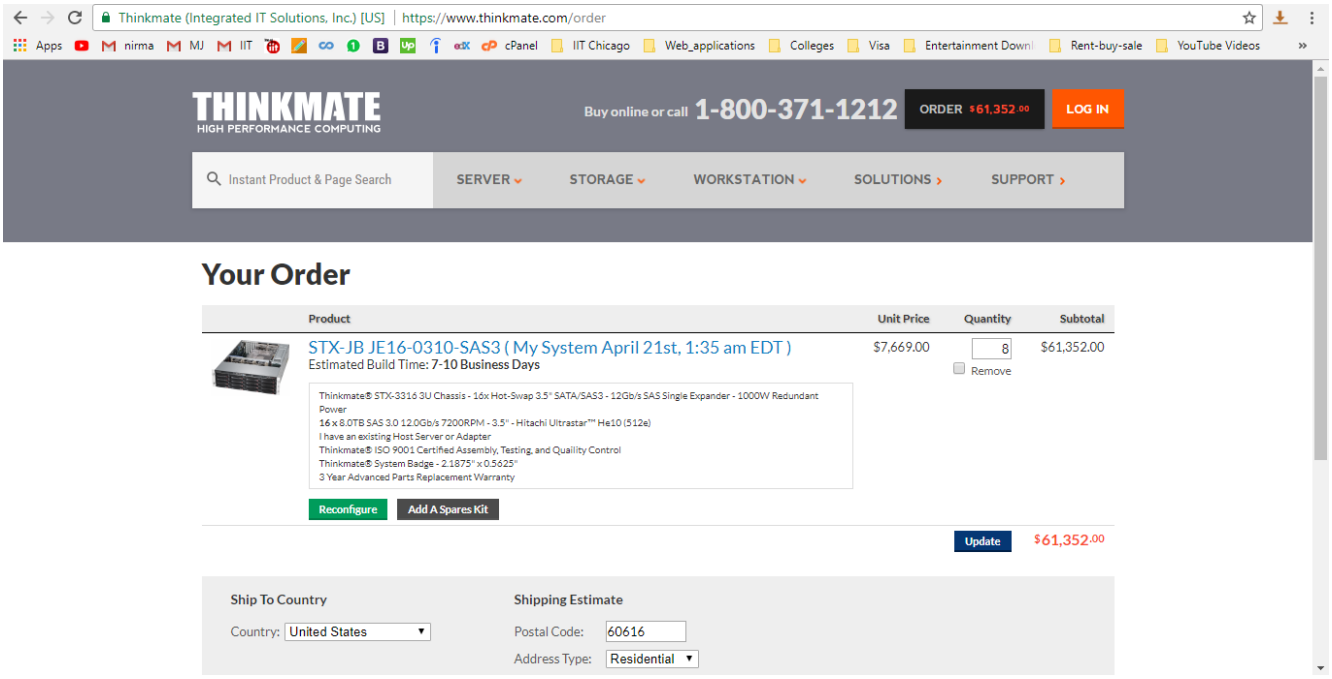


Non-blocking Cross Bisectional Bandwidth (CBB) Configuration

Cluster Configuration To Use	Switch	Fully Configured	Partially Configured		
			Switch Count	Port Count per Switch	Line Cards per Switch
Level 1 Switches	36-port Switch	57			
Level 2 Switches	108-port Switch		18	57	4

* In some scenarios, the cluster could have Level 2 switches in which the number of ports required are different between the various switches. This optimization is accounted for here. If your configuration output has two groups of switches specified, then your cluster can have two groups of switch types, in which one of the groups has less port count than the

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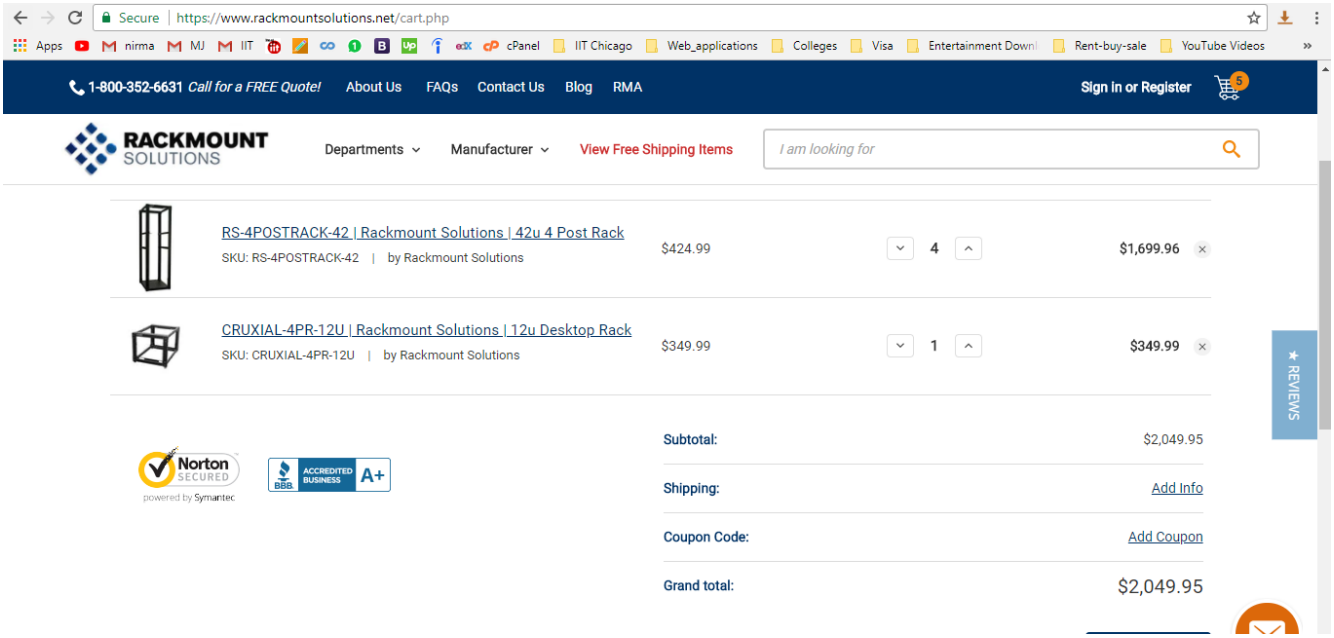
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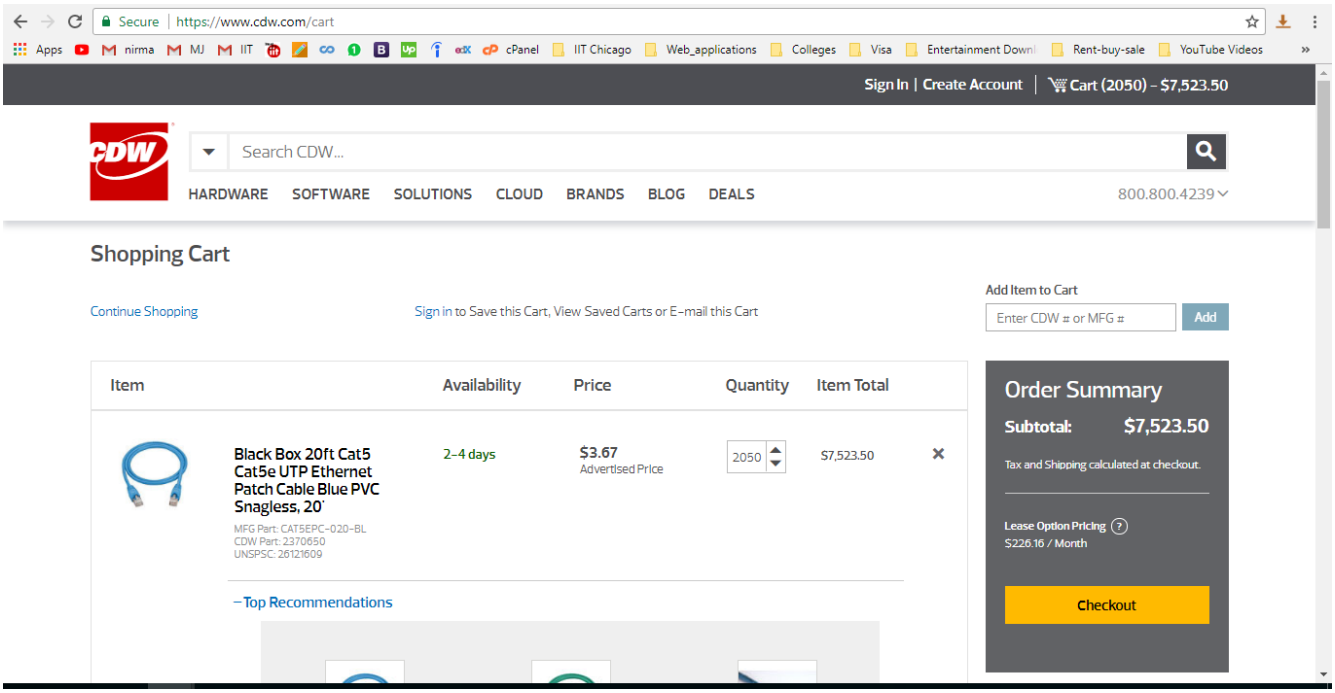
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