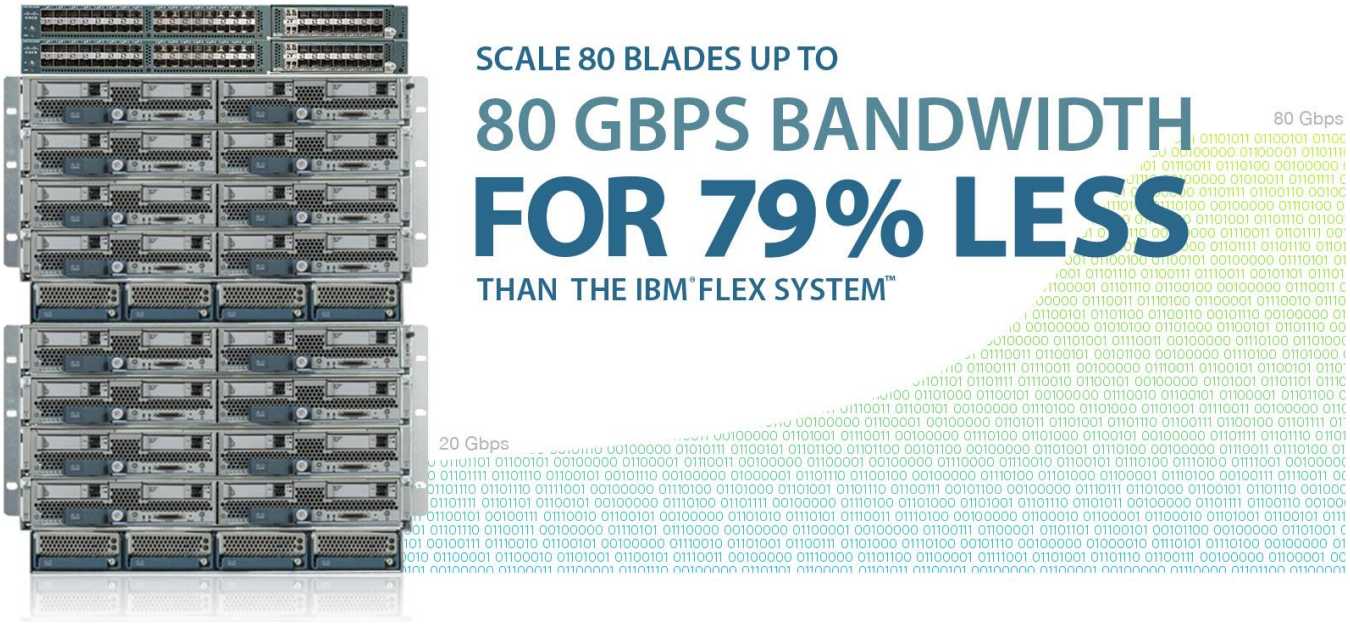
NETWORK SCALING COST ANALYSIS: CISCO UCS AND IBM FLEX SYSTEM



Modern blade servers have more power to drive network usage than ever before. In the past, a 1Gbps network connection supported traffic with ease, but new technologies such as network convergence and virtualization can congest even a 10Gbps link with bandwidth-hungry operations such as vMotion and Live Migration.

Bandwidth is an increasingly essential factor in companies being able to meet their computing needs. They need their infrastructure to support the current level of activity and to be able to scale up as demand increases.

In this paper, we examine the bandwidth scale-up costs of two solutions, the Cisco Unified Computing System (UCS) and the IBM Flex System. Due to their different designs, the costs vary dramatically. Upgrading from the baseline Cisco UCS configuration, with 20 Gbps of bandwidth, to a configuration with 80 Gbps of bandwidth, requires less than one-fourth the additional investment that the same upgrade on the IBM Flex System costs. The cost of the baseline Cisco UCS solution is also 22 percent lower than that of the comparable baseline IBM Flex System solution.

OCTOBER 2013
A PRINCIPLED TECHNOLOGIES COST ANALYSIS
Commissioned by Cisco Systems, Inc.

SUFFICIENT BANDWIDTH = A GOOD USER EXPERIENCE

In addition to bandwidth-intensive technologies such as vMotion and Live Migration, several newer technologies are driving the need for more and more network bandwidth. Virtual desktop has now evolved to allow high-end graphics processing units (GPUs) to send high-resolution, lossless videos and graphics from a server in the data center to multiple client devices over the LAN. These applications and videos maintain their high quality only when bandwidth is sufficient. Otherwise, quality degrades during the data transfer process, and the user experience deteriorates. Newer and faster storage arrays now incorporate solid-state drives (SSDs); this means that the server has greater access to disk I/O via network-attached storage (NAS) but can only benefit from the NAS if the network link supports the transfer of data. Companies must be able to maintain high levels of service as bandwidth needs increase over time. To achieve this in a cost-effective way, they need to plan their purchases with an eye to future growth and to understand the costs associated with scaling up.

To understand the impact of the pay-as-you-go approach to increasing bandwidth, we considered a hypothetical business environment requiring 80 compute nodes. The company is looking to start with a baseline configuration that provides 20 Gbps of upstream bandwidth to any single node, and intends to increase bandwidth in later configurations. We considered two solutions: Cisco UCS and IBM Flex System. To minimize additional hardware purchases when moving to the next tier of bandwidth, we selected blade components for the 20Gbps tier that provided the most flexibility for moving to higher tiers. We used MSRP prices obtained from the Cisco and IBM Web sites and configuration tools, as of September 30, 2013. As Figure 1 shows, when starting with the base configuration of 20 Gbps per compute node for both solutions, moving to greater levels of bandwidth—40 Gbps and 80 Gbps—is considerably less costly with Cisco UCS.

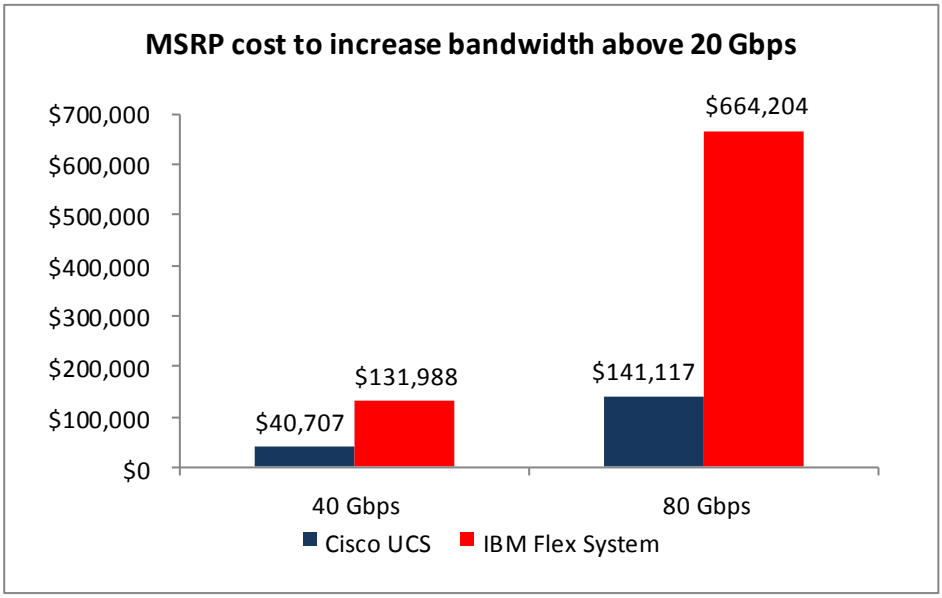


Figure 1: Increasing bandwidth on the Cisco UCS from 20 Gbps to 80 Gbps was 79 percent less expensive than doing so on the IBM Flex System. Smaller numbers are better.

THE UPGRADE PROCESS

Cisco UCS chassis

The Cisco UCS chassis contains eight half-height bays in only 6U, provides up to 160 Gbps to each chassis, and is capable of providing 80 Gbps of bandwidth to any blade. Unlike IBM, Cisco UCS allows customers to share bandwidth across the entire domain, ensuring that servers that need the bandwidth will get it without requiring switches in every chassis. This significantly affects solution costs when scaling from 20 Gbps to the blade to 40 Gbps or even to 80 Gbps. The chassis requires no integrated switches, as switching is handled upstream by the redundant Fabric Interconnect modules for the entire domain.

Components required for bandwidth increase

Our baseline configuration consists of 10 Cisco UCS 5108 Blade Server Chassis, each connected to redundant Fabric Interconnects through a single port. This provides 10 Gbps per fabric, for a total of 20 Gbps to each chassis. The VIC 1240 adapter by default enables 40 Gbps to each blade. With only a single FCoE connection to the Fabric Interconnects, the VIC can burst to 10 Gbps per Fabric Interconnect or 20Gbps per blade. This allows customers the flexibility to assign bandwidth based on application needs. Each Fabric Interconnect has 12 unified ports licensed, and we assign one port to the core network, one port to Fibre Channel SAN, and 10 ports for the 10 chassis. MSRP for this 80-blade configuration as of September 30, 2013 is $1,000,197.

To move to 40 Gbps, we would license one additional port on each Fabric Interconnect for each chassis and connect the chassis to the port on the Fabric Interconnect. No additional hardware is required. At this bandwidth tier, each Fabric Interconnect has 24 unified ports licensed – two ports to the core network, two ports to

Fibre Channel SAN, and 20 ports for the 10 chassis. Making this change increases the MSRP price by 4.1 percent over the initial investment, for a total of $1,040,905.

Expanding the bandwidth to 80 Gbps would require us to add a single piece of hardware, the mezzanine card port expander, which adds ports to the VIC 1240. Additionally, two more ports on each Fabric Interconnect for each chassis need to be licensed and connected to the chassis. At this tier, each Fabric Interconnect has 48 ports licensed – four ports to the core network, four ports to Fibre Channel SAN, and 40 ports for the 10 chassis. Making this change adds 14.1 percent to the list price of the base configuration, for a total of $1,141,314.

For details about the specific configurations and components used for the Cisco UCS environment, see Appendix A.

IBM Flex System Enterprise Chassis

The IBM Flex System Enterprise Chassis holds 14 half-height nodes with integrated network and storage switching modules. Multi-chassis control is possible with the inclusion of the fee-based IBM Flex System Manager, which occupies one node of a single chassis and can manage up to 16 chassis.

Components required for bandwidth increase

Our baseline configuration consisted of six IBM Flex System Enterprise Blade Chassis, each containing redundant Flex System Fabric CN4093 10Gb Scalable switches. This provided a total of 10 Gbps per side, for a total of 20 Gbps to each node in the chassis. Each switch utilized a single uplink to the core network and a single 8Gbps uplink to the Fibre Channel storage network. This configuration has an MSRP of $1,287,893 as of September 30, 2013.

Increasing the available bandwidth to 40 Gbps per node required purchasing one of the optional upgrade software packages for each switch in the chassis. We selected CN4093 upgrade 2, which provides six additional external Omni Ports and enables 14 additional ports within each switch. Each switch connects to the core network with two 10Gb uplinks, and to the storage network with two 8Gb Fibre Channel connections. The additional bandwidth adds 10.25 percent to the cost of the base configuration, for a total MSRP of $1,419,881.

Moving into the next tier requires the purchase of additional hardware and licensing. To move to 80 Gbps, requires adding two more switches to each chassis, and purchasing the CN4093 upgrade 2 package. Additionally, a second CN4054 10Gb Virtual Fabric Adapter must be added to every compute node. Each switch is connected with four 10Gb uplinks and four 8Gb Fibre Channel connections. The additional bandwidth substantially increases the cost of the environment, raising the list price by 51.6 percent over the cost of the base configuration, for a total of $1,952,097.

Figure 2 summarizes the MSRP pricing of the two solutions as of September 30, 2013.[1]

	Cisco UCS chassis	IBM Flex System Enterprise Chassis
20 Gbps	$1,000,197	$1,287,893
40 Gbps	$1,040,905	$1,419,881
80 Gbps	$1,141,314	$1,952,097

Figure 2: MSRP pricing for multiple configurations of the two solutions.

For details about the specific configurations and components used for the IBM Flex System environment, see Appendix B.

PRODUCT ARCHITECTURES

Cisco UCS

Cisco UCS 6248UP Fabric Interconnect

The Cisco UCS 6248UP 48-Port Fabric Interconnect provides converged access to both data and storage networks. Fabric Interconnects are typically deployed in redundant pairs.

Cisco UCS 2208XP Fabric Extenders

The Cisco UCS 2200 series extends the I/O fabric, enabling Fibre Channel over Ethernet (FCoE) fabric to connect all blades and chassis together. It is managed as an extension of the Fabric Interconnects and eliminates the need for redundant switches in each chassis.

Each Cisco UCS 2208XP Fabric Extender contains eight 10 Gigabit Ethernet, FCoE-capable, Small Form-Factor Pluggable (SFP+) ports for connecting the blade chassis to the Fabric Interconnect, and thirty-two 10-Gigabit Ethernet ports for connecting half-width bays through the midplane.

Fabric Extenders are typically configured in pairs for redundancy. Each fabric extender can provide up to 80 Gbps of I/O to the chassis.

Cisco UCS B200 M3

The Cisco UCS B200 M3 is a half-width blade providing up to two multi-core Intel® Xeon® processors E5-2600 and 24 DIMM slots supporting up to 768 GB of DDR3 RAM. Up to eight B200 M3 servers can reside in a single Cisco UCS 5108 Blade Server Chassis. The B200 M3 can house two hot-pluggable SAS or SATA hard disk drives (HDDs) or solid-state drives.

[1] IBM does offer a 160Gbps configuration using the IBM Flex System PCIe Expansion Node for each blade. This expansion node occupies an additional half-height slot in the Flex System Enterprise Blade Chassis, cutting the total number of blades per chassis in half; this reduction in blade density (seven total per chassis) significantly increases the cost of this extreme configuration.

Cisco UCSB-MLOM Virtual Interface Cards

- **Cisco UCSB-MLOM-40G-01.** The UCSB-MLOM-40G-01 is a four-port 10 Gbps mezzanine adapter capable of providing up to 40 Gbps to a half-height B200 M3 server.
- **UCSB-MLOM-PT-01.** The UCSB-MLOM-PT-01 is a port expander for use with the UCSB-MLOM-40G-01, which doubles the number of available ports, effectively doubling the total bandwidth available to a single node.

IBM Flex System

Flex System Fabric CN4093 10Gb Scalable Switch

The Flex System Fabric CN4093 switch is a scalable, converged switch that supports both 10Gb Ethernet and Fibre Channel (FC). The base configuration provides 14 10Gb internal ports, two external 10 Gbps SFP+ ports, and six external IBM Omni Ports, which are flexible ports providing either 10 Gb Ethernet or Fibre Channel connectivity based on the SFP selected. Additional ports can be activated with the purchase of optional software upgrades, providing a total of 42 available internal ports and the complete set of external ports.

IBM Flex System x240 Compute Node

The Flex System x240 computer is a half-height blade server with up to two multi-core Intel Xeon processors and 24 DIMM slots supporting up to 768 GB of DDR3 low profile RAM. Up to 14 Flex System x240 servers can be housed in a single IBM Flex System Enterprise Chassis. The x240 can be equipped with two hot-pluggable SAS or SATA HDDs or SSDs.

Flex System CN4054 Virtual Fabric Adapter

The CN4054 Virtual Fabric Adapter is a converged network adapter that provides 10 Gbps bandwidth per physical port. Enhanced functions, such as iSCSI and Fibre Channel over Ethernet capabilities, are added by purchasing a software upgrade for each adapter.

CONCLUSION

As organizations deploy converged infrastructure environments, entry costs play a significant role in hardware selection. Choosing a solution that provides easy upgrade paths when increased performance and capacity are necessary is another important factor. However, as our analysis demonstrates, it is equally important to consider the future costs associated with those upgrades. Selecting hardware based solely on initial acquisition costs can lead to substantially higher costs for future bandwidth increases.

We compare the total list pricing for each tier of the Cisco UCS solution and the IBM Flex System solution to highlight the differences in the cost of bandwidth between each environment. Not only does the Cisco UCS solution have a 22.3 percent lower initial investment cost, but the costs to increase bandwidth above the baseline configuration are significantly lower than doing so on the IBM Flex System.

APPENDIX A – CONFIGURATION DETAILS FOR THE CISCO UCS SOLUTION

The following tables provide detailed configuration details and cost data for the components in the Cisco UCS solution. We first present the 20Gbps solution, followed by the 40Gbps and 80Gbps solutions. All MSRP data is as of September 30, 2013 and come either from buildprice.cisco.com or directly from Cisco.

20Gbps Cisco UCS solution	Part number	Quantity	MSRP	Total MSRP
B200 M3 blade server	UCSB-B200-M3-U	80	$1,682.13	$134,570.40
Intel E5-2660 processors	UCS-CPU-E5-2660	160	$1,920.00	$307,200.00
8GB 1600MHz DDR3 RAM	UCS-MR-1X082RY-A	1,280	$180.80	$231,424.00
146GB 6Gb SAS 15K RPM SFF HDD	A03-D146GC2	160	$369.07	$59,051.20
VIC 1240 modular LOM	UCSB-MLOM-40G-01	80	$799.47	$63,957.60
VIC 1240 port expander	UCSB-MLOM-PT-01	0	N/A	$0.00
UCS 5108 Blade Chassis	N20-C6508-UPG	10	$3,199.47	$31,994.70
2500W Platinum PSU for UCS 5108	UCSB-PSU-2500ACPL	40	$499.20	$19,968.00
Fan module for UCS 5108 (included with chassis)	N/A	0	N/A	$0.00
2208XP FEX fabric extender modules	UCS-IOM-2208XP	20	$5,333.33	$106,666.60
Cisco R-series rack	RACK-UCS	2	$1,523.73	$3,047.46
UCS 6248UP Fabric Interconnect + 12pL	UCS-FI-6248UP	2	$17,066.67	$34,133.34
UCS 6248UP Chassis Accessory Kit	UCS-ACC-6248UP	0	N/A	$0.00
UCS 6248UP 16-port expander + 8pL	UCS-FI-E16UP	0	N/A	$0.00
UCS 6200 Series 1PORT license	UCS-LIC-10GE	0	N/A	$0.00
UCS SFP+ Copper Twinax cable	SFP-H10GB-CU5M	20	$260.00	$5,200.00
UCS 6248UP Power Supply	UCS-PSU-6248UP-AC	4	$746.00	$2,984.00
UCS 6248UP Fan Module (included)	N/A	0	N/A	$0.00
Total cost				**$1,000,197.30**

40Gbps Cisco UCS solution	Part number	Quantity	MSRP	Total MSRP
B200 M3 blade server	UCSB-B200-M3-U	80	$1,682.13	$134,570.40
Intel E5-2660 processors	UCS-CPU-E5-2660	160	$1,920.00	$307,200.00
8GB 1600MHz DDR3 RAM	UCS-MR-1X082RY-A	1,280	$180.80	$231,424.00
146GB 6Gb SAS 15K RPM SFF HDD	A03-D146GC2	160	$369.07	$59,051.20
VIC 1240 modular LOM	UCSB-MLOM-40G-01	80	$799.47	$63,957.60
VIC 1240 port expander	UCSB-MLOM-PT-01	0	N/A	$0.00
UCS 5108 Blade Chassis	N20-C6508-UPG	10	$3,199.47	$31,994.70
2500W Platinum PSU for UCS 5108	UCSB-PSU-2500ACPL	40	$499.20	$19,968.00
Fan module for UCS 5108 (included with chassis)	N/A	0	N/A	$0.00
2208XP FEX fabric extender modules	UCS-IOM-2208XP	20	$5,333.33	$106,666.60
Cisco R-series rack	RACK-UCS	2	$1,523.73	$3,047.46
UCS 6248UP Fabric Interconnect + 12pL	UCS-FI-6248UP	2	$17,066.67	$34,133.34
UCS 6248UP Chassis Accessory Kit	UCS-ACC-6248UP	0	N/A	$0.00
UCS 6248UP 16-port expander + 8pL	UCS-FI-E16UP	0	N/A	$0.00
UCS 6200 Series 1PORT license	UCS-LIC-10GE	24	$1,479.47	$35,507.28
UCS SFP+ Copper Twinax cable	SFP-H10GB-CU5M	40	$260.00	$10,400.00
UCS 6248UP Power Supply	UCS-PSU-6248UP-AC	4	$746.00	$2,984.00
UCS 6248UP Fan Module (included)	N/A	0	N/A	$0.00
Total cost				**$1,040,904.58**

80Gbps Cisco UCS solution	Part number	Quantity	MSRP	Total MSRP
B200 M3 blade server	UCSB-B200-M3-U	80	$1,682.13	$134,570.40
Intel E5-2660 processors	UCS-CPU-E5-2660	160	$1,920.00	$307,200.00
8GB 1600MHz DDR3 RAM	UCS-MR-1X082RY-A	1,280	$180.80	$231,424.00
146GB 6Gb SAS 15K RPM SFF HDD	A03-D146GC2	160	$369.07	$59,051.20
VIC 1240 modular LOM	UCSB-MLOM-40G-01	80	$799.47	$63,957.60
VIC 1240 port expander	UCSB-MLOM-PT-01	80	$320.00	$25,600.00
UCS 5108 Blade Chassis	N20-C6508-UPG	10	$3,199.47	$31,994.70
2500W Platinum PSU for UCS 5108	UCSB-PSU-2500ACPL	40	$499.20	$19,968.00
Fan module for UCS 5108 (included with chassis)	N/A	0	N/A	$0.00
2208XP FEX fabric extender modules	UCS-IOM-2208XP	20	$5,333.33	$106,666.60
Cisco R-series rack	RACK-UCS	2	$1,523.73	$3,047.46
UCS 6248UP Fabric Interconnect + 12pL	UCS-FI-6248UP	2	$17,066.67	$34,133.34
UCS 6248UP Chassis Accessory Kit	UCS-ACC-6248UP	2	N/A	$0.00
UCS 6248UP 16-port expander + 8pL	UCS-FI-E16UP	2	$8,533.33	$17,066.66
UCS 6200 Series 1PORT license	UCS-LIC-10GE	56	$1,479.47	$82,850.32
UCS SFP+ Copper Twinax cable	SFP-H10GB-CU5M	80	$260.00	$20,800.00
UCS 6248UP Power Supply	UCS-PSU-6248UP-AC	4	$746.00	$2,984.00
UCS 6248UP Fan Module (included)	N/A	0	N/A	$0.00
Total cost				**$1,141,314.28**

APPENDIX B – CONFIGURATION DETAILS FOR THE IBM FLEX SYSTEM SOLUTION

The following tables provide detailed configuration details and MSRP data for the components in the IBM Flex System solution. We first present the 20Gbps solution, followed by the 40Gbps, 80Gbps, and 160Gbps solutions. All MSRP data is as of September 30, 2013 from IBM's Standalone Solutions Configuration Tool.

20Gbps IBM Flex System solution	Part number	Quantity	MSRP	Total MSRP
x240 blade server, 1 x Intel Xeon processors E5-2660	8737L2U	80	$4,509.00	$360,720.00
Intel Xeon processors E5-2660	81Y5187	80	$1,959.00	$156,720.00
8GB 1600MHz DDR3 RAM	90Y3109	1,200	$189.00	$226,800.00
146GB 6Gb SAS 15K RPM SFF HDD	90Y8926	160	$369.00	$59,040.00
IBM Flex System PCIe Expansion Node	81Y8983	0	$2,069.00	$0.00
CN4054 10Gb Virtual Fabric Adapter	90Y3554	80	$1,099.00	$87,920.00
CN4054 Virtual Fabric Adapter-SW Upgrade	90Y3558	80	$769.00	$61,520.00
Flex System Enterprise Blade Chassis	8721A1U	6	$5,589.00	$33,534.00
Blade Chassis 2500W Power Module (2 included in the chassis)	43W9049	24	$439.00	$10,536.00
Redundant 80mm Fan Module (2 pack) (4 fans included in the chassis)	43W9078	12	$439.00	$5,268.00
Additional Chassis Mgt Module	68Y7030	6	$935.00	$5,610.00
IBM 42U Static Server rack	93614PX	2	$1,699.00	$3,398.00
Flex System Fabric CN4093 10Gb Scalable Switch	00D5823	12	$20,899.00	$250,788.00
CN4093 upgrade 2	00D5847	0	$10,999.00	$0.00
FSM Service Fabric Provisioning (per chassis)	90Y4226	6	$2,240.00	$13,440.00
Flex System Manager Node	8731A1U	1	$12,599.00	$12,599.00
Flex System Manager license (per chassis)	90Y4222	6	$12,600.00	$75,600.00
Total cost				**$1,287,893.00**

40Gbps IBM Flex System solution	Part number	Quantity	MSRP	Total MSRP
x240 blade server, 1 x Intel Xeon processors E5-2660	8737L2U	80	$4,509.00	$360,720.00
Intel Xeon processors E5-2660	81Y5187	80	$1,959.00	$156,720.00
8GB 1600MHz DDR3 RAM	90Y3109	1,200	$189.00	$226,800.00
146GB 6Gb SAS 15K RPM SFF HDD	90Y8926	160	$369.00	$59,040.00
IBM Flex System PCIe Expansion Node	81Y8983	0	$2,069.00	$0.00
CN4054 10Gb Virtual Fabric Adapter	90Y3554	80	$1,099.00	$87,920.00
CN4054 Virtual Fabric Adapter-SW Upgrade	90Y3558	80	$769.00	$61,520.00
Flex System Enterprise Blade Chassis	8721A1U	6	$5,589.00	$33,534.00
Blade Chassis 2500W Power Module (2 included in the chassis)	43W9049	24	$439.00	$10,536.00
Redundant 80mm Fan Module (2 pack) (4 fans included in the chassis)	43W9078	12	$439.00	$5,268.00
Additional Chassis Mgt Module	68Y7030	6	$935.00	$5,610.00
IBM 42U Static Server rack	93614PX	2	$1,699.00	$3,398.00
Flex System Fabric CN4093 10Gb Scalable Switch	00D5823	12	$20,899.00	$250,788.00
CN4093 upgrade 2	00D5847	12	$10,999.00	$131,988.00
FSM Service Fabric Provisioning (per chassis)	90Y4226	6	$2,240.00	$13,440.00
Flex System Manager Node	8731A1U	1	$12,599.00	$12,599.00
Flex System Manager license (per chassis)	90Y4222	6	$12,600.00	$75,600.00
Total cost				**$1,419,881.00**

80Gbps IBM Flex System solution	Part number	Quantity	MSRP	Total MSRP
x240 blade server, 1 x Intel Xeon processors E5-2660, 8 GB RAM	8737L2U	80	$4,509.00	$360,720.00
Intel Xeon processors E5-2660	81Y5187	80	$1,959.00	$156,720.00
8GB 1600MHz DDR3 RAM	90Y3109	1,200	$189.00	$226,800.00
146GB 6Gb SAS 15K RPM SFF HDD	90Y8926	160	$369.00	$59,040.00
IBM Flex System PCIe Expansion Node	81Y8983	0	$2,069.00	$0.00
CN4054 10Gb Virtual Fabric Adapter	90Y3554	160	$1,099.00	$175,840.00
CN4054 Virtual Fabric Adapter-SW Upgrade	90Y3558	160	$769.00	$123,040.00
Flex System Enterprise Blade Chassis	8721A1U	6	$5,589.00	$33,534.00
Blade Chassis 2500W Power Module (2 included in the chassis)	43W9049	24	$439.00	$10,536.00
Redundant 80mm Fan Module (2 pack) (4 fans included in the chassis)	43W9078	12	$439.00	$5,268.00
Additional Chassis Mgt Module	68Y7030	6	$935.00	$5,610.00
IBM 42U Static Server rack	93614PX	2	$1,699.00	$3,398.00
Flex System Fabric CN4093 10Gb Scalable Switch	00D5823	24	$20,899.00	$501,576.00
CN4093 upgrade 2	00D5847	24	$10,999.00	$263,976.00
FSM Service Fabric Provisioning (per chassis)	90Y4226	6	$2,240.00	$13,440.00
Flex System Manager Node	8731A1U	1	$12,599.00	$12,599.00
Flex System Manager license (per chassis)	90Y4222	6	$12,600.00	$75,600.00
Total cost				**$1,952,097.00**

160Gbps IBM Flex System solution	Part number	Quantity	MSRP	Total MSRP
x240 blade server, 1 x Intel Xeon processors E5-2660, 8 GB RAM	8737L2U	80	$4,509.00	$360,720.00
Intel Xeon processors E5-2660	81Y5187	80	$1,959.00	$156,720.00
8GB 1600MHz DDR3 RAM	90Y3109	1,200	$189.00	$226,800.00
146GB 6Gb SAS 15K RPM SFF HDD	90Y8926	160	$369.00	$59,040.00
IBM Flex System PCIe Expansion Node	81Y8983	80	$2,069.00	$165,520.00
CN4054 10Gb Virtual Fabric Adapter	90Y3554	320	$1,099.00	$351,680.00
CN4054 Virtual Fabric Adapter-SW Upgrade	90Y3558	320	$769.00	$246,080.00
Flex System Enterprise Blade Chassis	8721A1U	12	$5,589.00	$67,068.00
Blade Chassis 2500W Power Module (2 included in the chassis)	43W9049	48	$439.00	$21,072.00
Redundant 80mm Fan Module (2 pack) (4 fans included in the chassis)	43W9078	24	$439.00	$10,536.00
Additional Chassis Mgt Module	68Y7030	12	$935.00	$11,220.00
IBM 42U Static Server rack	93614PX	3	$1,699.00	$5,097.00
Flex System Fabric CN4093 10Gb Scalable Switch	00D5823	48	$20,899.00	$1,003,152.00
CN4093 upgrade 2	00D5847	48	$10,999.00	$527,952.00
FSM Service Fabric Provisioning (per chassis)	90Y4226	12	$2,240.00	$26,880.00
Flex System Manager Node	8731A1U	1	$12,599.00	$12,599.00
Flex System Manager license (per chassis)	90Y4222	12	$12,600.00	$151,200.00
Total cost				**$3,252,136.00**

ABOUT PRINCIPLED TECHNOLOGIES

Principled Technologies, Inc.
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We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.