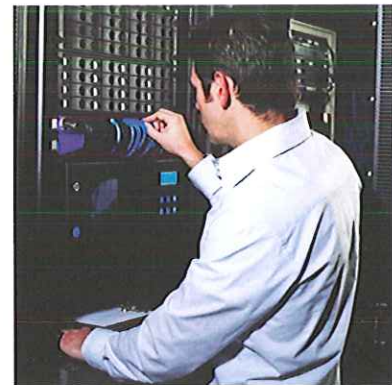


ORIGINAL



Proposal for State of West Virginia

RFQ ST012007 - Computer Network
Infrastructure





One Dell Way
Round Rock
TX 78682, USA

www.dell.com

Friday, April 06, 2012

Frank Whittaker
State of West Virginia
2019 Washington Street, East
Building 15
Charleston WV 25305-0130

Dear Mr Whittaker,

Thank you for this opportunity to submit a proposal for State of West Virginia's forthcoming technology project. We have studied the information provided to us about your business requirements and carefully analyzed your technology needs. The solution recommended for State of West Virginia has been designed to meet your needs in the most cost effective way without compromising on quality, service or ongoing support.

Dell is helping our customers to bring down the Total Cost of Ownership by simplifying IT. We are committed to providing solutions that will allow State of West Virginia to reclaim time and cost and increase the productivity of your IT. In addition, we have built environmental consideration into every stage of the Dell product lifecycle including power consumption, helping our customers demonstrate environmentally responsible procurement.

Our two proposals include the same server and storage offerings. The difference includes two different network options for your review. These options are industry leading networking technologies that meet your technical requirements, may increase functionality and lower your Total Cost of Ownership. We look forward to discussing how these options can help in the areas described.

It is important to note that our proposal includes what we call an Investment Pricing Strategy. Dell is looking to invest in our relationship at the state while at the same time, allowing you to acquire and see for yourself why our Dell Data Center Solutions are truly industry leading. We have included references that will attest to this statement. The pricing included in this proposal is heavily discounted and only applicable to this purchase. Again, Dell is looking to grow our relationship within the State of West Virginia Agencies and we look forward to the next step in this process.

Dell looks forward to working with you on this project. Should you have any questions regarding this response, please contact me at 512-723-3772 or online at Mary_Collins@Dell.com.

Dell's receipt of an Award or Purchase Order for RFP 12007STO for Computer Network Infrastructure from State of West Virginia and subsequent performance in relation to this response shall be governed by and understood to indicate State of West Virginia's acceptance of the WSCA (WN34ACA) contract. Any terms in RFP 12007STO for Computer Network Infrastructure or on a resulting Purchase Order from State of West Virginia to Dell shall not be applicable.

Sincerely,

A handwritten signature in blue ink that reads "M. Collins".

Mary Collins
Proposals Manager

Title Page

Subject - RFQ Response - Computer Network Infrastructure

RFQ Number - STO12007

Vendor's Name - Dell Marketing, LP

Address: One Dell Way, Round Rock, TX 78682

Phone: 512-723-3772

Fax: 512-283-9092

Contact: Mary Collins

Email: Mary_Collins@Dell.com



04/06/2012

Mary Collins – Proposal Manager

Date



Table of Contents

RFQ Forms	4
Attachment A - Vendor Response Sheet	11
2.3.1	11
2.3.2	16
2.3.3	16
2.3.4	18
2.3.5	19
2.4 Project Goals and Objectives.....	20
Attachment B - Mandatory Requirements.....	33
Attachment C - Cost Sheet.....	41
Purchasing Affidavit.....	42
Contract Terms and Conditions	43
Attachments - Supporting Documentation.....	44

©Dell Inc. All rights reserved worldwide. Dell and the Dell logo are trademarks of Dell Inc. in the US and other countries. All third-party trademarks and brands referenced in any of these documents are the property of their respective owners.



RFQ Forms

Immediately following this page, please find the requested RFQ forms.

Dell's receipt of an Award or Purchase Order for RFP 12007STO for Computer Network Infrastructure from State of West Virginia and subsequent performance in relation to this response shall be governed by and understood to indicate State of West Virginia's acceptance of the WSCA (WN34ACA) contract. Any terms in RFP 12007STO for Computer Network Infrastructure or on a resulting Purchase Order from State of West Virginia to Dell shall not be applicable.





State of West Virginia
Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

Request for Quotation

RFQ NUMBER

STO12007

PAGE

1

ADDRESS CORRESPONDENCE TO ATTENTION OF:

FRANK WHITTAKER
304-558-2316

RFQ COPY

TYPE NAME/ADDRESS HERE

Dell Marketing, LP
One Dell Way
Round Rock, TX 78613

STATE TREASURER
MAIN CAPITOL BUILDING
SUITE E-145
CHARLESTON, WV 25305 304-343-4000

DATE PRINTED	TERMS OF SALE	SHIP VIA	F.O.B.	FREIGHT TERMS		
03/06/2012	Net 30					
BID OPENING DATE: 04/10/2012		BID OPENING TIME 01:30PM				
LINE	QUANTITY	UOP	CAT. NO.	ITEM NUMBER	UNIT PRICE	AMOUNT
0001	1	IS		205-05		
COMPUTER NETWORK INFRASTRUCTURE						
REQUEST FOR PROPOSAL (RFP)						
THE WEST VIRGINIA PURCHASING DIVISION, FOR THE THE WEST VIRGINIA STATE TREASURER'S OFFICE, IS SOLICITING PROPOSALS FOR REPLACEMENT OR NETWORK INFRASTRUCTURE COMPONENTS PER THE ATTACHED SPECIFICATIONS.						
MANDATORY PRE-BID						
A MANDATORY PRE-BID WILL BE HELD ON 3/16/12 AT 10:30 A.M. RM EB96, BLDG. 1, 1900 KANAWHA BLVD. E. CHARLESTON. ALL INTERESTED PARTIES ARE REQUIRED TO ATTEND THIS MEETING. FAILURE TO ATTEND THE MANDATORY PRE-BID SHALL RESULT IN DISQUALIFICATION OF THE BID. NO ONE PERSON MAY REPRESENT MORE THAN ONE BIDDER.						
AN ATTENDANCE SHEET WILL BE MADE AVAILABLE FOR ALL POTENTIAL BIDDERS TO COMPLETE. THIS WILL SERVE AS THE OFFICIAL DOCUMENT VERIFYING ATTENDANCE AT THE MANDATORY PRE-BID. FAILURE TO PROVIDE YOUR COMPANY AND REPRESENTATIVE NAME ON THE ATTENDANCE SHEET WILL RESULT IN DISQUALIFICATION OF THE BID. THE STATE WILL NOT ACCEPT ANY OTHER DOCUMENTATION TO VERIFY ATTENDANCE. THE BIDDER IS RESPONSIBLE FOR ENSURING THEY HAVE COMPLETED THE INFORMATION REQUIRED ON THE ATTENDANCE SHEET. THE PURCHASING DIVISION AND THE STATE AGENCY WILL NOT ASSUME ANY RESPONSIBILITY FOR A BIDDER'S FAILURE TO COMPLETE THE PRE-BID ATTENDANCE SHEET. IN						
SEE REVERSE SIDE FOR TERMS AND CONDITIONS						
SIGNATURE			TELEPHONE		DATE	
			512-723-3772		4/6/2012	
TITLE			FAX		ADDRESS CHANGES TO BE NOTED ABOVE	
Proposal Manager			74-2616805			

WHEN RESPONDING TO RFQ, INSERT NAME AND ADDRESS IN SPACE ABOVE LABELED 'VENDOR'





State of West Virginia
Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

Request for
Quotation

RFQ NUMBER
STO12007

PAGE
2

ADDRESS CORRESPONDENCE TO ATTENTION OF:
FRANK WHITTAKER 304-558-2316

V E N D O R	RFQ COPY
	TYPE NAME/ADDRESS HERE
	Dell Marketing, LP One Dell Way Round Rock, TX 78682

S H I P T O	STATE TREASURER MAIN CAPITOL BUILDING SUITE E-145 CHARLESTON, WV 25305 304-343-4000

DATE PRINTED	TERMS OF SALE	SHIP VIA	F.O.B.	FREIGHT TERMS		
03/06/2012	Net 30					
BID OPENING DATE: 04/10/2012		BID OPENING TIME 01:30PM				
LINE	QUANTITY	UOP	CAT. NO.	ITEM NUMBER	UNIT PRICE	AMOUNT
<p>ADDITION, WE REQUEST THAT ALL POTENTIAL BIDDERS INCLUDE THEIR E-MAIL ADDRESS AND FAX NUMBER.</p> <p>ALL POTENTIAL BIDDERS ARE REQUESTED TO ARRIVE PRIOR TO THE STARTING TIME FOR THE PRE-BID. BIDDERS WHO ARRIVE LATE, BUT PRIOR TO THE DISMISSAL OF THE TECHNICAL PORTION OF THE PRE-BID WILL BE PERMITTED TO SIGN IN. BIDDERS WHO ARRIVE AFTER CONCLUSION OF THE TECHNICAL PORTION OF THE PRE-BID, BUT DURING ANY SUBSEQUENT PART OF THE PRE-BID WILL NOT BE PERMITTED TO SIGN THE ATTENDANCE SHEET.</p> <p>ALL TECHNICAL QUESTIONS MUST BE SUBMITTED IN WRITING TO FRANK WHITTAKER IN THE WV PURCHASING DIVISION VIA EMAIL AT FRANK.M.WHITTAKER@WV.GOV OR VIA FAX AT 304-558-4115. DEADLINE FOR ALL TECHNICAL QUESTIONS IS 03/20/12 AT 4:00 PM. ALL TECHNICAL QUESTIONS WILL BE ADDRESSED BY ADDENDUM AFTER THE DEADLINE.</p> <p>NOTICE TO PROCEED: THE SOLUTION IS TO BE INSTALLED AND OPERATIONAL WITHIN 75 CALENDAR DAYS AFTER THE NOTICE TO PROCEED IS RECEIVED. UNLESS OTHERWISE SPECIFIED, THE FULLY EXECUTED PURCHASE ORDER WILL BE CONSIDERED NOTICE TO PROCEED.</p> <p>LIFE OF CONTRACT: THE ANNUAL MAINTENANCE WILL BE ADDED BY CHANGE ORDER AND EXTEND FOR A PERIOD OF ONE (1) YEAR OR UNTIL SUCH "REASONABLE TIME" THEREAFTER AS IS NECESSARY TO OBTAIN A NEW CONTRACT OR RENEW THE ORIGINAL CONTRACT. THE "REASONABLE TIME" PERIOD SHALL NOT EXCEED TWELVE (12) MONTHS. DURING THIS "REASONABLE TIME" THE VENDOR MAY TERMINATE THIS CONTRACT FOR ANY REASON UPON GIVING THE DIRECTOR OF PURCHASING 30 DAYS WRITTEN NOTICE.</p>						
SEE REVERSE SIDE FOR TERMS AND CONDITIONS						
SIGNATURE			TELEPHONE		DATE	
TITLE Proposal Manager			512-723-3772		4/6/2012	
FAX 74-2616805			ADDRESS CHANGES TO BE NOTED ABOVE			

WHEN RESPONDING TO RFQ, INSERT NAME AND ADDRESS IN SPACE ABOVE LABELED 'VENDOR'





State of West Virginia
Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

Request for Quotation

RFQ NUMBER

STO12007

PAGE

3

ADDRESS CORRESPONDENCE TO ATTENTION OF:

FRANK WHITTAKER
304-558-2316

RFQ COPY

TYPE NAME/ADDRESS HERE

Dell Marketing, LP
One Dell Way
Round Rock, TX 78682

VENDOR

SHIP TO

STATE TREASURER
MAIN CAPITOL BUILDING
SUITE E-145
CHARLESTON, WV 25305 304-343-4000

DATE PRINTED	TERMS OF SALE	SHIP VIA	F.O.B.	FREIGHT TERMS		
03/06/2012	Net 30					
BID OPENING DATE: 04/10/2012		BID OPENING TIME 01:30PM				
LINE	QUANTITY	UOP	CAT. NO.	ITEM NUMBER	UNIT PRICE	AMOUNT
<p>UNLESS SPECIFIC PROVISIONS ARE STIPULATED ELSEWHERE IN THIS CONTRACT DOCUMENT BY THE STATE OF WEST VIRGINIA, ITS AGENCIES, OR POLITICAL SUBDIVISIONS, THE TERMS, CONDITIONS, AND PRICING SET FORTH HEREIN ARE FIRM FOR THE LIFE OF THE CONTRACT.</p> <p>RENEWAL: THIS CONTRACT MAY BE RENEWED UPON THE MUTUAL WRITTEN CONSENT OF THE SPENDING UNIT AND VENDOR, SUBMITTED TO THE DIRECTOR OF PURCHASING THIRTY (30) DAYS PRIOR TO THE EXPIRATION DATE. SUCH RENEWAL SHALL BE IN ACCORDANCE WITH THE TERMS AND CONDITIONS OF THE ORIGINAL CONTRACT AND SHALL BE LIMITED TO FOUR (4) ONE (1) YEAR PERIODS.</p> <p>CANCELLATION: THE DIRECTOR OF PURCHASING RESERVES THE RIGHT TO CANCEL THIS CONTRACT IMMEDIATELY UPON WRITTEN NOTICE TO THE VENDOR IF THE COMMODITIES AND/OR SERVICE SUPPLIED ARE OF AN INFERIOR QUALITY OR DO NOT CONFORM TO THE SPECIFICATIONS OF THE BID AND CONTRACT HEREIN.</p> <p>OPEN MARKET CLAUSE: THE DIRECTOR OF PURCHASING MAY AUTHORIZE A SPENDING UNIT TO PURCHASE ON THE OPEN MARKET, WITHOUT THE FILING OF A REQUISITION OR COST ESTIMATE, ITEMS SPECIFIED ON THIS CONTRACT FOR IMMEDIATE DELIVERY IN EMERGENCIES DUE TO UNFORESEEN CAUSES (INCLUDING BUT NOT LIMITED TO DELAYS IN TRANSPORTATION OR AN UNANTICIPATED INCREASE IN THE VOLUME OF WORK.)</p> <p>BANKRUPTCY: IN THE EVENT THE VENDOR/CONTRACTOR FILES FOR BANKRUPTCY PROTECTION, THE STATE MAY DEEM THE CONTRACT NULL AND VOID, AND TERMINATE SUCH CONTRACT WITHOUT FURTHER ORDER.</p> <p>THE TERMS AND CONDITIONS CONTAINED IN THIS CONTRACT</p>						
SEE REVERSE SIDE FOR TERMS AND CONDITIONS						
SIGNATURE			TELEPHONE		DATE	
			512-723-3772		4/06/2012	
TITLE		FEN		ADDRESS CHANGES TO BE NOTED ABOVE		
Proposal Manager		74-2616805				

WHEN RESPONDING TO RFQ, INSERT NAME AND ADDRESS IN SPACE ABOVE LABELED 'VENDOR'





State of West Virginia
Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

Request for
Quotation

RFQ NUMBER

STO12007

PAGE

4

ADDRESS CORRESPONDENCE TO ATTENTION OF:

FRANK WHITTAKER
304-558-2316

RFQ COPY

TYPE NAME/ADDRESS HERE

Dell Marketing, LP
One Dell Way
Round Rock, TX 78682

VENDOR

SHIP TO

STATE TREASURER
MAIN CAPITOL BUILDING
SUITE E-145

CHARLESTON, WV
25305 304-343-4000

DATE PRINTED	TERMS OF SALE	SHIP VIA	F.O.B.	FREIGHT TERMS		
03/06/2012	Net 30					
BID OPENING DATE: 04/10/2012		BID OPENING TIME 01:30PM				
LINE	QUANTITY	UOP	CAT. NO.	ITEM NUMBER	UNIT PRICE	AMOUNT
<p>SHALL SUPERSEDE ANY AND ALL SUBSEQUENT TERMS AND CONDITIONS WHICH MAY APPEAR ON ANY ATTACHED PRINTED DOCUMENTS SUCH AS PRICE LISTS, ORDER FORMS, SALES AGREEMENTS OR MAINTENANCE AGREEMENTS, INCLUDING ANY ELECTRONIC MEDIUM SUCH AS CD-ROM.</p> <p>REV. 01/17/2012</p> <p>NOTICE</p> <p>A SIGNED BID MUST BE SUBMITTED TO:</p> <p>DEPARTMENT OF ADMINISTRATION PURCHASING DIVISION BUILDING 15 2019 WASHINGTON STREET, EAST CHARLESTON, WV 25305-0130</p> <p>THE BID SHOULD CONTAIN THIS INFORMATION ON THE FACE OF THE ENVELOPE OR THE BID MAY NOT BE CONSIDERED:</p> <p>SEALED BID</p> <p>BUYER: 44</p> <p>RFQ. NO.: STO12007</p> <p>BID OPENING DATE: 04/10/2012</p> <p>BID OPENING TIME: 1:30 PM</p>						
SEE REVERSE SIDE FOR TERMS AND CONDITIONS						
SIGNATURE			TELEPHONE		DATE	
			512-723-3772		4/6/2012	
TITLE		FAX		ADDRESS CHANGES TO BE NOTED ABOVE		
Proposal Manager		74-2616805				

WHEN RESPONDING TO RFQ, INSERT NAME AND ADDRESS IN SPACE ABOVE LABELED 'VENDOR'





State of West Virginia
Department of Administration
Purchasing Division
2019 Washington Street East
Post Office Box 50130
Charleston, WV 25305-0130

Request for Quotation

RFQ NUMBER	PAGE
STO12007	5

ADDRESS CORRESPONDENCE TO ATTENTION OF:
FRANK WHITTAKER 304-558-2316

V E N D O R	RFQ COPY
	TYPE NAME/ADDRESS HERE
	Dell Marketing, LP
	One Dell Way Round Rock, TX 78682

S H I P T O	STATE TREASURER
	MAIN CAPITOL BUILDING
	SUITE E-145
	CHARLESTON, WV 25305 304-343-4000

DATE PRINTED	TERMS OF SALE	SHIP VIA	F.O.B.	FREIGHT TERMS		
03/06/2012	Net 30					
BID OPENING DATE: 04/10/2012		BID OPENING TIME 01:30PM				
LINE	QUANTITY	UOP	CAT. NO.	ITEM NUMBER	UNIT PRICE	AMOUNT
<p>PLEASE PROVIDE A FAX NUMBER IN CASE IT IS NECESSARY TO CONTACT YOU REGARDING YOUR BID:</p> <p>512-283-9092</p> <p>CONTACT PERSON (PLEASE PRINT CLEARLY):</p> <p>Mary Collins</p> <p>***** THIS IS THE END OF RFQ STO12007 ***** TOTAL: _____</p>						
SEE REVERSE SIDE FOR TERMS AND CONDITIONS						
SIGNATURE			TELEPHONE		DATE	
[Signature]			512-723-3772		4/6/2012	
TITLE		FEIN		ADDRESS CHANGES TO BE NOTED ABOVE		
Proposal Manager		74-2616805				

WHEN RESPONDING TO RFQ, INSERT NAME AND ADDRESS IN SPACE ABOVE LABELED 'VENDOR'





Attachment A - Vendor Response Sheet

2.3.1

An organization chart identifying the Vendor's overall business structure and locations, including an explanation of the various services offered by the company.

Vendor Response -

Company Facts - Dell at a Glance

Dell is a global information technology company that offers its customers a broad range of solutions and services delivered directly by Dell and through other distribution channels. We are focused on providing technology solutions that are more efficient, more accessible, and easier to manage.

Dell Inc. is a holding company that conducts its business worldwide through its subsidiaries. Our global corporate headquarters is located in Round Rock, Texas.

Business Strategy

Dell built its reputation as a leading technology provider through listening to customers and developing solutions that meet customer needs. A few years ago, we initiated a broad transformation of the company to become an end-to-end technology solutions company.

We are expanding our enterprise solutions, which include servers, networking, and storage offerings. In services, we are adding more capabilities to provide end-to-end technology solutions to our customers, including managed security services focused on threat intelligence and security consulting. We are also focused on growing our end-user computing business, which includes desktop and mobility offerings. Software is a critical part of enterprise solutions and end-user computing, and we are expanding our capabilities in this business. Since the beginning of Fiscal 2011, we have acquired more than ten companies whose offerings and intellectual property enhance our solutions business.

Products and Services

We design, develop, manufacture, market, sell, and support a wide range of products, solutions, and services. We also provide various customer financial services to our Commercial and Consumer customers.

Enterprise Solutions

Our enterprise solutions include servers, networking, and storage products.

- **Servers and Networking** — Our PowerEdge line of servers is designed to offer customers affordable performance, reliability, and scalability. Our portfolio includes high performance rack, blade, and tower servers for enterprise customers and value tower servers for small organizations, networks, and remote offices. During Fiscal 2012, we expanded our PowerConnect campus networking product offerings with a full suite of Dell Force10 data center networking solutions. We have also recently introduced our 12th generation of PowerEdge servers, allowing customer to run their applications more effectively and their data centers more efficiently.
- **Storage** — We offer a comprehensive portfolio of advanced storage solutions, including storage area networks, network-attached storage, direct-attached storage, and various backup systems. Our acquisition of Compellent Technologies, Inc. in Fiscal 2012 has further expanded our network storage offerings, and we have added a variety of increasingly flexible new Dell EqualLogic ("EqualLogic"), Dell PowerVault, and Dell DX Object storage choices that allow customers to grow capacity, add performance, and protect their data in a more economical manner. The flexibility



and scalability offered by our Dell PowerVault and EqualLogic storage systems help organizations optimize storage for diverse environments with varied requirements. During Fiscal 2012, we shifted more of our portfolio of storage solutions to Dell-owned storage products.

Services

Our services include a broad range of configurable IT and business services, including infrastructure technology, consulting and applications, and product-related support services. We provide them on a stand-alone basis or within a comprehensive solution. Based on our customer engagement model, we group our services into three categories: transactional, outsourcing, and project-based. Within those categories, we offer a variety of services to our customers as part of an overall solution.

- **Transactional** – Transactional services are closely tied to the sale of our servers, storage, and client offerings. They include support and extended warranty services, managed deployment, enterprise installation, and configuration services.
- **Outsourcing** – Outsourcing services are designed to reduce customer costs, increase the efficiency and improve the quality of customer business operations. They include data center and systems management, network management, life cycle application development and management, and business process outsourcing services.
- **Project-based** – We also offer short-term services that address a wide array of client needs, including IT infrastructure, applications, business process, and business consulting.

We offer the following services based on the business strategic needs:

- **Support and Development Services** – Support and deployment services are closely tied to the sale of our servers, storage, networking and client offerings, as well as multivendor support services. These services include the majority of the services we currently classify as transactional services.
- **Infrastructure, Cloud and Security Services** – These services include infrastructure and security managed services, cloud computing, infrastructure consulting and security consulting, and threat intelligence. We often define the infrastructure technology strategies for our customers through the identification and delivery of new technology offerings and innovations.
- **Applications and Business Process Services** – Applications services include application development and maintenance, application migration and management services, package implementation, testing and quality assurance functions, business intelligence and data warehouse solutions, and application consulting services. Business process services involve back office administration, call center management, and other technical and administration services.

Software and Peripherals

We offer Dell-branded printers and displays and a multitude of third-party peripheral products such as printers, televisions, notebook accessories, mice, keyboards, networking and wireless products, digital cameras, and other products. We also sell a wide range of third-party software products, including operating systems, business and office applications, anti-virus and related security software, entertainment software, and products in various other categories. We are focusing our participation in this area on higher-value offerings.

Client Products

We offer a wide variety of mobility and desktop products, including notebooks, workstations, tablets, smartphones, and desktop PCs.

- **Commercial** – Our Latitude, Optiplex, Vostro, and Dell Precision workstation lines of mobility notebooks and desktop PCs are designed with our Commercial customers in mind. The Latitude line of notebooks and the Optiplex line of desktop PCs deliver industry leading design, durability, security, and manageability to drive enterprise efficiency and reduce the total cost of ownership. The Vostro line is designed to customize technology, services, and expertise to suit the specific needs of small businesses. We also offer the Precision line of mobile and desktop



workstations for professional users who demand advanced workstation performance capabilities to run sophisticated applications. During Fiscal 2012, we introduced the new Vostro 3000 series notebooks, and the Dell Precision M4600 and M6600 mobile workstations, and made enhancements to our Dell Latitude E-family of notebooks.

- **Consumer** – For our Consumer customers, we offer the Inspiron, XPS, and Alienware lines of notebooks and desktop PCs. The Inspiron line is designed for the mainstream user seeking a personalized smart investment that is easy to use, while the XPS line is designed for customers seeking un-compromised form plus function, with high performance and craftsmanship. We target sales of our Alienware line to customers seeking advanced multimedia capabilities for high performance gaming.

Financial Services

We offer or arrange various financing options and services for our Commercial and Consumer customers in the U.S. and Canada through Dell Financial Services ("DFS"). DFS offers a wide range of financial services, including originating, collecting, and servicing customer receivables primarily related to the purchase of Dell products. DFS offers private label credit financing programs to qualified Consumer and Commercial customers and offers leases and fixed-term financing primarily to Commercial customers. Financing through DFS is one of several other sources of funding that our customers may select.

Product Development

We focus on developing scalable technologies that incorporate highly desirable features and capabilities at competitive prices. We employ a collaborative approach to product design and development in which our engineers, with direct customer input, design innovative solutions and work with a global network of technology companies to architect new system designs, influence the direction of future development, and integrate new technologies into our products. We manage our research, development, and engineering ("RD&E") spending by targeting those innovations and products that we believe are most valuable to our customers and by relying on the capabilities of our strategic relationships. Through this collaborative, customer-focused approach, we strive to deliver new and relevant products to the market quickly and efficiently. In Fiscal 2012, we opened the Dell Silicon Valley Research and Development Centre, bringing the total number of global research and development centers we operate to 12. Our total research, development, and engineering expenses were \$856 million, \$661 million, and \$624 million for Fiscal 2012, Fiscal 2011, and Fiscal 2010, respectively.

Manufacturing and Materials

Third parties manufacture the majority of the client products we sell under the Dell brand. We use contract manufacturers and manufacturing outsourcing relationships to achieve our goals of generating cost efficiencies, delivering products faster, better serving our customers, and building a world-class supply chain. Our manufacturing facilities are located in Austin, Texas; Penang, Malaysia; Xiamen, China; Hortolândia, Brazil; Chennai, India; and Lodz, Poland.

Our manufacturing process consists of assembly, software installation, functional testing, and quality control. We are certified to the ISO (International Organization for Standardization) 9001: 2008 Quality management systems standard. This certification includes most of our global sites that design, manufacture, and service our products.





Geographic Operations

Our global corporate headquarters is located in Round Rock, Texas. We have operations and conduct business in many countries located in the Americas, Europe, the Middle East, Asia and other geographic regions.



Dell Management Structure

Dell's executive leadership guides the company's strategy across global, customer-centered organizations.

<p>Executive Leadership</p>  <p>Michael S. Dell Chairman of the Board Chief Executive Officer</p>			
<p>Senior Officers</p>			
 <p>Stephen F. Schuckenbrock President Dell Services</p>	 <p>Brad R. Anderson President Enterprise Solutions</p>	 <p>Jeffrey W. Clarke Vice Chairman & President End User Computing Solutions</p>	 <p>Stephen J. Felice President Chief Commercial Officer</p>
 <p>Lawrence P. Tu Senior Vice President, General Counsel</p>	 <p>Nnamdi J. Orakwue Executive Assistant to the CEO</p>	 <p>David L. Johnson Senior Vice President Corporate Strategy</p>	 <p>Brian T. Gladden Senior Vice President Chief Financial Officer</p>
 <p>Steve H. Price Senior Vice President, Human Resources</p>	 <p>Karen H. Quintos Senior Vice President Chief Marketing Officer</p>		

The executive leadership is responsible for the long-term direction and strategy of the business as well as being involved in the day-to-day operations. In doing so, they keep close to the needs of our customers and also to the rapid changes in the IT industry. The aim is to ensure that Dell offers a range of IT products and services which continue to meet or exceed the expectations of our customers.

Dell sells and supports products and services in over 190 countries, either directly or through a series of dedicated local partners. We have manufacturing facilities worldwide and provide technical support from Customer Support Centers across the globe, ensuring that we offer the best combination of excellent customer services, support and customer value.



State of West Virginia Dell Account Team

Dell understands the responsibility of the direct relationship - that is, to reconfigure our business every day based on what customers like State of West Virginiatell us and to be accountable for everything we do. Dell seeks to develop and use direct customer relationships to understand The University's needs and to deliver high quality computer products and services tailored to meet those needs.

Led by your currently assigned Account Executive, Mitch Mahoney, State of West Virginiawill have an assigned account team comprised of distinct Dell contacts for each key operation. Your account team will be fully informed and accountable for the State of West Virginiarelationship.

Dependent upon the complexity and scope of your projects, your cross-functional Dell Account Team may include:

Title	Responsibility
Account Executive Mitch Mahoney 513-227-6885 Mitch_Mahoney@Dell.com	A single point-of-contact who is responsible for overall account management and the customer's experience with Dell
Sales Representative Guy Youngblood 512-513-8919 Guy_Youngblood@Dell.com	Handles day-to-day product inquires, configuration, and pricing
Inside Sales Manager and Regional Sales Manager Mark Reisman - Inside 512-513-9048 Mark_Reisman@Dell.com Mitch Breneman - Outside 614-264-6774 Mitch_Breneman@Dell.com	Senior relationship managers available for escalated business issues
System Engineer and/or System Consultant David Toshok 724-602-1318 David_Toshok@Dell.com	Provides pre-sales technical configuration and systems consultation
Technical Sales Representative Jim Skelton 512-513-9410 Jim_Skelton@Dell.com	Provides assistance with servers, storage, networking, and other technical topics



Services Account Executive Richard Hansen 440-463-8625 Richard.Hansen@Dell.com	Coordinates professional services including deployment, support and consulting
--	--

Working closely with the State of West Virginia, your Dell account team becomes familiar with all the details and unique requirements of your organization. Dell will provide responsive, professional account management to manage the relationship with the State of West Virginia. The overall goal of Dell's account team will be to plan, execute, measure, and report on the delivery of Dell's products and services.

2.3.2

A minimum of three (3) references is requested. At least one (1) of these references should be from the public sector. All references should be from accounts of a similar scope and complexity as the project outlined in this RFP and include telephone number and email address.

Vendor Response

Judith Molnar
Sr Dir IT Xavier University
molnarj@xavier.edu
513-607-0484

Clay Fletcher - OK Tax Commission
cfletcher@oktax.state.ok.us
(405)521-4510 Office
(405)740-0488 Cell

Ron Wilson
Dir IT - DE Health and Human Services
302-255-9223

2.3.3

Vendor should provide resumes of proposed project team members which provide adequate combined experience in completing similar projects; include copies of any staff certifications or degrees applicable to this project.

Vendor Response

Dell does not publish or share employee resumes due to confidentiality reasons. Additionally, in a pre-award scenario, while requirements for Account Team resources may be scoped, assignment of personnel might be pending the project rollout.

Dell is confident in our ability to hire and retain the most qualified candidates available. While employee resumes are not available due to their confidential nature, Dell is pleased to offer the following job overviews:



To provide the RFP-required support to Department of Administration, State of West Virginia, Dell and our partners maintain a staff of experienced and certified technicians, with expertise and/or certifications in the following areas:

Project management
Novell (CNA, CNE, MCNE)
Microsoft (MCPS, MCSE)
A+
Network +
Cisco (CCNA, CCDA, wireless)
Dell Premier

Following is a description of the technical roles that might be used for this project and their associated qualifications:

Senior Technology Engineer—Brings more than 10 years experience directly supporting networking, servers, storage, and desktop technologies. He/she will have multiple certifications, such as CCNA, MCSE, A+, and VMWare. Typically, the Senior Technology Engineer provides support to other technicians and may oversee and validate the quality of services delivered by other technical resources. He/she is able to plan technology deployments and provide work plans for other staff to follow. This individual can also be responsible for managing a strategic, mission critical, complex, large-scale project.

Information Technology Specialist—With more than 5 years of hands-on support of servers, desktops, and networking devices, the Information Technology Specialist will hold at least one major certification, such as MCSE, and one or more minor A+ certifications. He/she has hands-on experience in troubleshooting and deploying the stated technologies. The IT specialist will be skilled at working with the systems as an integrated solution.

Information Technology Employee—Has more than 2 years of hands-on desktop support experience. This individual serves as a computer technician, accomplishing various tasks including installation, trouble-shooting, and repair of new and existing PCs. The IT Employee may also support the maintenance and administration of both a computer network and connected desktop and laptop computers. He/she will be A+ certified and hold a minor certification, such as MCP.

Configuration/Installation—Typically, the Installer has less than 2 years of hands-on experience and will hold an A+ certification. The Installer may perform desktop and laptop troubleshooting, but primarily provides backup support for a more skilled technician. His/her primary job function is the de-installation, delivery, imaging, installation, and basic desktop setup. The Installer will know how to replace sub-assemblies and may be used to perform part replacement services on warranty repairs.



2.3.4

Vendor response should provide a minimum of two (2) successful projects related to the project outlined in this RFP. The referenced projects should have a successfully completed delivery and implementation. Projects that are in process, but not completed, may be used as options. The Vendor should have had primary responsibility (not acting as a sub-contractor) for the various phases of the projects including: analysis, project/process design, pilot/test phases, and implementation. Vendor should clearly include the description of past projects completed entailing the location of the project, project manager name and contact information, type of project, and what the project goals and objectives were and how they were met.

Vendor Response

David Crass
UW Milwaukee
Director of Information Technology Services
davidc@uwm.edu
414.229.6383
146 Dell Servers
7 MD storage arrays

Oklahoma Tax Commission
Dell Storage in excess of \$1.5m
Multiple PowerEdge Servers
All sold and implemented by Dell Services
Clay Fletcher
cfletcher@oktax.state.ok.us
(405)521-4510 Office
(405)740-0488 Cell

University of North Texas
Philip Baczewski
Director of Academic Computing
(940) 565-3886
baczewski@unt.edu
Project consisted of 128*PE1950's, 8*R910's, 9*Dell Storage Arrays, 5*PC6248 switches

University of North Texas
Dr. David Hrovat
Department of Chemistry
940-565-4041
hrovat@unt.edu

Todd Hamblin Nevada DMV Sr. Dir IT
thamblin@dmv.nv.gov



2.3.5

Vendor should identify any and all subcontractors that will be involved in the delivery and ongoing support of this procurement. The primary vendor will be responsible for any and all work performed by the subcontractors.

Vendor Response -

For the purpose of this response, Dell is not proposing engaging any of our service partners. If in the future or subsequent information is made available that requires additional resources, Dell has recognized that to provide the best and most competitive offerings to customers, we had to focus on our acknowledged areas of expertise (product development, manufacturing and supplier logistics). We project manage many of our service and program manage all of them. However, for many aspects of end-to-end customer solutions, we have sought out and partnered with top industry suppliers for services such as field installation, integration, project management (where relevant) and support.

State of West Virginia can be assured that Dell retains ownership of the end-to-end relationship. To ensure the best customer experience at all times, our core team of consultancy, engineering and project management experts is deployed to support complex requirements and high-end product introductions.

Partnership with 'best-in-class' service providers gives Dell's customers a broader range of high quality services and support than any single, vertically integrated company can provide. Dell offers one of the most comprehensive service and support programs in the industry, backed by a combined worldwide force of more than 50,000 engineers.



2.4 Project Goals and Objectives

2.4.1 The following sets of questions are explanation based, concerning the Unified Storage Array that may be proposed.

a. Does the array have 8Gbps Fibre Channel connections to the SAN switches?

Vendor response: **Yes**

b. Does the array have the capability to support 10Gbps FCoE for storage presentation?

Vendor response: **Yes**

c. Does the array have the capability to support 10Gbps iSCSI for storage presentation?

Vendor response: **Yes**

d. Does the array support automatic, dynamic read/write memory (cache) allocation?

Vendor response: **Yes**

e. Does the array support both 2.5" and 3.5" disk drives?

Vendor response: **Yes**

f. Does the array support RAID 1/0 (striped and mirrored)?

Vendor response: **Yes**

g. Does the array support RAID 5 (single parity)?

Vendor response: **Yes**

h. Does the array support RAID 6 or RAID-DP (double parity)?

Vendor response: **Yes**

i. Can the storage administrator choose which tier of disk in a storage pool is used when creating a new LUN?

Vendor response: **Yes**

j. Can individual LUNs be expanded "on the fly" without down time on the system using the LUN?

Vendor response: **Yes**

k. Can individual LUNs be converted from thick to thin provisioned and vice versa?

Vendor response: **No - All LUNs are thin provisioned**

2.4 Project Goals and Objectives

l. Does the array support space reclamation on existing thin provisioned LUNs?
Vendor response: **Yes**

m. Can individual LUNs be manually migrated between disk types in a storage pool without down time on the system using the LUN?

Vendor response: **Yes**

n. Does the array support the exclusion of particular LUNs from automatic tiering?

Vendor response: **Yes**

o. Are full copies (clones) of LUNs available for use immediately after initiating clone operation?

Vendor response: **Yes**

p. Are full copies (clones) mountable by a different host?

Vendor response: **Yes**

q. Does the replication technology in the array support both local and remote protection?

Vendor response: **Yes**

r. Does the storage array utilize 10Gbps Ethernet for the NAS (CIFS/NFS) functionality?

Vendor response: **Yes**

s. Does the storage array support NDMP for backup of raw file systems?

Vendor response: **No**

t. Does the NDMP support allow for file and folder level restoration without the need to restore the entire NAS file system containing those items?

Vendor response: **N/A**

u. Does the CIFS file server support Windows 2008 R2 native-mode Active Directory domains?

Vendor response: **Yes**

v. Does the CIFS file server support Volume Shadow Copy to allow end-user or support staff recovery of files and folders using the "Previous Versions" features built into the Windows client operating systems when utilizing snapshot technology on the CIFS file shares?

Vendor response: **Yes**

w. Does the CIFS file server support ABE (access-based enumeration)?



Vendor response: **Yes**

- x. Does the array support de-duplication of data presented via file protocols (CIFS/NFS)?

Vendor response: **Yes**

- y. Does the array support compression of data presented via file protocols (CIFS/NFS)?

Vendor response: **Yes**

- z. Does the array provide the ability to administer the system via a command line interface (CLI installed on a remote system or direct SSH/telnet interface)?

Vendor response: **Yes**

- aa. Does the array provide the ability to script administrative actions for bulk operations?

Vendor response: **Yes**

- 2.4.1.1 Does the array support the use of solid state drives (SSD) or enterprise flash drives (EFD) as an extension of read/write cache to enhance performance and alleviate hot spots from sudden, unexpected spikes in workload? If yes, response should provide details on how this works within the array and any limitations of this technology.

Vendor Response: **No**

- 2.4.1.2 How many total active paths does a host have to an individual LUN?

Vendor Response: **The maximum possible number of active paths to any LUN on a Dell Compellent Storage Center is 24. In the solution quoted for this project, there are 2 - 8Gbps Fibre Channel ports in each host, so in this case there will be 2 active paths per host, and thus 2 active paths per LUN.**

- 2.4.1.3 What is the total bandwidth available for a host to an individual LUN?

Vendor Response: **The maximum possible number of active paths to any LUN on a Dell Compellent Storage Center is 24. In the solution quoted for this project, there are 2 - 8Gbps Fibre Channel ports in each host, so in this case there will be 2 active paths per host, and thus 2 active paths per LUN.**

- 2.4.1.4 What is the total number of drives and drive enclosures supported by the array (expandability)?

Vendor Response: **The total number of drives supported by the configured Dell Compellent Storage Center is 960. The maximum number of enclosures supported in this solution is either 80 - 12bay, 3.5" drive, SAS2 enclosures, or 40 - 24-bay, 2.5" drive, SAS2 enclosures.**



- 2.4.1.5 When implementing the data-at-rest encryption does the array provide internal key management system, utilize (or require) an external key management system or rely on drive-based encryption without the need for a key management system?

Vendor Response: The array does not currently have data-at-rest as a feature set. It will support the use of host- and switch-based encryption. It is being evaluated as a possible feature of the storage array.

- 2.4.1.6 How many tiers of storage (drive types) may be placed in a single storage pool?

Vendor Response: The Compellent array supports up to 3 drive types in a single storage pool. By supporting multiple pools within a single storage array, configurations can include all 4 drive types (SSD, 15K, 10K, 7.2K) in a single array. For example, one pool might contain SSD/15K/7.2K, while another pool might contain SSD/10K/7.2K.

- 2.4.1.7 Does the array support automatic data tiering within a configured storage pool to allow migration of data to higher or lower speed disks based on an activity algorithm? If yes, response should explain how the automatic data tiering works in the proposed unified storage array.

Vendor Response: Yes. Data is progressed not only through drive types (15K, 10K, etc.), but also through RAID types. New data being written to the array might be initially stored as RAID-10 protection on 15K drives, then progressed to RAID-5 protection on 15K drives, then later progressed to RAID-6 on 7.2K drives. The Compellent Data Progression algorithms move data in 2MB (default) chunks, and spread the data for each LUN across all of the drives in each tier. The Data Progression algorithms run daily, on a scheduled basis. Less-used data will be progressed downward to slower drives, while more-often-used data is progressed upward to faster drives. An additional data progression feature will ensure that the most commonly used data remains on the outer 20% of each disk drive, ensuring the lowest seek latencies for the data that is being accessed the most.

- 2.4.1.8 Does the array support policies on automatic tiering to allow SAN administrators to designate particular LUNs that should only be migrated to higher (or lower) speed disks? If yes, response should explain how this functionality is implemented in the proposed array.

Vendor Response: Yes. When creating a LUN, the administrator may elect to allow a LUN to use the default settings (the LUN will be spread across all tiers in the pool), or he may choose a specific tier of disk on which the LUN will reside. This is done through a simple drop-down list in the configuration wizard. Once a LUN has been created, the tier settings can easily be changed to either the default setting or to select a different tier, without no impact to server operations.



- 2.4.1.9 Does the array allow scheduled policy changes for the automatic tiering of individual LUNs based on regularly occurring events? (An example would be the ability to schedule a particular LUN to only be migrated to higher speed disks during a time period that is known to be very busy)

Vendor Response: **Yes**

- 2.4.1.10 Does the array allow dynamic expansion of storage pools through the addition or more drives and/or RAID arrays into the storage pool? If yes, response should provide details on how this feature is implemented and any limitations imposed on this process.

Vendor Response: **Yes.** When creating a LUN, the administrator may elect to allow a LUN to use the default settings (the LUN will be spread across all tiers in the pool), or he may choose a specific tier of disk on which the LUN will reside. This is done through a simple drop-down list in the configuration wizard. Once a LUN has been created, the tier settings can easily be changed to either the default setting or to select a different tier, without no impact to server operations.

- 2.4.1.11 Does the array support de-duplication of data contained on LUNs presented via block level protocol (FC/FCoE/iSCSI)? If yes, response should explain this functionality on the proposed array.

Vendor Response: **No**

- 2.4.1.12 How many snapshots of a single LUN can be made? Response should include any details on performance degradation when utilizing multiple snapshots on a LUN.

Vendor Response: **Response should include any details on performance degradation when utilizing multiple snapshots on a LUN.** There are many variables involved in determining this, yet several hundred per volume is common, and thousands is possible. The Dell Compellent Storage Center is designed to be able to support this many snapshots without performance degradation, and in fact many of our customers are doing this in production on a daily basis.



- 2.4.1.13 Please outline the typical storage requirement for snapshots, both individual and multiple incremental snapshots of the same LUN? Also, response should provide a brief explanation of how snapshot technology is implemented on the array.

Vendor Response: Compellent snapshots are extremely efficient. When a snapshot is taken, all blocks that currently make up the LUN are locked from further updates. New and changed data being written to that LUN are written to new blocks in the pool. Unlike many other storage technologies, Compellent does not require a pre-defined and allocated space for snapshots. Multiple snapshots can be taken of a single LUN, any snapshot can be mounted as a new LUN back to the same host or to a different host, without impacting the other snapshots that have been taken. The additional storage required for snapshots is completely dependent on the data change rate of the LUN. If a LUN has a change rate of 10% per day and a snapshot is kept for 5 days, then the space required would be about 50% of the size of the LUN.

- 2.4.1.14 Does the replication technology in the array have the ability to take multiple snapshots of the LUNs to enable recovery or testing with copies of those LUNs at a user configurable interval? If yes, response should provide details on how this technology is implemented in the array.

Vendor Response: Yes. When a LUN is created, the administrator chooses the snapshot frequency as well as the duration (how long the snapshot is kept before automatic deletion). These settings can be easily changed at a later time, and are completely scheduled and controlled by the storage array. There is no need for external job scheduling. The frequency and duration settings are stored in templates that make selection at LUN creation time very simple. Templates can contain multiple schedules, allowing for very sophisticated snapshot implementations. For example, a business-critical LUN might have the following snapshot configuration:

1. snapshots taken every 5 minutes between 8:00am and 5:00pm, kept for 8 hours
2. snapshots taken every hour between 5:00pm and 8:00am, kept for 24 hours
3. snapshots taken every Saturday at 12:00 noon and kept for 1 week
4. snapshots taken the last day of the month and kept for 12 months

This configuration would be defined in a template and applied with a single click each time a business-critical LUN is created.

- 2.4.1.15 What are the typical bandwidth requirements of the replication technology after initial seeding of the data to the remote site has been completed?

Vendor Response: The bandwidth required for replication is completely dependent on the amount of data that is changing between replication intervals.

- 2.4.1.16 Is the data being replicated compressed or de-duplicated to reduce bandwidth requirements?

Vendor Response: The Compellent array can compress the amount of replicated data that is being sent across the network. Compellent also supports the use of network-bandwidth-reduction appliances available from several third-party vendors.

2.4.1.17 Is the data being replicated encrypted between the source and destination arrays?

Vendor Response: **Compellent does not currently encrypt data that is being replicated.**

2.4.1.18 Does the replication technology support RPO goals of 15 minutes or less using asynchronous replication to a remote site? Response should detail any bandwidth or latency requirements to meet this goal.

Vendor Response: **Compellent can support RPO goals of 15 minutes or less, providing that the bandwidth available for replication is adequate. Please see response to 2.4.1.15 for details on bandwidth requirements.**

2.4.1.19 Does the array have the capability to serve as a CAS/WORM device to replace optical storage systems? If so, what level of compliance does the CAS functionality provide?

Vendor Response: **N/A as the array does not have this capability**

2.4.2 The following sets of questions are explanation based, concerning the Server Hardware that may be proposed.

a. Do the proposed servers support 16GB DIMMs?

Vendor response: **Yes**

b. Do the servers support 32GB DIMMs?

Vendor response: **Yes**

c. Do the proposed servers contain more than the required minimum of 192GB RAM per server?

Vendor response: **No, 192GB of Memory has been configured in each of the R620 Servers.**

2.4.2.1 What is the total available processing power of the servers in the proposed solution? Please provide a breakdown on core count, core speed and total processing power (GHz) for the proposed servers.

Vendor Response: **Each of the (7) Dell R620 servers come standard with 2 sockets. Each socket has an 8-core E5-2650 2.0GHz processor, for a total of 16 processors per server. Per the example referenced in the addendum, here is a breakdown on how it relates to Hyperthreading. The Intel hardware projects both physical and logical cores to the Operating System or HyperVisor. HyperThreading within Intel SandyBridge allows a single core to simultaneously process up to 2 threads. Hence, an 8 Core System will be seen as 16 Logical cores. Workloads that offer parallel execution of threads can benefit from Hyper Threading. The OS or HyperVisor queues and schedules threads for execution against the logical cores. This provides greater performance and a more efficient method of execution for workloads that have a degree of threading. For workloads that are more serial in nature and don't exhibit the same level of threading, the benefits may be negligible. The actual amount of compute capacity before or after HyperThreading is the same. Citing the example shown in the addendum, based on the 2 threads per core, then a total of 32GHz per server with HyperThreading enabled.**



2.4.2.2 How many DIMMs can the servers in the proposed solution hold (without add-ons)?

Vendor Response: 24 DIMMS

2.4.2.3 Are add-ons (drawers, trays, add-on blades, etc.) available to increase the number of DIMMs that can be installed in a server? If so, what is the maximum number of DIMMs that can be installed in the servers with any available add-ons?

Vendor Response: Add-on's (drawers, trays, etc) are not available on the R620's. A total of 24 DIMMS slots are available

2.4.2.4 What is the maximum RAM supported by the servers without add-ons (drawers, trays, etc.)? With add-ons?

Vendor Response: You can have up to 768GB of memory (24 DIMMS) on each of the R620 servers. No add-on devices are available for the R620's

2.4.2.5 What size and speed DIMMs are being used in the proposed server configuration? Response should provide a detailed description of the RAM layout utilized on the Servers.

Vendor Response: The 192GB of memory is composed of 12 x 16GB 1600MHz memory DIMMS. There are (4) channels and (3) Slots for memory per socket. There will be a 16GB DIMM in slot 1 Channel (0,1,2,3) as well as a 16GB DIMM in slot 2 Channel (0,2). A total of 6 x16GB DIMMS per socket or 12 total across both sockets.

2.4.2.6 If proposing Rack Mount Servers:

2.4.2.6.1 How many available PCI-Express slots do the servers in the configuration have?

Vendor Response: There are (3) PCIe Gen 3 slots in the R620 servers. Each of the (3) slots are x16 slots. 2 are x16 with x16 bandwidth and 1 is x16 with x8 bandwidth.

2.4.2.6.2 What is the speed of the PCI-Express slots in the servers? Response should provide a detailed listing of the available PCI-e expansion slots and their speeds and note which are already populated.

Vendor Response: The PCIe slots are PCIe Gen 3. 2 of the PCIe slots are x16 with x16 bandwidth and 1 is x16 with x8 bandwidth. There will be a dual-port 8Gb Qlogic 2652 FC HBA occupying the x16 slot (x8 bandwidth) . The 2nd and 3rd slot's (x16 with x16 bandwidth) are open. The Dual-Port 10Gb NIC is part of the LOM (Lan on Motherboard).



2.4.2.7 If proposing Blade Servers: N/A - proposing Rack Mount Servers.

2.4.2.7.1 How many total slots are in the proposed chassis?

Vendor Response:

2.4.2.7.2 Are the blade chassis in this proposal equipped with all required power supplies, fans and I/O modules/switches to support fully populating the blade chassis without additional cost beyond the purchase of the blade servers?

Vendor Response:

2.4.2.7.3 How many slots are used by the servers included in this proposal?

Vendor Response:

2.4.3 The following sets of questions are explanation based, concerning the Network Switches that may be proposed.

- a. Due to the core competency of the WVSTO staff as well as other WV state agencies we would prefer to continue utilizing Cisco networking equipment within our data center for Ethernet connectivity. Does the proposed solution include Cisco network equipment?

Vendor response: No, however Dell feels that our Powerconnect and Force10 products are an excellent fit for this proposal. In addition to meeting all the technical requirements, the Dell CLI is substantially similar to Cisco IOS, which reduces management and training costs. The hardware is supported and tested with Dell's storage and server products, allowing Dell to provide a fully integrated solution. Please see the attached documentation on the Force10 CLI for reference.

- b. Does the proposed solution include licenses for VMware distributed virtual switch modules to allow both the physical and virtual network infrastructure to be managed through a common interface (whether command line, browser-based GUI, etc.)?

Vendor response: No, however the Dell Force10 switches include a feature called "Open Automation" which allows a level of integration between the switching environment and VCenter, allowing some network management from inside Vcenter. Please see the attached documentation for more information.



2.4 Project Goals and Objectives

2.4.3.1 Does the network equipment for server connectivity in the proposed solution have expansion capabilities (port modules, etc.), and, are those expansion slots available for future use or populated as part of the proposed solution? If yes, response should detail the expansion capabilities of the proposed network switches.

Vendor Response: Yes.

- The Dell Force10 S55 switches has 2 I/O module bays. One module bay is populated with a 2 port SFP+ module to provide uplink connectivity for the switch. The other I/O bay is empty, allowing future expansion with a 2xSFP+ or stacking module.
- The Dell Force10 S4810 switch has 48 SFP+ ports and 4 QSFP ports. It is a fixed configuration switch, however the 4 QSFP modules are not used in the current design and can be populated in the future with 40Gb/s optics for stacking or uplink use.
- (Alternate) The Dell Powerconnect 8024 switch is a fixed configuration switch and has 24 SFP+ interfaces.
- (Alternate) The Dell Powerconnect 7048R switch has 2 I/O module bays. One module bay is populated with a 2 port SFP+ module to provide uplink connectivity for the switch. The other I/O bay is empty, allowing future expansion with a 2xSFP+ or stacking module.

2.4.3.2 Does the propose network equipment include, or have the capability to support, other network protocols, specifically FCoE (fibre channel over Ethernet) and iSCSI? If yes, response should outline any additional modules or license costs to enable the support of these protocols on the proposed network switches.

Vendor Response: The proposal does not include any special hardware or software to support FCoE or iSCSI, however the Dell Force10 and PowerConnect switches are fully certified for iSCSI use with Dell Compellent and Equallogic. The switches do not have any software support for FCoE at this time.

2.4.4 The following sets of questions are explanation based concerning the General Solution being proposed.

- a. Does the proposed solution include a centralized, unified monitoring system that gives overall status information about the hardware included in the solution (switches, storage and servers)?

Vendor Response: Open Manage Essentials (OME) can monitor the servers and you can import the MIBs to monitor Powerconnect, Force10 and Compellent.



- b. Does the proposed solution include a single point of contact for all support issues (hardware and software) when utilized to run a vSphere environment?

Vendor Response: Dell will be the single point of contact for all support related issues. A toll free number will be provided when the support agreement has been established.

- c. Does the propose solution include direct OEM support from the vendors of each component utilized in the solution to allow escalation of support issues to the OEM technicians by either the WVSTO or our single point of support for the propose solution?

Vendor Response: Yes, support for all of Dell proposed solution will come directly from Dell. Support for any existing S/W (ie: VMWARE) should come from your existing support channel.

- d. Does the proposed solution include regular (quarterly or bi-annually), pre-tested and validated firmware updates direct from a single source to allow the WVSTO to keep all hardware in the solution up-to-date without having to go through internal research, testing and validation of firmware as it is released by the OEMs?

Vendor Response: Fully tested firmware updates for the Dell servers is published/released on a regular basis. Historically they have been released on a quarterly basis. Regular access to firmware updates is included with the maintenance contracts on the specified Dell switches. While there is not a published release schedule, Dell regularly releases fully tested bugfix and feature updates via the Dell support web site. Dell also does of software images with Compellant and Equallogic storage and provides "qualified" lists containing recommended software images.

- e. The proposed solution should take into consideration existing WVSTO licensing and should only include software licensing that is necessary to support the proposed solution that is not already owned by the WVSTO (see appendix for list of current VMware licensing). Have you taken existing WVSTO licensing into account and only included additional licenses, not already owned by the WVSTO in your proposed solution?

Vendor Response: Dell has only included the software needed to manage the Dell Servers, storage and Switches (Dell proposed hardware). Existing WVSTO software was taken into account when proposing the solution

- 2.4.4.1 Does the proposed solution ship as a single unit (all hardware racked, all internal power, network, SAN and other cables connected) ready to connect to power and core networking equipment and begin deployment and configuration of storage, networking and the vSphere environment?

Vendor Response: The Dell equipment will arrive at WVSTO as separate components. Dell services will come to WVSTO to install and configure the hardware and cables in the Dell provided racks at the primary and D/R locations.



2.4.4.2 The WVSTO would like to keep the network traffic for the hosts, the network traffic for hardware management and the storage network traffic separated. This serves a few purposes, the first being segregation of traffic with dedicated resources for each type of traffic, to try and insure peak performance of the solution; the second being the ability to keep the management traffic on high performance (gigabit), but lower-cost switches that don't need the capabilities of the switches used to connect the VMware hosts to the network.

2.4.4.2.1 Does the propose solution include separate switch infrastructure for the hosts, the hardware management interfaces and storage (fibre channel) networks? If yes, response should provide some details on the internal network layout of the proposed solution and how it meets this goal.

Vendor Response: The proposed infrastructure includes a redundant 1Gb/s network at each site based on Dell Force10 S55 switches for management and housekeeping network traffic. A pair of Dell Force10 S4810 switches is proposed to provide a redundant, nonblocking 10Gb/s infrastructure for user traffic. A pair of Fiberchannel switches provides a redundant Fiberchannel network for SAN connectivity. Each server has sufficient network interfaces to allow 1 connection to each switch. An alternate configuration utilizing Dell Powerconnect switches is also presented, providing the same functionality, but with fewer available ports for future expansion.

2.4.4.3 Does the proposed solution include a centralized, unified management system that allows baseline configuration tasks to be performed? If it does, can the following tasks be performed through this management system? If so, response should outline the following capabilities to perform that function:

NDMP

Vendor Response: No

2.4.4.3.1 Define VLANs available (trunked) into the network switches from the core network

Vendor Response: N/A

2.4.4.3.2 Define storage available to the various vSphere clusters

Vendor Response: vSphere plug in will allow you to assign storage to the clusters

2.4.4.3.3 Deployment of operating system (vSphere, Windows, etc.) to the physical servers included in the solution from user-provided ISO images?

Vendor Response: The Dell Management plugin for VMware vCenter provides the ability to update firmware on Dell PowerEdge servers in an automated fashion. It also provides warranty reporting for the servers within the vCenter.

2.4 Project Goals and Objectives

2.4.4.3.4 Creation of vCenter instances to manage vSphere hosts?

Vendor Response: Dell has not included any additional VMWARE tools in the proposal. Based on conversations with VMWARE, the native VMWARE management tools (ie: Vcenter) should provide all the tools to manage the VM's in your environment.

2.4.4.3.5 Does the management system provide any additional capabilities not outlined above? If it does, response should detail any notable capabilities.

Vendor Response: The Dell Management plugin for VMware vCenter provides the ability to update firmware on Dell PowerEdge servers in an automated fashion. It also provides warranty reporting for the servers within the vCenter. Dell also provides extensive integration with other industry leading management tools such as Microsoft System Center and BMC.



Attachment B - Mandatory Requirements

2.5.1 Unified Storage Platform

2.5.1.1 The unified storage systems must allow presentation of storage through block and file level protocols and meet the following requirements for usable capacity.
Affirm: Yes

2.5.1.1.1 The storage array for the production center must provide a minimum usable capacity of at least 17TB for virtualized servers in a dedicated physical or virtual storage pool.
Affirm: Yes

2.5.1.1.2 The storage array for the production data center must provide a minimum useable capacity of 5 TB for NAS file shares in a dedicated physical or virtual storage pool.
Affirm: Yes

2.5.1.1.3 The storage array for the production data center must provide a minimum useable capacity of 3 TB for virtual desktops in a dedicated physical or virtual storage pool.
Affirm: Yes

2.5.1.1.4 The storage array for the disaster recovery data center must provide a minimum useable capacity of 17 TB for replicated virtual servers.
Affirm: Yes

2.5.1.1.5 The storage array for the disaster recovery data center must provide a minimum useable capacity of 5 TB for replicated NAS file shares.
Affirm: Yes

2.5.1.1.6 The storage array for the disaster recovery data center must provide a minimum useable capacity of 3 TB for replicated virtual desktops.
Affirm: Yes

2.5.1.1.7 The storage array for the disaster recovery data center must provide a minimum additional useable capacity of 10 TB.
Affirm: Yes

2.5.1.2 The proposed storage array must be a unified storage array that allows presentation of storage via block (Fibre Channel) and file (CIFS, NFS) protocols.
Affirm: Yes

2.5.1.3 The proposed storage array must have a minimum of 4Gbps fibre channel connectivity to the SAN switch infrastructure.
Affirm: Yes

2.5.1.4 The proposed storage array must have two storage controllers for the block level protocol in an active/active configuration with at least two fibre channel connections to the SAN switch infrastructure providing a total of 4 paths to the storage array.
Affirm: Yes



2.5.1.5 The proposed storage array must have two filers for the file level protocols in an active/passive or active/active configuration with at least two (2) 1Gbps or two (2) 10Gbps Ethernet connections per filer to the network infrastructure.

Affirm: Yes

2.5.1.6 The proposed storage array for the production data center must provide a minimum of 20,000 IOPs dedicated to the virtualized server environment.

Affirm: Yes

2.5.1.7 The proposed storage array for the production data center must provide a minimum of 8,000 IOPs dedicated to the virtual desktop environment.

Affirm: Yes

2.5.1.8 The proposed storage array for the production data center must provide dedicated capacity to support NAS file shares for up 120 users and 3 TB of data.

Affirm: Yes

2.5.1.9 The proposed storage array for the disaster recovery site must provide a minimum of 60% of the total IOPs of the production storage array.

Affirm: Yes

2.5.1.10 The proposed storage array must support Solid State Drives (SSD) or Enterprise Flash Drives (EFD) (Tier 0).

Affirm: Yes

2.5.1.11 The proposed storage array must support high speed (10K and 15K RPM) Fibre Channel (FC) or Serial Attached SCSI (SAS) drivers (Tier 1 and Tier 2).

Affirm: Yes

2.5.1.12 The proposed storage array must support 7.2K RPM near-line SAS or ATA drives (Tier 3).

Affirm: Yes

2.5.1.13 The proposed storage array must support virtual (thin) provisioning for volumes presented via block level (FC) protocol.

Affirm: Yes

2.5.1.14 The unified storage systems must support the ability to do snapshots and clones of volumes presented via block level protocols. It must also support the ability to do snapshots of the file systems presented via file level protocols.

Affirm: Yes

2.5.1.15 The proposed storage array must include the ability to make clones of volumes presented via block-level (FC) protocol.

Affirm: Yes

2.5.1.16 The proposed storage array must include the ability to take snapshots of volumes presented via block-level (FC) protocol.

Affirm: Yes

2.5.1.17 The proposed storage array must include the ability to take snapshots of file systems presented via file-level protocols (CIFS, NFS).

Affirm: Yes



2.5.1.18 The proposed storage array must include IP-based, asynchronous replication for the storage presented via block level (FC) protocol.

Affirm: Yes

2.5.1.19 The proposed storage array must include IP-based, asynchronous replication for the file systems presented via file level (CIFS, NFS) protocols.

Affirm: Yes

2.5.1.20 The proposed storage array must have the capability to support data-at-rest encryption.

Affirm: Yes via third-party encryption tools.

2.5.1.21 The proposed storage array must have a single, unified management tool that allows the configuration and monitoring of all features and functionality of the array.

Affirm: Currently has a single interface for all block-level SAN access, and a separate interface for creation and management of NAS file-systems. Storage LUNs used by the NAS system are created and managed within the block-level storage array.

2.5.1.22 The proposed storage array must support all of the primitives defined in the VMware vSphere API for Array Integration (VAAI) specifications for vSphere 5.0 for storage presented via block level (FC) protocol.

Affirm: Yes

2.5.1.23 The proposed storage array must include full, active-active, load balanced multi-path support for connected VMware vSphere 5.0 hosts (not the default most recently used or round robin provided by VMware).

Affirm: No - multipath support uses operating system MPIO.

2.5.1.24 The proposed storage array must include plug-ins for VMware vCenter to enable the creation and management of LUNs (from assigned storage pools) for the vSphere environment to ensure proper alignment and optimization of the LUNs.

Affirm: Yes

2.5.1.25 The proposed array must include replication technology that integrates with VMware Site Recovery Manager (SRM) 5.0 to allow SRM to leverage the native replication technologies of the array to copy data to the disaster recovery site.

Affirm: Yes

2.5.1.26 The proposed array must have the capability to enable call-home functionality for sending hardware alerts to the OEM when failures are detected on the array to enable rapid, pro-active response from technical support to replace or repair defective hardware.

Affirm: Yes

2.5.1.27 The unified storage systems must have an expected product life of at least 5 years.

Affirm: Yes

2.5.1.28 The unified storage systems must include 5 years of support with a guaranteed response time of 4 hours and 24x7x365 availability coverage.

Affirm: Yes



2.5.2 Fibre Channel Switches

2.5.2.1 The proposed solution shall include two independent fibre channel switches at each site.

Affirm: Yes

2.5.2.2 The fibre channel switches must have autosensing 8 Gbps ports (support 8/4/2 Gbps).

Affirm: Yes

2.5.2.3 The proposed fibre channel switches must have management capabilities via a command line interface (telnet/SSH).

Affirm: Yes

2.5.2.4 The proposed fibre channel switches must have a browser-based management interface.

Affirm: Yes

2.5.2.5 The proposed fibre channel switches must include some internal diagnostics.

Affirm: Yes

2.5.2.6 The proposed fibre channel switches must include native alerting and reporting (without the need for a monitoring server).

Affirm: Yes

2.5.2.7 The proposed fibre channel switches must include a native way to display performance metrics.

Affirm: Yes

2.5.2.8 The proposed fibre channel switch configuration must support non-disruptive firmware upgrades.

Affirm: Yes

2.5.2.9 The proposed fibre channel switches must have the capability to be either an NPV edge device or an NPIV core device.

Affirm: Yes

2.5.2.10 The proposed fibre channel switches must have the capability to support multiple fabric environments in a single physical switch.

Affirm: Yes

2.5.2.11 The proposed fibre channel switches must support aggregated ISL (inter-switch link) connectivity; i.e., several physical ISLs behaving as one virtual ISL.

Affirm: Yes

2.5.2.12 The proposed fibre channel switches must support traffic engineering using FSPF.

Affirm: Yes

2.5.2.13 The fibre channel switches must have at least 12 ports active each.

Affirm: Yes

2.5.2.14 The fibre channel switches must have at least 24 ports total each.

Affirm: Yes



2.5.2.15 The fibre channel switches must have redundant power supplies and fans.

Affirm: Yes

2.5.2.16 The fibre channel switches must have an expected product life of at least 5 years.

Affirm: Yes

2.5.2.17 The fibre channel switches must include 5 years of support with a guaranteed response time of 4 hours and 24x7x365 coverage.

Affirm: Yes

2.5.3 Network Switches

2.5.3.1 The network switch(es) must support both 10Gbps and 1Gbps connectivity.

Vendor response: The Maintenance network (S55) supports 1Gb/s with 10Gb/s uplinks to the datacenter network. The Primary network (S4810) supports 10Gb/s via SFP+ and 1Gb/s via SFP modules. 1GBaseT SFP modules are supported in the S4810

2.5.3.2 The network switch(es) must have a minimum of 16 ports available for connection of additional network devices not included in the proposed solution.

Vendor response: The switches in our primary proposal have at least 16 ports available per switch. Our alternate switch proposal has a minimum of 16 ports available distributed between the 2 redundant switches.

2.5.3.3 The network switch(es) must have redundant power supplies and fans.

Vendor response: All switches include redundant power and fans.

2.5.3.4 The network switch(es) used for server connectivity must include layer 3 support (if a dedicated management network is present it does not need to support layer 3).

Vendor response: All ethernet switches proposed include Layer3 support.

2.5.3.5 The network switch(es) must support Link Aggregation Control Protocol (LACP): IEEE 802.3ad.

Vendor response: All proposed switches ~~The Dell Force10 OS~~ support LACP and staticly configured Link aggregation.

2.5.3.6 The network switch(es) must support VLAN trunking.

Vendor response: All proposed switches ~~The Dell Force10 OS~~ supports VLAN trunking via 802.1q encapsulation.



2.5.3.7 The network switch(es) must support IEEE 802.1q VLAN encapsulation.

Vendor response: ~~The Dell Force10 S55 and S4810~~ All proposed switches supports 802.1q encapsulation.

2.5.3.8 The network switch(es) must support Jumbo Frames on all ports (up to 9216 bytes).

Vendor response: ~~The Dell Force10 S55 and S4810~~ All switches proposed support jumbo frames on all ports.

2.5.3.9 The network switch(es) must support CLI management (console, telnet and/or SSH).

Vendor response: ~~The Dell Force10 S55 and S4810 support~~ All switches proposed support CLI access via SSH or telnet.

2.5.3.10 The network switch(es) must support SNMP.

Vendor response: All switches proposed support ~~The Dell Force10 S55 and S4810 support~~ SNMP v1, v2c and v3.

2.5.3.11 The network switch(es) must have an expected product life of at least 5 years.

Vendor response: ~~The Dell Force10 S55 and S4810~~ All Ethernet- switches are proposed with a 5 year service and support contract and will be fully supported during that length of time.

2.5.3.12 The network switch(es) must include 5 years of support with a guaranteed response time of 4 hours and 24x7x365 coverage.

Vendor response: ~~The Dell Force10 S55 and S4810~~ All switches are proposed with a 5 year service and support contract, including 4 hour response to the locations specified.

2.5.4 Server Hardware

2.5.4.1 There must be at least 7 identically configured servers per site (production and DR), 14 servers in total.

Affirm: Yes

2.5.4.2 The proposed servers must be dual CPU socket servers.

Affirm: Yes

2.5.4.3 The proposed servers must use 6-core Intel 5600 series or 10-core Intel E7 series processors or superior.

Affirm: Yes - using 8 core E5-2600 series

2.5.4.4 Each server must have at least 192GB of RAM installed with all RAM running at full clock speed (no clock speed step down across memory channels).

Affirm: Yes

2.5.4.5 Each server must include a minimum of two (2) 10Gbps network connections.

Affirm: Yes



2.5.4.6 Each server must include a minimum of two (2) 8Gbps fibre channel (SAN) connections.

Affirm: Yes

2.5.4.7 The servers must include remote management capabilities (DRAC, iLO or equivalent).

Affirm: Yes

2.5.4.8 The servers must have fully redundant internal components (power supplies, fans, etc.).

Affirm: Yes

2.5.4.9 The servers must have an expected product life of at least 5 years.

Affirm: Yes

2.5.4.10 The servers must include 5 years of support with a guaranteed response time of 4 hours and 24x7x365 coverage.

Affirm: Yes

2.5.5 Rack Mount Servers (If this solution is proposed)

2.5.5.1 All of the PCI-Express slots in the servers must run at a minimum of 4x speed.

Affirm: Yes

2.5.5.2 The servers must have at least two available PCI-Express slots for expansion capabilities.

Affirm: Yes

2.5.6 Blade Servers (If this solution is proposed) N/A

2.5.6.1 In the proposed blade solution the individual blade servers at each site must be split as evenly as possible across two blade chassis (elimination of single point of failure and provide extra expansion capabilities through number of available slots for blades).

Affirm: _____

2.5.6.2 Each blade chassis must include fully redundant I/O and management modules.

Affirm: _____

I certify that the proposal submitted meets or exceeds all the mandatory specifications of this Request for Proposal. Additionally, I agree to provide any additional documentation deemed necessary by the State of West Virginia to demonstrate compliance with said mandatory specifications.

Dell Marketing, LP

(Company)

Mary Collins, Proposal Manager



(Representative Name, Title)

512-723-3772/512-283-9092

(Contact Phone/Fax Number)

04/06/2012

(Date)

2.6 Oral Presentations

If requested, Dell would comply and welcome the opportunity to present additional information about the solution and technologies being proposed.



Attachment C - Cost Sheet

Please find the requested Cost Sheet in the included sealed envelope.



Purchasing Affidavit

RFQ No. STO12007STATE OF WEST VIRGINIA
Purchasing Division**PURCHASING AFFIDAVIT**

West Virginia Code §5A-3-10a states: No contract or renewal of any contract may be awarded by the state or any of its political subdivisions to any vendor or prospective vendor when the vendor or prospective vendor or a related party to the vendor or prospective vendor is a debtor and the debt owed is an amount greater than one thousand dollars in the aggregate.

DEFINITIONS:

"Debt" means any assessment, premium, penalty, fine, tax or other amount of money owed to the state or any of its political subdivisions because of a judgment, fine, permit violation, license assessment, defaulted workers' compensation premium, penalty or other assessment presently delinquent or due and required to be paid to the state or any of its political subdivisions, including any interest or additional penalties accrued thereon.

"Debtor" means any individual, corporation, partnership, association, limited liability company or any other form or business association owing a debt to the state or any of its political subdivisions. "Political subdivision" means any county commission; municipality; county board of education; any instrumentality established by a county or municipality; any separate corporation or instrumentality established by one or more counties or municipalities, as permitted by law; or any public body charged by law with the performance of a government function or whose jurisdiction is coextensive with one or more counties or municipalities. "Related party" means a party, whether an individual, corporation, partnership, association, limited liability company or any other form or business association or other entity whatsoever, related to any vendor by blood, marriage, ownership or contract through which the party has a relationship of ownership or other interest with the vendor so that the party will actually or by effect receive or control a portion of the benefit, profit or other consideration from performance of a vendor contract with the party receiving an amount that meets or exceeds five percent of the total contract amount.

EXCEPTION: The prohibition of this section does not apply where a vendor has contested any tax administered pursuant to chapter eleven of this code, workers' compensation premium, permit fee or environmental fee or assessment and the matter has not become final or where the vendor has entered into a payment plan or agreement and the vendor is not in default of any of the provisions of such plan or agreement.

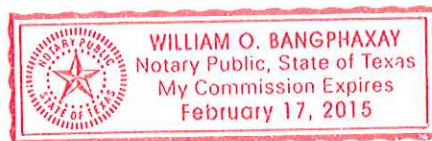
Under penalty of law for false swearing (West Virginia Code §61-5-3), it is hereby certified that the vendor affirms and acknowledges the information in this affidavit and is in compliance with the requirements as stated.

WITNESS THE FOLLOWING SIGNATUREDell Marketing, LP

Vendor's Name: _____

Authorized Signature: M. Collins Date: 4-6-12State of TexasCounty of Williamson, to-wit:Taken, subscribed, and sworn to before me this 6 day of April, 2012.My Commission expires 2-17, 2012.

AFFIX SEAL HERE

NOTARY PUBLIC William Bangphaxay

Contract Terms and Conditions

Dell's receipt of an Award or Purchase Order for RFP 12007STO for Computer Network Infrastructure from State of West Virginia and subsequent performance in relation to this response shall be governed by and understood to indicate State of West Virginia's acceptance of the WSCA (WN34ACA) contract. Any terms in RFP 12007STO for Computer Network Infrastructure or on a resulting Purchase Order from State of West Virginia to Dell shall not be applicable.



Attachments - Supporting Documentation





Force10

Dell Force10 FTOS Command Line Interface (CLI)

Industry-standard CLI Syntax with Enhanced Manageability Features; Consistent Show, Configuration, Debugging and CLI Navigation Commands across Switch/Router Product Lines.

The power of one: consistency

FTOS, the Dell Force10 Operating System, is a powerful and robust operating system that runs on all Dell Force10 switch/router product lines. Dell Force10's switch/router platforms derive from a single code base which follows a linear, sequential release path, which enables them to deliver uniform solution sets. Dell Force10 ensures that customers benefit from stable code, consistent configuration environment, and simpler software management.

Streamlined management

- Common management functionality and common user interface across Dell Force10 product lines make operating the network easier
- Simpler product training and learning curve because system configuration, diagnostics, troubleshooting and software maintenance are identical across platforms
- Support for the same CLI, SNMP, and XML management models throughout the entire network greatly simplifies life-cycle management of the infrastructure

Optimizing your operations

The Dell FTOS CLI combines the predominant, de-facto industry standard show, configuration and debugging syntax with enhanced usability and navigation features. As a result, the administration, configuration, and trouble-shooting operations are highly intuitive, enabling you to achieve leaner operations.

Rich feature set

The Dell FTOS CLI is a primary method of administering, configuring, and monitoring FTOS applications and Dell Force10 switches/routers. The FTOS CLI is a significant asset in protecting training investments. It is fully compliant with the predominant, de-facto industry standard CLI. Certified engineers will be immediately familiar with the Dell Force10 CLI and productive from day one.

The CLI has many powerful features which make it very convenient for usage on a daily basis, which include:

- On-line help and auto-completion
- Interactive or automated modes
- Integration of Unix-like features such as grep and diff for configuration management
- Accessible over industry standard access protocols, such as Telnet, SSHv2, and serial console
- Configurations can be archived by the archive manager, and used for automated configuration rollback to restore a known working configuration

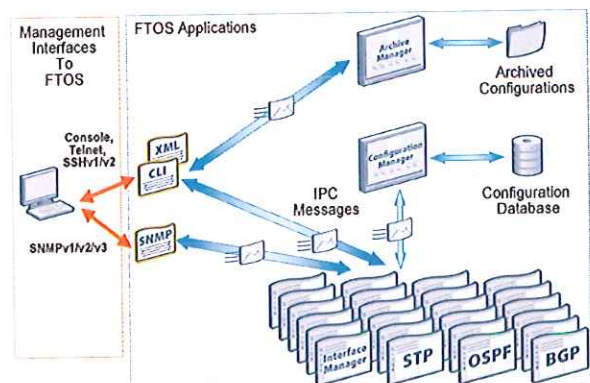


Figure 1. FTOS software architecture

```
s4810#show version
Force10 Networks Real Time Operating System Software
Force10 Operating System Version: 1.0
Force10 Application Software Version: 8.3.7.0
Copyright (c) 1999-2010 by Force10 Networks, Inc.
Build Time: Thu Dec 16 12:27:33 2010
Build Path: /sites/sjc/work/build/buildspaces/build19/ES-3-7/SW/SRC
s4810 uptime is 1 week(s), 1 day(s), 21 hour(s), 1 minute(s)

System image file is "system://A"

System Type: S4810
Control Processor: Freescale QorIQ P2020 with 2147483648 bytes of memory.
128M bytes of boot flash memory.

  1 52-port GE/TE/FG (SE)
  48 Ten GigabitEthernet/IEEE 802.3 interface(s)
  4 Forty GigabitEthernet/IEEE 802.3 interface(s)

.....

z9000#show version
Force10 Networks Real Time Operating System Software
Force10 Operating System Version: 1.0
Force10 Application Software Version: 29000-3-3-11-233
Copyright (c) 1999-2011 by Force10 Networks, Inc.
Build Time: Tue Apr 26 11:30:05 PDT 2011
Build Path: /sites/sjc/work/build/buildspaces/build02/29000-3-3-11/SW/SRC
z9000 uptime is 19 hour(s), 56 minute(s)

System image file is ""

System Type: 29000
Control Processor: Intel Jasper Forest with 3474927616 bytes of memory.
32M bytes of boot flash memory.

  1 32-port TE/FG (S2)
  4 Ten GigabitEthernet/IEEE 802.3 interface(s)
  31 Forty GigabitEthernet/IEEE 802.3 interface(s)

.....

s60#show version
Force10 Networks Real Time Operating System Software
Force10 Operating System Version: 1.0
Force10 Application Software Version: 8.3.3.4
Copyright (c) 1999-2010 by Force10 Networks, Inc.
Build Time: Sat Nov 20 02:31:14 2010
Build Path: /sites/sjc/work/build/buildspaces/build01/ES-3-3/SW/SRC
s60 uptime is 1 week(s), 2 day(s), 0 hour(s), 2 minute(s)

System image file is "system://B"

System Type: s60
Control Processor: Freescale MPC8536E with 2147483648 bytes of memory.
128M bytes of boot flash memory.

  1 48-port E/FE/GE (SC)
  48 GigabitEthernet/IEEE 802.3 interface(s)
```

Figure 2. FTOS running on the E-Series, S-Series and Z-Series switch/router platforms

FTOS Command Line Interface

Simplified operations through the FTOS CLI

- Identical CLI on all platforms
- Ranges and aliases for bulk configuration
- Line card pre-configuration
- Configuration locking
- Configuration commit and rollback
- Online serviceability and diagnostics
- "monitor interface" command
- "show run <context>" command

- Configuration file "diff" command
- Command history shows timestamp, users and CLI commands
- Full-featured "grep" and "no-more" pipe for all commands with unlimited pipes
- ACLs and routing policies with sequence numbers, remarks and "resequence" command
- "do" command in configuration mode
- "send" command to write all users (Unix write/wall functionality)
- "show configuration" context while in configuration mode

Specifications: FTOS

IEEE Compliance

802.1AB	LLDP
802.1ad	Q-in-Q
802.1ag	Connectivity Fault Management
802.1D	Bridging, STP
802.1p	L2 Prioritization
802.1Q	VLAN Tagging, Double VLAN Tagging, GVRP
802.1s	MSTP
802.1w	RSTP
802.1X	Network Access Control
802.3ab	Gigabit Ethernet (10GBASE-T)
802.3ac	Frame Extensions for VLAN Tagging
802.3ad	Link Aggregation with LACP
802.3ae	10 Gigabit Ethernet (10GBASE-X)
802.3af	Power over Ethernet
802.3ak	10 Gigabit Ethernet (10GBASE-CX4)
802.3ba	40 Gigabit Ethernet (40GBASE-X) on optical ports
802.3ba	100 Gigabit Ethernet on optical ports 100 GBASE-LR4/SR4
802.3i	Ethernet (10BASE-T)
802.3u	Fast Ethernet (100BASE-TX)
802.3x	Flow Control
802.3z	Gigabit Ethernet (1000BASE-X)
ANSI/TIA-1057	LLDP-MED
Force10	RRRP (Force10 Redundant Ring Protocol)
Force10	PVST+

RFC and I-D Compliance

General Internet Protocols

768	UDP	1990	PPP Multilink Protocol
793	TCP	1994	PPP CHAP
854	Telnet	2474	Differentiated Services
959	FTP	2615	PPP over SONET/SDH
1321	MD5	2698	Two Rate Three Color Marker
1350	TFTP		
1661	PPP	3164	Syslog
1989	PPP Link Quality Monitoring	4254	SSHv2
		draft-ietf-bfd-base-03	BFD

General IPv4 Protocols

791	IPv4	1812	Routers
792	ICMP	1858	IP Fragment Filtering
826	ARP	2131	DHCP (server and relay)
1027	Proxy ARP	2338	VRRP
1035	DNS (client)	3021	31-bit Prefixes
1042	Ethernet Transmission	3046	DHCP Option 82
1191	Path MTU Discovery	3069	Private VLAN
1305	NTPv3	3128	Tiny Fragment Attack Protection
1519	CIDR		
1542	BOOTP (relay)		

General IPv6 Protocols

1981	Path MTU Discovery (partial)	2675	Jumbograms
2460	IPv6	3587	Global Unicast Address Format
2461	Neighbor Discovery (partial)		
2462	Stateless Address Autoconfiguration (partial)	4291	Addressing
		4443	ICMPv6
2463	ICMPv6	5798	VRRPv3 for IPv6
2464	Ethernet Transmission		

IPv6 Routing Protocols

2080	RIPng	5340	OSPFv3
2545	BGP-4 extensions for IPv6	4601	PIM-SM for IPv4/IPv6
5308	IS-IS for IPv6		

RIP

1058	RIPv1	2453	RIPv2
------	-------	------	-------

OSPF

1587	NSSA	3101	OSPF NSSA
1745	OSPF/BGP interaction	3623	Graceful Restart
1765	OSPF Database overflow	4222	Prioritization and Congestion Avoidance
2154	MD5		OSPF Link-State Advertisement (LSA)
2328	OSPFv2		
2370	Opaque LSA		

IS-IS

1142	IS-IS	5301	Dynamic Hostname Exchange
1195	IPv4 Routing		
2763	Dynamic Hostname	5302	Dynamic Wide Prefixes
2966	Domain-wide Prefixes	5303	Three-way Handshake
3373	Three-way Handshake	5304	MD5
3567	MD5	5305	TE Extensions to IS-IS
3784	Wide Metrics	5306	Restart Signaling for IS-IS
5120	Multi-topology		
draft-ietf-isis-igmp-p2p-over-lan-06			Point-to-Point Operation
draft-ietf-isis-ip-v6-06			IPv6 Routing
draft-kaplan-isis-ext-eth-02			Extended Frame Size

BGP

1997	Communities	4360	Extended Communities
2385	MD5	4893	4-byte ASN
2439	Route Flap Damping	4724	BGP Graceful Restart
2545	Multiprotocol Extensions for IPv6	4760	Multiprotocol Extensions
2796	Route Reflection	5396	4-byte ASN Representation
2842	Capabilities		
2858	Multiprotocol Extensions	5492	Capabilities Advertisement
2918	Route Refresh		
3065	Confederations		
4271	BGP-4		
draft-ietf-idr-bgp4-20			BGPv4
draft-ietf-idr-restart-06			Graceful Restart
draft-michaelson-4byte-as-representation-05			4-byte ASN Representation (partial)

Multicast

1112	IGMPv1	3569	SSM for IPv4/IPv6
2236	IGMPv2	3618	MSDP
2710	MLDv1	3910	MLDv2
3376	IGMPv3	3973	PIM-DM
4541	IGMPv1/v2/v3, MLDv1 Snooping, MLDv2 Snooping		
draft-ietf-pim-sm-v2-new-05			PIM-SM for IPv4/IPv6

MPLS

2702	Requirements for TE Over MPLS		
3031	MPLS Architecture		
3032	MPLS Label Stack Encoding		
3209	RSVP-TE Extensions to RSVP for LSP Tunnels		
3630	TE Extensions to OSPF Version 2		
3784	IS-IS Extensions for TE		
3812	MPLS-TE MIB		
3913	MPLS LSR MIB		
4090	Fast Reroute Extensions to RSVP-TE for LSP Tunnels		
4379	Detecting MPLS Data Plane Failures (TE/LDP)		
	Ping & Traceroute		
5036	LDP Specification		
5063	Extensions to GMPLS RSVP Graceful Restart		

Network Management

1155	SMIv1	2578	SMIv2
1156	Internet MIB	2618	RADIUS Authentication MIB
1157	SNMPv1		
1212	Concise MIB Definitions	2665	Ethernet-like Interfaces MIB
1215	SNMP Traps		
1493	Bridges MIB	2674	Extended Bridge MIB
1657	BGP-4	2787	VRRP MIB
1724	RIPv2 MIB	2819	RMON MIB (groups 1, 2, 3, 9)
1850	OSPFv2 MIB		Interfaces MIB
1901	Community-based	2863	RADIUS
	SNMPv2	2865	IGMP MIB
1905	SNMPv2	2933	RMON High Capacity MIB
1907	SNMP MIB	3273	
2011	IP MIB		
2012	TCP MIB	3416	SNMPv2
2013	UDP MIB	3418	SNMP MIB
2024	DLSw MIB	3434	RMON High Capacity Alarm MIB
2096	IP Forwarding Table MIB		
2233	Interfaces MIB		
2558	SONET/SDH MIB		

2570	SNMPv3	3580	802.1X with RADIUS
2571	Management Frameworks	3815	LDP MIB
2572	Message Processing and Dispatching	4292	IPv6 Forwarding Table MIB
2574	SNMPv3 USM	4293	IPv6 MIB
2575	SNMPv3 VACM	5060	PIM MIB
2576	Coexistence Between SNMPv1/v2/v3		

ANSI/TIA-1057 LLDP-MED MIB

draft-grant-tacacs-02 TACACS+

draft-ietf-idr-bgp4-mib-06 BGP MIBv1

draft-ietf-isis-wg-mib-16 IS-IS MIB

IEEE 802.1AB LLDP MIB

IEEE 802.1AB LLDP DOT1 MIB

IEEE 802.1AB LLDP DOT3 MIB

IPv4 Multicast MIB

ISIS MIB

ruzin-mstp-mib-02 MSTP MIB (traps)

sFlow.org sFlowv5

sFlow.org sFlowv5 MIB (version 1.3)

MIBs

FORCE10-BGP4-V2-MIB	FORCE10-MON-MIB
FORCE10-CHASSIS-MIB	FORCE10-PRODUCTS-MIB
FORCE10-COPY-CONFIG-MIB	FORCE10-SMI
FORCE10-CS-CHASSIS-MIB	FORCE10-SS-CHASSIS-MIB
FORCE10-FIB-MIB	FORCE10-SYSTEM-COMPONENT-MIB
FORCE10-FORWARDING-PLANE-STATS-MIB	FORCE10-TC-MIB
FORCE10-IF-EXTENSION-MIB	FORCE10-TRAP-ALARM-MIB
FORCE10-LINKAGG-MIB	

Management and security

HP OpenView support	RMON (groups 1, 2, 3, 9)
Industry-standard CLI	Secure copy (scp)
Interface access control	sFlow traffic accounting
Layer 2 and 3 ACLs	SNMPv1/v2/v3
NTPv3	XML configuration and command output
Port mirroring	
Port monitoring	
RADIUS/TACACS+ authentication	

Automation

Virtual Server Networking	Smart Scripting
Bare Metal Provisioning	Programmatic Management

Quality of Service and Rate Policing

Weighted Fair Queuing (WFQ)

Virtualization

VRF-Lite

Other

ACL-based accounting
Destination-based MAC accounting
DNS Client
Ping & Traceroute

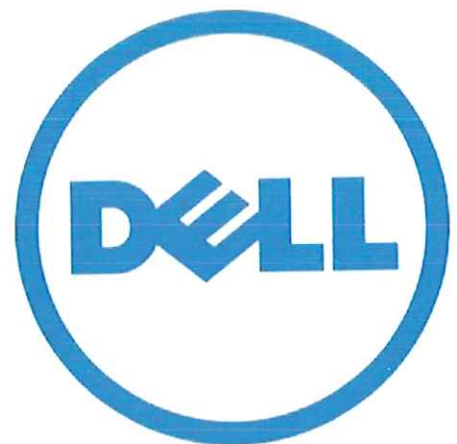
Feature capabilities vary between the Z-series, E-Series, C-Series and S-Series due to hardware differences. Consult the data sheets and product manuals for specific details on supported software features for each platform.

Learn more at Dell.com/Networking



Network Automation with the Dell Force10 Open Automation Framework

A Dell Technical White Paper



THIS WHITE PAPER IS FOR INFORMATIONAL PURPOSES ONLY, AND MAY CONTAIN TYPOGRAPHICAL ERRORS AND TECHNICAL INACCURACIES. THE CONTENT IS PROVIDED AS IS, WITHOUT EXPRESS OR IMPLIED WARRANTIES OF ANY KIND.

© 2012 Dell Inc. All rights reserved. Reproduction of this material in any manner whatsoever without the express written permission of Dell Inc. is strictly forbidden. For more information, contact Dell.

Dell, the *DELL* logo, and the *DELL* badge, *PowerConnect*, and *PowerVault* are trademarks of Dell Inc. *Symantec* and the *SYMANTEC* logo are trademarks or registered trademarks of Symantec Corporation or its affiliates in the US and other countries. *Microsoft*, *Windows*, *Windows Server*, and *Active Directory* are either trademarks or registered trademarks of Microsoft Corporation in the United States and/or other countries. Other trademarks and trade names may be used in this document to refer to either the entities claiming the marks and names or their products. Dell Inc. disclaims any proprietary interest in trademarks and trade names other than its own.

March 2012

Contents

The Open Virtual Data Center	2
The Promise of Virtualization - Realized Through Automation	2
Managing the Complete Virtualized Environment	3
Toward Cloud Computing	3
Customization in Large Complex Environments	4
Choosing Open Automation	5
Force10's Open Automation Framework	5
FTOS and the FTOS Command Line Interface (CLI)	5
Open Automation Overview	7
Bare Metal Provisioning	7
Smart Scripting	8
Virtual Server Networking	8
Programmatic Management	8
Web GUI, Portal & Script Store	8
Automation Use Cases	8
Bare-Metal Provisioning	8
Network Automation with Smart Scripting	9
Configuration Management	10
Alert Notification	10
VM/VLAN Auto-Provisioning	11
Conclusion	11

Figures

Figure 1. Based on NetBSD.	6
Figure 2. The Force10 Open Automation Framework.	7
Figure 3. Bare Metal Provisioning	9
Figure 4. Smart Scripting	9
Figure 5. The Force10 Open Automation Framework	10
Figure 6. Smart Scripting can provide alert notification	10
Figure 7. Virtual Server Networking communicates with hypervisor management tools	11

The Open Virtual Data Center

It has been said that the shift to a virtual data center will be the most significant IT transformation since the invention of the mainframe. This transformation promises to join virtualized computing and storage layers to a virtualized network stack, while enabling new agile models such as cloud computing. At the same time, it is vital for the success of this technology that the transition to the virtual data center not bring back the proprietary restrictions and limitations that were the hallmark of the mainframe era.

While initial virtualization efforts have been very successful at consolidating server and storage resources, organizations and the industry in general are just beginning to understand how these virtualization initiatives will impact their data center networks. Many great minds and diverse organizations are grappling with the best ways to manage the virtualized data center - operating virtual machines, virtual storage, and virtual networking devices in concert to accomplish key application and business goals. Virtualization technology alone can easily result in more complexity - not less - and effective network automation technology is essential in order for the benefits of virtualization to be fully realized.

As with many technologies, some of the initial vendor-sponsored forays into the automation space have attempted to simplify the problem by providing single-source proprietary solutions. Networking vendors in particular have sought to revolutionize traditional data center operational practices with new architectures that work only with their servers and storage. In contrast, Dell realizes that for automation to be truly successful it must represent an evolutionary (rather than revolutionary) step - and it must work in concert with traditional datacenter operational practices.

Most large data centers are complex heterogeneous environments that require considerable customization around standard interfaces and protocols. Dell believes that the network should retain its customary role in automation - responding to orchestration requests from everything from applications, to hypervisors, to management frameworks. Through its Open Network Automation Framework, Dell is pioneering a model that delivers innovative, open standards-based automation technology that will enable organizations to transform their virtualized data center infrastructure - becoming more agile, flexible, and efficient even as they develop new ways to deliver applications and services.

The Promise of Virtualization - Realized Through Automation

To date, much of the adoption of virtualization technology has centered on consolidation, allowing organizations to better utilize and manage their computational and storage resources. Initial benefits of consolidation through virtualization have included:

- Better utilization of servers and storage
- Simple provisioning of virtual machines
- Workload balancing by deploying additional virtual resources

At the same time, most realize that consolidation is only the first step towards a virtualized data center. In particular, the adoption of server and storage virtualization is causing IT managers to

examine how virtualization technology impacts their networks, and how the network needs to change to allow virtualization technology to realize its full potential. While most networks today remain relatively static - virtualized networks must become dynamic to match the characteristics of virtualized servers and storage.

In short, IT managers are grappling with two key questions:

- How does the network need to change so that it can function in this new virtual environment?
- How can virtual servers, storage and network elements be managed together in a cohesive synchronized virtualized environment?

Managing the Complete Virtualized Environment

In the past, servers, storage, and networking could all be managed separately, as they were treated as relatively separate domains. Increasingly, however, organizations need to consider how they will manage virtual machines (VMs), virtual storage, and virtual network devices in tandem to benefit the increasingly virtualized applications that they serve. Failure to embrace these challenges can actually result in far greater complexity and higher costs, easily outweighing the benefits obtained from earlier consolidation efforts.

For example, virtual sprawl has already become a sobering reality for many organizations that have embraced virtualized environments. A symptom of this larger management challenge, virtual sprawl can occur very quickly - much faster than physical server sprawl. Creating hundreds or even thousands of virtual machines is relatively fast and simple. Managing large numbers of virtual machines is more complex, presenting challenges that include:

- Tracking and managing large numbers of virtual machines
- Understanding where individual virtual machines are physically hosted
- Understanding who created or owns a particular VM
- Stipulating policy around VM creation, migration, resource allocation, or VM destruction
- Making sure that a migrating VM has access to its required networks, virtual LANS (VLANs), and data
- Securing new VMs by either mandating that a uniform access and protection template be applied to a new VM, or that a finely-tuned VM-specific profile be applied
- Locating stranded or orphaned VMs that never go away, while consuming valuable resources

Put simply, virtualization technology offers greater flexibility at the cost of increased complexity. Automation addresses the greater complexity caused by virtualization, reducing operational costs for large-scale virtualization efforts. Automation ultimately assists with real-time visibility and management of heavily virtualized environments, reducing risk through a policy-driven framework that helps eliminate human-generated errors.

Policy-based event management and enforcement of standard configurations help shorten the path to a tangible return on investments. The result can be improved availability as organizations are able to perform better network management, and remediation may be automated, where appropriate.

Toward Cloud Computing

Cloud computing technology in particular requires and assumes network automation in addition to virtualization. With cloud computing, resources need to be able to grow, shrink and move dynamically

as demanded by the dynamic nature of the workload. For example, an overloaded application might need to be relocated to a different server with more CPU capacity. When this happens, the entire virtual environment would need to move as well, including:

- Storage connections
- Networking connections
- VLAN and port profile configurations

More than just moving the VM to a new machine, all of these connections would need to be redefined in advance on the switch where the new host for the VM is connected. Only then would the application have the same access, data, and management networks, and remain connected to the appropriate VLAN with all its previous QoS and security policies. Moves such as this need to be accommodated whether the application is being transported to a virtual machine hosted within the same rack, or across the data center.

Moreover, if these changes result in a network bottleneck, automation would need to allow network devices to respond by:

- Moving domains to encompass more servers or adding I/O
- Reserving bandwidth for specific applications
- Changing policies to prioritize applications
- Providing for multi-tenancy beyond the traditional limited static resource allocation

Customization in Large Complex Environments

Complicating the situation, effective automation must also be multi-level - allowing everything from applications, to virtual machines, to management systems to participate, as required by the data center. With the high level of customization prevalent in large data centers, it is important that data center managers have a way to define what they monitor and what they automate. Counter to a one-size-fits all approach, large organizations require the ability to customize their virtualization and automation solutions to fit their own unique needs.

In large data centers, there is also no presumption that any one vendor has a lock on the network, server, or storage infrastructure - and most are loathe to swap out their existing management infrastructure. Viable automation solutions must work with the established environment, interoperating with a wide variety of heterogeneous servers, storage, and networking equipment. Automation technology must also remain agnostic to hypervisor, virtual switch, and server choices, without artificial constraints that include or exclude any particular approach, vendor, or technology. Ultimately, data centers need to be able to own their own intellectual property, from custom-designed operational models to scripts that are used to achieve automation - requiring an open standards-based approach.

Choosing Open Automation

With automation technology still in the early stages, network vendors have taken a variety of approaches. In order to achieve an out-of-the-box operational model, some networking vendors have chosen proprietary architectures to simplify either the computing and storage stack or the network, or both. Unfortunately, these approaches ultimately constrain adopters to the innovations of a single vendor and limit the ability of the organization to customize their own environment. Different approaches to automating virtualized environments include:

- Vertically-integrated network automation. This approach involves a highly integrated proprietary architecture that requires the customer to source all elements of the stack (servers, storage, networking, management software) from a single vendor, or a closed system of vendors. This approach also usually assumes management of all layers of the operational stack by the network vendor - counter to modern data center practices.
- Network-controlled automation. In this approach, the monitoring, management, and provisioning of virtual environments is controlled from, or by the network, representing a huge cultural and operational shift by data center managers.
- Open network automation. Open network automation exploits open industry standards that allow the data center network fabric to be controlled by existing hypervisor or middleware tools. Because this approach is server and application centric (rather than network centric), it is consistent and tracks well with current data center operations.

Dell Force10's Open Automation Framework

Dell Force10's Open Automation Framework is made possible through the ubiquitous Dell Force10 switch operating system - FTOS - that runs across all Dell Force10 switches and routers. By delivering the same operating system across its entire switch and router line, Dell Force10 ensures that organizations benefit from stable code, a consistent feature set, and simpler software management. FTOS also gives Dell Force10's switches an extensible and autonomous operational model that is essentially more like a server than a traditional switch. FTOS adds server-style intelligence and general programmability to Dell Force10's switches and routers, greatly extending their capabilities.

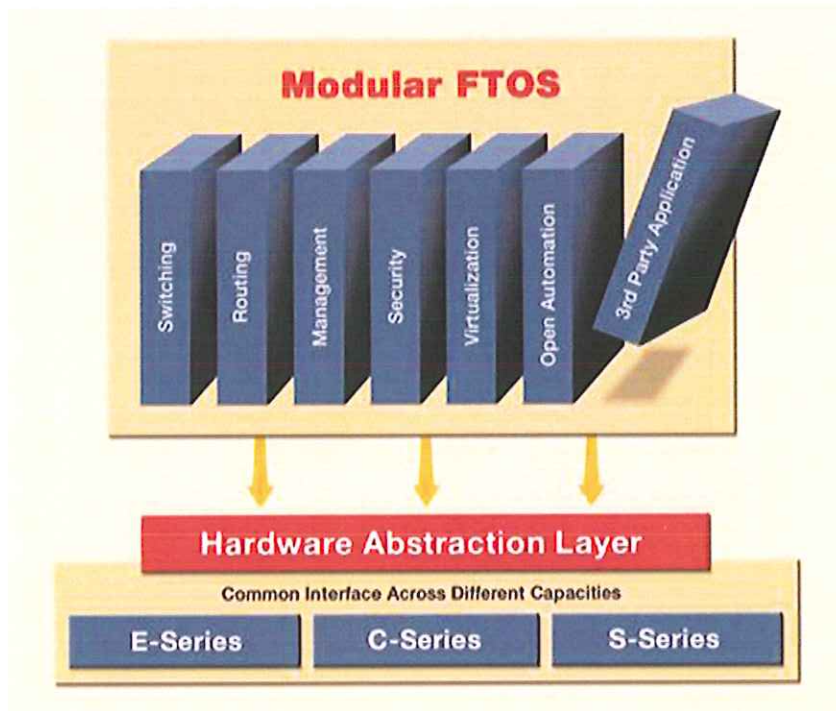
FTOS and the FTOS Command Line Interface (CLI)

An extensible and modular operating system, FTOS is based on NetBSD, with application code developed and maintained by Dell Force10 software engineers. FTOS supports everything from bare-metal switch provisioning to network virtualization, and also provides intelligence and extensibility that allows Dell Force10 switches to participate fully in customized automation. This unified approach offers the following distinct advantages:

- Common management functionality and a common user interface across the Dell Force10 product line make operating the network easier.
- Streamlined product training and a consistent learning curve result since system configuration, diagnostics, troubleshooting, and software maintenance are identical across all platforms.
- Support for the same CLI, SNMP, and XML management models is provided throughout the entire network, greatly simplifying life-cycle management for infrastructure.

A hardware abstraction layer (Figure 1) is used to make FTOS portable across product lines, allowing organizations to deploy applications across multiple switches and routers without recoding for each platform.

Figure 1. Based on NetBSD, the modular and extensible FTOS operating system runs across all Dell Force10 switches and routers.



The NetBSD kernel at the heart of FTOS provides a stable operating system, handling memory allocation and process scheduling, while all other applications run as independent and modular processes in their own protected memory space.

- Separate OS and application functions limit application scope, and provide inherent platform stability.
- Memory protection prevents processes from corrupting each other.
- Preemptive process scheduling prevents processes from monopolizing the CPU.
- Application processes are provided for each Layer 2 and Layer 3 protocol, as well as management functions, security services, and other FTOS functions.

The FTOS CLI is the primary method of managing an FTOS switch or router, and it supports interactive or automated logins using CLI scripting. The CLI is also responsible for communicating with the FTOS application process over inter-process communications (IPC) for sending configuration information or requesting output for a show command. The FTOS CLI combines industry-standard show, configuration, and debugging syntax with enhanced usability and navigation features. As a result, configuration and troubleshooting is similar to working on an IOS platform, but more flexible.

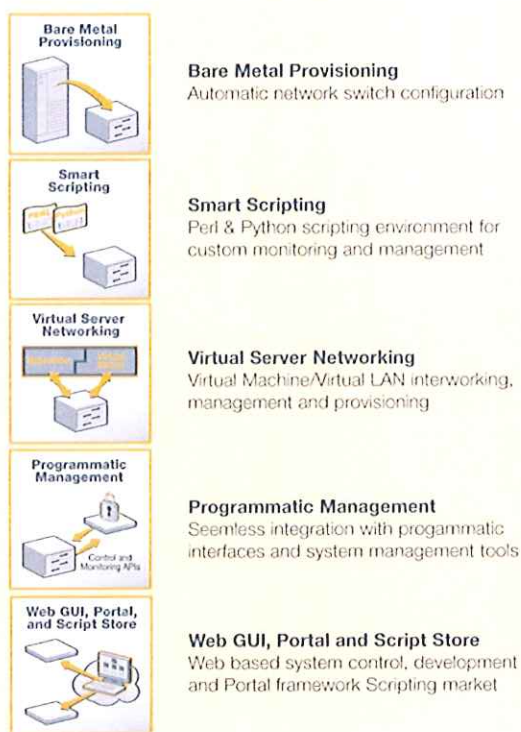
- The FTOS CLI is accessible over the serial console, or via Telnet or SSHv1/v2 for interactive or automated management.
- A "terminal xml" command enables an XML front-end to the CLI.
- Support for common tools such as Expect and RANCID is provided.
- Eventual integration of UNIX-like features such as "grep" and "diff" for scripting.

Open Automation Overview

Running on FTOS, Dell Force10's Open Automation Framework (Figure 2) is designed to transform the data center network into a policy-driven cloud computing fabric, and to provide data center network managers with greater visibility into how the network is performing. Open Automation incorporates Bare Metal Provisioning, Smart Scripting, Virtual Server Networking, Programmatic Management and Web GUI/Interface, which streamline the network fabric's ability to participate in automated, policy-driven, real-time workload allocation in response to changing application and service demands.

The Open Automation and Virtualization Frameworks leverage the company's extensive Technology Alliance Partner Program that today includes more than 25 data center-focused technology partners. Coupled with Dell Force10 technology, these partners provide the foundation for dynamic data centers by aligning compute resources with resource needs.

Figure 2. The Dell Force10 Open Automation Framework.



Bare Metal Provisioning

Automated bare metal configuration reduces operational expenses, accelerates switch installation, simplifies OS upgrades and increases network availability by automatically configuring Dell Force10 switches. This eliminates the need for a network administrator to manually configure the switch, resulting in faster installation, elimination of configuration errors and enforcement of standard configurations. Upon installation, the Dell Force10 switch searches the network for a DHCP server. The DHCP server provides the Dell Force10 switch with an IP address and the location of a TFTP server. The TFTP server maintains a configuration file and an approved version of FTOS, the operating system for Dell Force10 switches. The Dell Force10 switch automatically configures itself by loading the configuration file and FTOS.

Smart Scripting

Smart scripting increases network availability and manageability by allowing network administrators to deploy custom monitoring and management scripts on Dell Force10 switching platforms. With this capability, network administrators can implement version control systems, automatically generate alerts, create custom logging tools and automate management of network devices. Virtually any function that can be performed through the CLI can be implemented with smart scripting. Smart scripting provides a scripting environment that supports Perl and Python, making it easy for IT administrators to quickly develop scripts without having to learn a new scripting language.

Virtual Server Networking

Virtual environments require network infrastructure to be dynamic in order to ensure network connectivity and security policies are maintained when VMs are migrated. Virtual server networking facilitates communications between Dell Force10 network switches and virtual machine management software to orchestrate automated VM/VLAN provisioning and virtual machine migration. This is a powerful capability that greatly simplifies many of the tasks associated with virtualized computing environments. Our virtual server networking software supports VMware vSphere 4.0/4.1 and Citrix XenServer 5.6.

Programmatic Management

Programmatic management greatly improves network manageability by allowing Dell Force10 network devices to be managed by third party system management tools via standard programmatic interfaces. The programmatic management environment and set of interfaces communicate directly with third-party system management tools, avoiding the need for a dedicated network management tool.

Web GUI Interface

Ease and breadth of connectivity remain a paramount necessity for both equipment and development communities. The Web GUI Interface addresses Web connectivity in a general sense for Dell Force10 platforms but also offers more advanced capabilities to help simplify management tasks and customize GUI environments. The advanced Web user interface is a significant step up from traditional web-based switching platforms interfaces. Customers can simply and easily tailor management and user interfaces with either in-house or third-party tools to create custom management and GUI environments.

Automation Use Cases

Organizations ultimately have highly diverse requirements for automation, and automation frameworks must be flexible enough to accommodate a wide range of automation activities. While a particular idea or approach may be advantageous to one organization, it might not be useful to another. Organizations may also choose to implement similar functionality in different ways depending on their own needs. The use cases that follow offer a number of practical examples for ways that the Dell Force10 Open Automation Framework could be used to accomplish a wide range of automation tasks. These descriptions represent only a sampling of the possible automation scenarios, and other approaches are certainly possible.

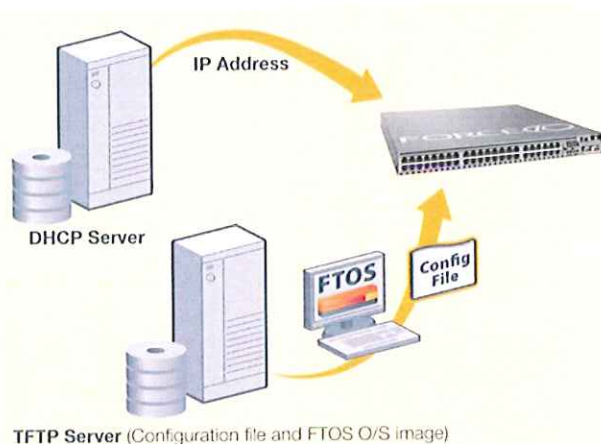
Bare-Metal Provisioning

When deploying or managing a large number of switches, it is often desirable to rapidly and automatically provision network resources. Doing so in an automated fashion helps to:

- Reduce deployment time
- Minimize human error
- Enforce standard and/or secured configurations

Similar to existing server capabilities, FTOS will allow switches to perform bare-metal provisioning - such as that supported on the Dell Force 10 S60 top of rack switch (Figure 3). Through this process, the switch can be configured with an operating system and a detailed configuration based on pre-defined templates. With the Dell Force10 Open Automation Framework, switches advertise their presence after connecting to the network, getting provisioned in return with an appropriate FTOS version, updated startup configuration, and an IP management address through a DHCP and TFTP server.

Figure 3. Bare Metal Provisioning configuration supports rapid provisioning of network resources.

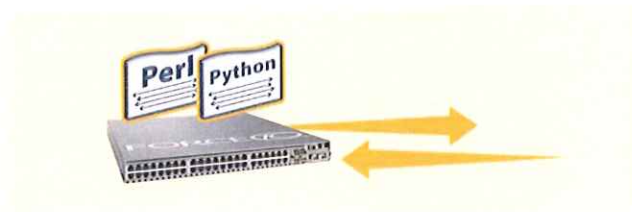


Network Automation with Smart Scripting

Large complex data centers typically have their own unique needs and requirements for monitoring and managing their network infrastructure. Using Smart Scripting on Dell Force10 switches and routers, IT administrators can create custom PERL or Python scripts to manage and interact with their Dell Force10 switches and routers (Figure 4). A wide variety of automation tasks can be implemented, including:

- Automating management
- Building visibility and/or discovery programs
- Creating custom logging
- Reporting configuration information
- Reporting switch memory usage, VLANs, etc.
- Producing custom interfaces with applications
- Supporting custom provisioning

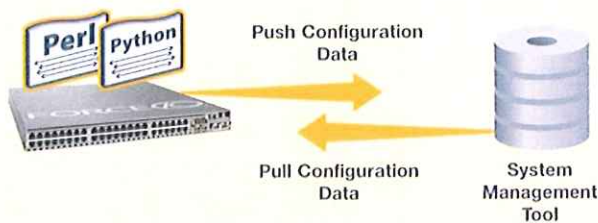
Figure 4. Smart Scripting allows for a wide variety of automation activities to be implemented on Dell Force10 switches and routers.



Configuration Management

Keeping an up-to-date CMDB is critical and challenging, especially in large and complex networked data center environments. As shown in Figure 5, the Dell Force10 Open Automation Framework could be used to automatically send a notification if a switch configuration is changed. At the same time, configuration data could also be retrieved (pulled) from the CMDB to drive actual configuration and management of the switch. For instance, a central database of standard configurations could be maintained. When a change is made to the standard configuration, that configuration could then be pushed to all of the appropriate switches.

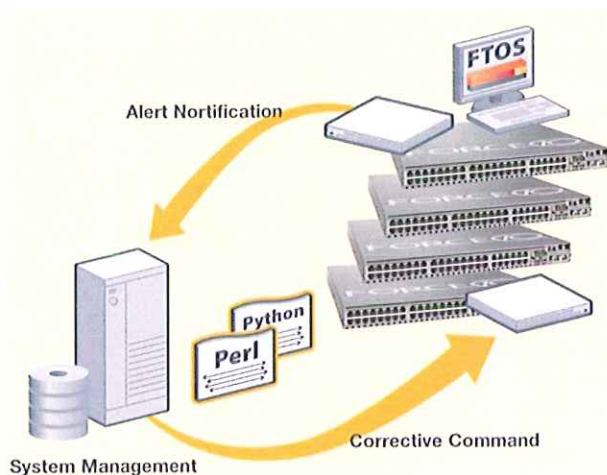
Figure 5. The Dell Force10 Open Automation Framework enables bidirectional communication of configuration data with third party system management tools.



Alert Notification

Proactively noticing and responding to outages and performance issues is vital, particularly in highly automated cloud computing environments. Using standard scripting, organizations use the Dell Force10 Open Automation Framework to build and deploy custom alert modules that notify management tools when network performance issues occur (Figure 6). System management tools or virtualization management tools are able to initiate responses to any issues based on pre-defined policies - potentially deploying additional resources or redeploying virtual machines.

Figure 6. Smart Scripting can provide alert notification from a Dell Force10 switch to third party system management tools.

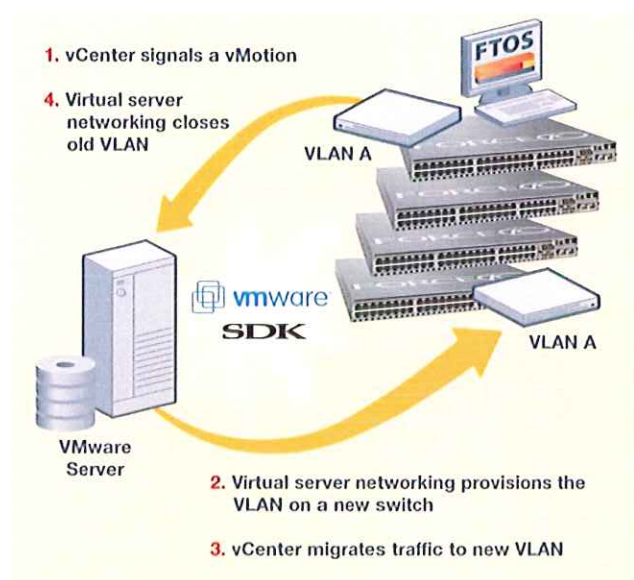


VM/VLAN Auto-Provisioning

For applications to operate seamlessly across a migration event, network configurations must become a part of the process. Associated VLANs must be made available on the physical switches where VMs will be located in advance of moving the virtual machines.

As shown in Figure 7, the Dell Force10 Open Automation Framework could be used with features such as VMware vMotion, configuring a VLAN and port on another switch to accommodate a virtual machine migration. In this scenario, a management application such as VMware vCenter would use VMware vMotion to move the virtual machine. In this case the VMware SDK would run directly on the Dell Force10 switch, registering with vCenter. When vCenter initiates a vMotion event, the switch is notified.

Figure 7. Virtual Server Networking communicates with hypervisor management tools, such as VMware vSphere, to coordinate VM and VLAN migration.



Conclusion

Deriving a return on virtualization investments means deploying effective automation techniques that can simplify the virtualized environment while allowing a policy-based deployment model. While many network vendors have chosen a proprietary path to automation, Dell Force10's approach is to utilize open and industry-standard technologies based on the extensible and modular FTOS operating system - across a range of the heterogeneous Dell Force10 switch and routers portfolio.

Rather than asking organizations to rethink their entire computing, storage, and networking stacks, Dell Force10 is committed to operating as seamlessly as possible as a part of the heterogeneous data center. This open and innovative approach gives large complex data center IT departments the control and flexibility they need to deploy powerful Dell Force10 switches and routers without disrupting the existing infrastructure, operations, or policies that drive their organizations - and their bottom lines.