Muroc Joint Unified School District

Technology Review

April 19, 2010

Joel D. Montero
Chief Executive Officer

FCMAT
FISCAL CRISIS & MANAGEMENT ASSISTANCE TEAM
CSIS California School Information Services

April 19, 2010

Rob Challinor, Superintendent
Muroc Joint Unified School District
17100 Foothill Avenue
North Edwards, CA 93523

Dear Superintendent Challinor:

In November 2009, the Muroc Joint Unified School District entered into a study agreement with the Fiscal Crisis and Management Assistance Team (FCMAT) for FCMAT to perform the following:

1. Conduct an end-to-end network discovery audit to fully document the district's network and identify network elements for replacement/upgrade.
2. Based on the output of the network discovery audit, provide recommendations regarding cabling that needs to be replaced or installed to improve network reliability and performance.
3. Based on the output of the network discovery audit, provide recommendations regarding network elements that need to be replaced, upgraded, and/or installed to improve network reliability and performance.

FCMAT visited the district to collect data, conduct interviews and review documents. This report is the result of those activities. Thank you for allowing us to serve you, and please give our regards to all the employees of the Muroc Joint Unified School District.

Sincerely,

Joel D. Montero
Chief Executive Officer

FCMAT
Joel D. Montero, Chief Executive Officer
1300 17th Street - City Centre, Bakersfield, CA 93301-4533 • Telephone 661-636-4611 • Fax 661-636-4647
422 Petaluma Blvd North, Suite. C, Petaluma, CA 94952 • Telephone: 707-775-2850 • Fax: 707-775-2854 • www.fcmat.org
Administrative Agent: Christine L. Frazier - Office of Kern County Superintendent of Schools

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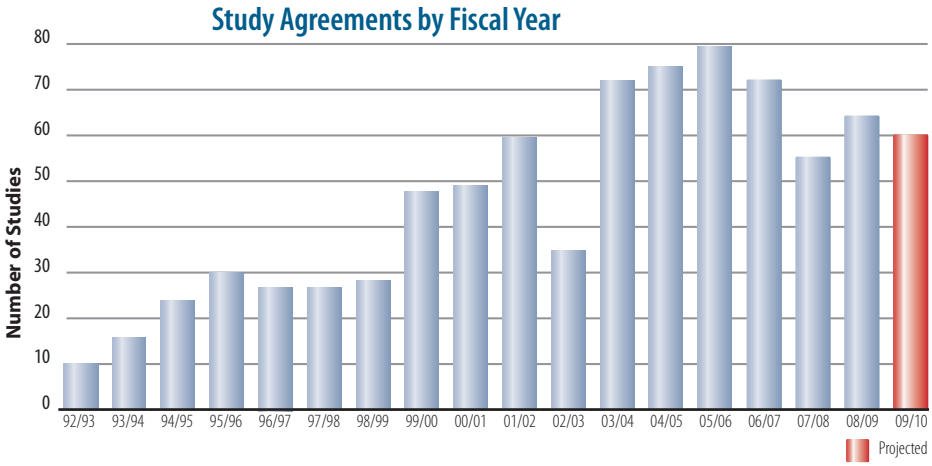
Foreword - FCMAT Background

The Fiscal Crisis and Management Assistance Team (FCMAT) was created by legislation in accordance with Assembly Bill 1200 in 1992 as a service to assist local educational agencies (LEAs) in complying with fiscal accountability standards.

AB 1200 was established from a need to ensure that LEAs throughout California were adequately prepared to meet and sustain their financial obligations. AB 1200 is also a statewide plan for county offices of education and school districts to work together on a local level to improve fiscal procedures and accountability standards. The legislation expanded the role of the county office in monitoring school districts under certain fiscal constraints to ensure these districts could meet their financial commitments on a multiyear basis. AB 2756 provides specific responsibilities to FCMAT with regard to districts that have received emergency state loans. These include comprehensive assessments in five major operational areas and periodic reports that identify the district's progress on the improvement plans.

In January 2006, SB 430 (charter schools) and AB 1366 (community colleges) became law and expanded FCMAT's services to those types of LEAs.

Since 1992, FCMAT has been engaged to perform nearly 750 reviews for local educational agencies, including school districts, county offices of education, charter schools and community colleges. Services range from fiscal crisis intervention to management review and assistance. FCMAT also provides professional development training. The Kern County Superintendent of Schools is the administrative agent for FCMAT. The agency is guided under the leadership of Joel D. Montero, Chief Executive Officer, with funding derived through appropriations in the state budget and a modest fee schedule for charges to requesting agencies.



Total Number of Studies..... 743
Total Number of Districts in CA.....1,050

Management Assistance..... 705 (94.886%)
Fiscal Crisis/Emergency 38 (5.114%)

Note: Some districts had multiple studies.
Eight (8) districts have received emergency loans from the state.
(Rev. 12/8/09)

Introduction

Background

Located in Central California, the Muroc Joint Unified School District serves approximately 2,000 students in kindergarten through twelfth grade at two elementary, two comprehensive junior-senior high schools, and one alternative high school. The district unified in 1953 and encompasses 578 square miles in Kern and San Bernardino counties.

In August 2009, the Fiscal Crisis and Management Assistance Team (FCMAT) received a request for management assistance from the district. The study agreement specifies that FCMAT will complete the following:

1. Conduct an end-to-end network discovery audit to fully document the district's network and identify network elements for replacement/upgrade.
2. Based on the output of the network discovery audit, provide recommendations regarding cabling that needs to be replaced or installed to improve network reliability and performance.
3. Based on the output of the network discovery audit, provide recommendations regarding network elements that need to be replaced, upgraded, and/or installed to improve network reliability and performance.
4. Based on the output of the network discovery audit, create a new WAN design that improves network reliability and performance. These documents shall include a map and descriptions of recommended backbone elements, maps and descriptions of recommended network elements for each site LAN, and recommended network element configurations.

The purpose of this report is to review the on-site report and documentation completed by the technology firm FusionStorm and develop a network design recommendation to upgrade the district's current network infrastructure.

Study Team

The FCMAT study team was composed of the following members:

Andrew Prestage
FCMAT Management Analyst
Bakersfield, California

Leonel Martínez
FCMAT Public Information Specialist
Bakersfield, CA

Robert Black *
Network Engineer
FusionStorm, Inc.
Bakersfield, CA

Brad White *
Senior Network Engineer
Lightspeed Systems
Bakersfield, CA

*As members of this study team, these consultants were not representing their employers but were working solely as independent contractors for FCMAT.

Study Guidelines

FCMAT visited the district in January and February 2010 to conduct interviews, collect data and review documentation. This report is the result of those activities and is divided into the following sections:

I. Executive Summary

II. Network Discovery Audit

III. Appendices

Executive Summary

The Fiscal Crisis and Management Assistance Team (FCMAT) conducted an end-to-end network discovery audit to fully document the district's network and identify network elements for replacement/upgrade. The Muroc Joint Unified School District's telecommunications cabling infrastructure is made up of copper and fiber optic cabling and associated patch panels that house cable connections. The cable infrastructure is capable of meeting the district's telecommunications needs and does not need to be modernized or replaced at any of the sites.

Except for the telecommunications cabling infrastructure, the district's entire network architecture is obsolete based on today's standards. Without exception, every network device in the district is well beyond its predicted useful life and should be replaced. The district relies on technologies that are outdated and no longer supported or that are expensive to support.

The district's data communications protocol is called Asynchronous Transfer Mode (ATM). To address incompatibilities between ATM and other more traditional network standards (i.e. Ethernet) a new network standard called Local Area Network Emulation (LANE) was developed. Because of the complexities of managing the hybrid ATM/Ethernet network, the district staff must rely almost entirely on outside contractors for network support and maintenance.

Technology Department staff members indicated that the district has not invested in any new network equipment in the last 11 years. Instead, the district repairs or replaces components of the original network equipment as needed. This has become increasingly difficult as LANE-enabled ATM devices are available only on the used market and have become difficult to obtain. In the shrinking ATM equipment market, vendors are few, prices are typically high, and extended support is uncertain at best. The Ethernet market has a vast pool of vendors, lower prices, and widely available vendor and consultant support. In addition, Ethernet networks are easier to design, operate, and manage.

Without exception, every network device in the district is well beyond its predicted useful life and should be replaced.

The district should replace the entire ATM-based network infrastructure with Ethernet/IP-based networks except for the telecommunications cabling infrastructure. The network replacement will reduce district staff reliance on outside contractors and make the network easier to manage and maintain.

Based on the availability of funding, the district will need to consider adopting a transition approach that is sequential and gradual, or parallel and more rapid. Conducting the LAN transition gradually will minimize the impact on the district's budget, but converting all sites simultaneously may ultimately prove to be less costly. Although the

recommendations contained in this report reflect Cisco and HP hardware specifications, FCMAT does not endorse any individual network hardware manufacturer. Network hardware from competing hardware manufacturers should be considered based on price, ratings and performance considerations.

Findings and Recommendations

Network Discovery Audit

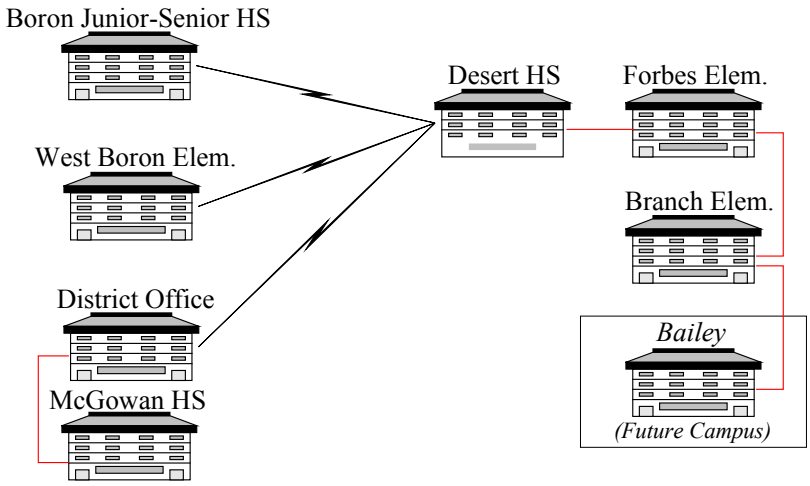
Telecommunications Cabling Infrastructure

The Muroc Joint Unified School District's telecommunications cabling infrastructure is composed of all copper and fiber optic cabling and associated patch panels that house cable connections. The existing cable infrastructure can meet the district's telecommunications needs and does not need to be updated or replaced at any of the sites.

Wide Area Network

The district's wide area network (WAN) consists of the district office, West Boron Elementary School and Boron Junior-Senior High School, which are connected by T-1 circuits to Desert High School in the city of Edwards as shown in the diagram below.

Wide-Area Network



The T-1 circuits are connected with Paradyne T-1 Extenders that plug into Customer Premise equipment.

Campus buildings are connected with ATM circuits (OC3) over multimode fiber.

McGowan High School is connected to the district office with multimode fiber optic cable. Forbes and Branch Elementary schools are connected to Desert High School via multimode fiber optic cable, and Bailey school is connected to Branch Elementary with multimode fiber optic cable. At one time, the district WAN functioned using microwave equipment located at the district office, and although this equipment is still present, it is not used to support connectivity.

Local Area Networks

Each of the district's five school sites is equipped with a local-area network (LAN) to achieve various instructional, administrative, and communications objectives. The five LANs are connected with data transmission lines referred to as the network backbone. The result is a WAN with backbone connections that link the five separate LANs.

The LAN at each school is based on a similar architecture. At each site, an asynchronous transfer mode (ATM) backbone connects the main distribution frame (MDF) and all intermediate distribution frames (IDFs). Edge devices such as workstations, routers, switches and other endpoints are connected to the LAN over a 10-megabit (Mb) or 100-Mb Ethernet connections. The core switches located in the MDFs are Fore Systems ASX-1000 or ASX-200BX ATM switches. Some MDSs also have Marconi ESR-5000 switches. The district staff indicated that the Fore Systems switches perform layer-2 segmentation to support multiple virtual LANs (VLANs) at each site. In addition, the Fore Systems switches are connected to a server in the MDF that has an ATM card installed, and this switch performs layer-3 routing for the site LAN. Network traffic in the IDFs is handled predominantly by Fore Systems ES-3810 switches. These switches have an ATM uplink to the network backbone, and a combination of 8-port 10/100-MB and 10-MB blades installed. Some site IDFs are equipped with Marconi 24-port switches, and a couple of remote site locations are equipped with Asante hubs.

Except for the telecommunications cabling infrastructure, the district's entire network architecture is obsolete.

The MDF at each site is equipped with an APC 3000 uninterruptible power supply (UPS). It is difficult to determine whether these UPS devices are sized correctly to support the network elements present, or even whether the critical network elements are plugged into the UPS devices. Common power strips are available in all the IDFs, however, no UPS systems are installed.

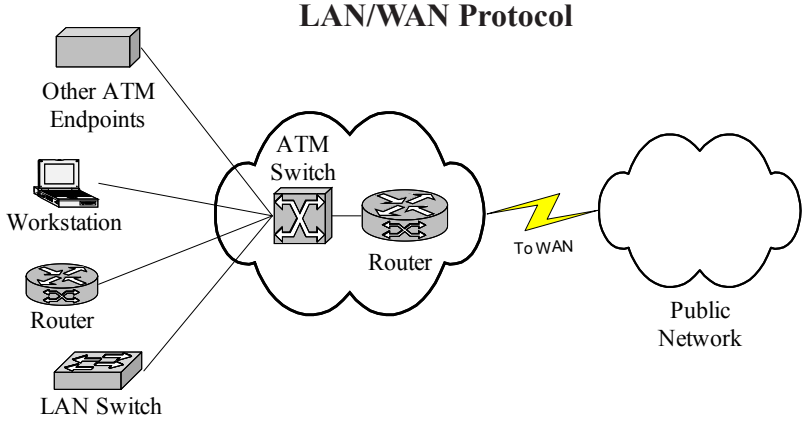
Network Architecture and Protocol

Except for the telecommunications cabling infrastructure, the district's entire network architecture is obsolete. Every network device is well beyond its predicted useful life and should be replaced. The network relies on technologies that are outdated and no longer supported or are expensive to support.

In computing, a protocol is a set of rules used by computers to communicate with each other across a network. Many protocols and data transmission technologies have been introduced over the years, and most have increasingly sophisticated formatting, transmitting, error detection, and error correction capabilities. The specific protocol implemented at the district is called Asynchronous Transfer Mode (ATM). First developed in the mid-1980s, ATM's initial goal was to provide a single data communication technology that could support the transmission of video, audio, images, text and e-mail.

While most ATM implementations are composed of an ATM WAN backbone connecting multiple Ethernet-based LANs, the district's unique ATM implementation extends to individual LANs at the school sites as shown in the following diagram.

LAN/WAN Protocol



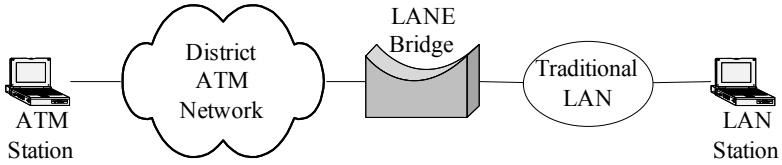
In a typical ATM network, the ATM protocol is used to enable high-speed data communications over the core network and/or backbone connections. Outside the core network, the intermediate links between the backbone and a network's "edge devices" are referred to as "backhaul links." The standard LAN access method used to support LAN data communications over backhaul links is known as Ethernet. Therefore, while ATM supports high-speed server-to-server, core network, and backbone connections, it is not typically used to support communications over the intermediate links that connect the backbone with edge devices. Despite this, the original designers of the district's network configured data communications over the backhaul links to use the same ATM protocol to the edge devices.

Extending the ATM protocol to the edge devices such as workstations, routers, switches and other endpoints would not have been a problem if the district's edge devices had been configured to use the ATM protocol for data communications as shown below.

An ATM Network with ATM-attached Edge Devices

However, the district's edge devices were attached using the traditional Ethernet standard. The ATM Forum, a nonprofit industry consortium, was founded in 1991 to develop implementation agreements. The ATM Forum identified and resolved incompatibilities between ATM and Ethernet by defining a new standard referred to as Local Area Network Emulation (LANE). The LANE standard allowed ATM-attached network devices to emulate Ethernet, enabling communications between ATM-attached devices and traditional LAN-attached devices. This included ATM-to-LAN connectivity as well as LAN-to-LAN connectivity across ATM. This unique connectivity is depicted below.

District ATM Network Depicting LANE Bridge



The introduction of LANE extended the ATM equipment's reach to traditional LANs. However, the original manufacturers of LANE-enabled ATM devices are no longer in business because the market for this type of technology did not gain the user acceptance or market share needed to justify ongoing operations. As a result, LANE-enabled ATM devices are available only on the used market and have become increasingly difficult to obtain.

Because the district's network infrastructure is ATM-based, the district staff must rely almost entirely on outside contractors to manage and operate the network. The staff indicated that instead of investing in any new equipment over the last 11 years, the district repairs and replaces parts of the original network equipment as needed. Staff members can perform minor switch support functions, but must rely on contracted support for advanced configuration and troubleshooting. When equipment malfunctions, the district receives replacement parts from the vendor. During site visits, district technicians pointed out that several of the switches are known to have bad ports, and support staff members moved cable connections to other ports instead of replacing defective equipment.

Although still used by large telecommunications service providers with legacy networks, the ATM protocol is being phased out in favor of packet-switched networks that are more compatible with the Internet protocol (IP) and Ethernet technologies. In the shrinking ATM equipment marketplace, vendors are few, prices are typically high, and extended support is uncertain at best. However, the Ethernet marketplace has a vast pool of vendors, lower prices, and widely available vendor and consultant support. In addition, Ethernet networks are easier to design, operate, and manage.

The recommendations outlined for each school site below assume that each site will host a separate LAN infrastructure. The LAN infrastructure at each site should consist of the existing cabling infrastructure connected to Ethernet-based network elements. Each site LAN will include one main facility referred to as the MDF and possibly one or more IDFs. An MDF connects the high-speed lines that come into each site with the internal network and serves as the "hub" of the site LAN. Each IDF houses cable mounting racks that interconnect cabling between an MDF and edge devices such as workstations.

Recommendations

The district should:

1. Replace the entire ATM-based network infrastructure with Ethernet/IP-based networks except for the telecommunications cabling infrastructure. Transitioning to Ethernet/IP-based networks at the site level will reduce the district staff's reliance on outside contractors and make the network easier to manage and maintain. The district staff will be able to resolve network problems much more quickly and will help technicians understand how the district's network infrastructure can facilitate teaching, learning, staff development, and business functions.

2. Go to bid for the required network equipment identified in this report. Although the recommendations contained within this report reflect Cisco and HP hardware specifications, FCMAT does not endorse any individual network hardware manufacturer. Network hardware from competing hardware manufacturers should be considered based on price, ratings and performance considerations.

3. Obtain a five-year support contract from the vendor to cover all new network equipment. At the very least, a three-year support contract should be obtained if five-year support contracts are unavailable.

4. Consider following a LAN transition strategy based on one of the alternatives outlined below. Funding is an important consideration because equipment replacement is expensive.

    - Alternative 1: Sequential, Site-based Cutover. This entails replacing each ATM-based school site LAN with an Ethernet/IP-based network one at a time while maintaining an ATM WAN core. The ATM WAN core at Desert High School would be replaced with an Ethernet/IP-based core after the transition of all other school site LANs. This would make the conversion gradual, and the impact on the district's budget would be reduced since equipment replacement could be conducted as funding sources allow.

    - Alternative 2: Parallel, Districtwide Cutover. Conducting the LAN transition for all sites at the same time would allow the district to transfer all sites to the new network simultaneously. Although this approach would require

substantially higher costs in the near term, it would likely require less consultant support and reduce the total cost in time and finances required to replace the current network infrastructure.

5. Ensure that Desert High School continues to serve as the physical "hub" for the new district WAN topology.

6. Ensure the following fiber optic connections are either Fast Ethernet (100 megabits per second - Mbps) or Gigabit Ethernet (1,000 Mbps) connections.

    - The connection from Desert High School to Forbes Elementary School
    - The one from Forbes Elementary School to Branch Elementary School
    - The one from Branch Elementary School to Bailey Elementary School
    - The one from the district office to McGowan High School.

    The speed selected for each connection should depend the distance between the sites. The Fast Ethernet fiber optic equipment supports a maximum distance of 2 kilometers (km) on 62.5 micrometer multimode fiber-optic cable and the Gigabit Ethernet fiber optic equipment supports a maximum distance of 550 meters on 62.5 micrometer multimode fiber optic cable. The maximum distance supported for Gigabit Ethernet if single-mode fiber optic cable is used is 10 km.

7. Install a Cisco 2921 (or similarly rated) router at Desert High School (vendor part number CISCO2921/K9). If a Cisco 2921 router is installed, it should contain three Cisco HWIC-1CE1T1-PRI modules. These modules will be used to terminate the T-1 circuits to the district office, West Boron Elementary School, and Boron Junior-Senior High School. No additional CSU/DSU units will be required.

8. Ensure the fiber optic connection to Forbes Elementary School is set at the fastest supported speed (either 100 Mbps Fast Ethernet or 1,000 Mbps Gigabit Ethernet). If Cisco equipment is selected and used with multimode fiber optic cable, the vendor part number required is GLC-FE-100FX. If multimode fiber optic cable is used at Gigabit Ethernet speeds, the part is GLC-SX-MM, and if single-mode fiber optic cable was used, the part is GLX-LH-SM. This router contains two additional copper-based Gigabit Ethernet connections, each supporting a maximum distance of 300 meters. One Gigabit Ethernet connection should be connected to the switch in the MDF room for the LAN at Desert High School, and the other should be connected to an upstream firewall.

9. Implement a Cisco ASA 5520 (or similarly rated) firewall. If the Cisco 5520 is selected, the corresponding vendor part number is ASA5520-BUN-K9.

10. Implement a Cisco 2901 Internet access router. If the Cisco 2901 is selected, the corresponding vendor part number is CISCO2901/K9. This router will contain two Cisco HWIC-1CET1-PRI modules. These modules will be used to terminate the two T-1 circuits that connect to the district's upstream Internet provider.

11. Ensure that the Cisco ASA 5520 firewall is connected to the district's Cisco 2901 Internet access router. This will protect the district's network resources and staff by selectively restricting access to inappropriate Web content and/or blocking inappropriate inbound traffic.

12. Ensure that the MDF at each site contains an HP ProCurve 5406zl (or similarly rated) Ethernet switch. If the HP ProCurve 5406zl chassis is selected, the corresponding vendor part number is J8697A.

13. Ensure that each 5406zl Ethernet switch is equipped with a power supply module. The power supply module is required to provide power to the 5406zl switch. If an HP power supply module is selected, the corresponding vendor part number is J8712A. A single power supply module will provide enough power for normal operation; however, a second power supply module installed in each 5406zl will provide redundancy in the event of the power supply modules fails. A redundant power supply can be added by requesting an additional J8712A.
14. Ensure that each MDF 5406zl is equipped with a Small Form-factor Pluggable (SFP) card to support connections to each of the site IDF's. If the site does not have IDFs, this card is not required. Forbes Elementary, Branch Elementary, Bailey Elementary, and McGowan High schools will also use an SFP card to connect to their appropriate upstream school site in the WAN. If an HP SFP card is selected, the corresponding vendor part number is J8706A. The use of plug-in SFP modules is required to provide the physical connections from the J8706A. If HP cards are selected, the vendor part numbers for these modules are J9054B (if a Fast Ethernet connection is required over multimode fiber optic cable), or J4859C if a Gigabit Ethernet connection is required over either multimode or single-mode fiber optic cable.

    If individual computers are to be connected to equipment in an MDF, each 5406zl Ethernet switch will require one or more J8702A cards. Each J8702A card provides 24 ports of copper-based 10/100/1000 Mbps Ethernet connectivity, and each MDF 5406zl Ethernet switch can support up to five of these modules. Lifetime HP support that includes next business day hardware replacement and software updates is included in the purchase price of this equipment.

15. Ensure that one or more HP ProCurve 2810 (or similarly rated) Ethernet switches are installed in each IDF. One or more ProCurve 2810 switches can also be added if additional connectivity is required at the MDF beyond 120 Ethernet ports. There are two models of the HP ProCurve 2810 Ethernet switch. If the HP

ProCurve 2810 switch is selected, the J9021A model has 24 available ports and the J9022A has 48 available ports. Each IDF should have the appropriate number of ProCurve 2810 switches installed to support the number of computer connections required.

16. Ensure that each ProCurve 2810 is equipped with an optical module to connect it to the site 5406zl MDF switch. The corresponding vendor part number for the optical modules are J9054B (if a Fast Ethernet connection is required over multimode fiber) or J4859C if a Gigabit Ethernet connection is required over either multimode or single-mode fiber optic cable. An identical module will also need to be installed in the J8706A SFP card in the MDF 5406zl Ethernet switch. Each ProCurve 2810 switch should be directly connected to the MDF 5406zl switch if possible. If a single IDF contains several 48-port 2810 Ethernet switches that would outstrip the number of fiber-optic connections back to the MDF, these switches can be daisy chained to each other with a single switch connecting to the 5406zl Ethernet switch in the MDF. Lifetime HP support that includes next business day hardware replacement and software updates is included in the purchase price of this equipment.

17. Ensure that a Cisco 2901 (or similarly rated) router is installed at the district office, West Boron Elementary School, and Boron Junior-Senior High School to facilitate the connection to Desert High School. The corresponding vendor part number if the Cisco 2901 router is selected is CISCO2901/K9. These routers will also contain a single HWIC-1CE1T1-PRI module that will terminate the T-1 circuits present at each site. The Cisco 2901 router also includes two additional copper-based Gigabit Ethernet ports, and one of these ports will be used to connect to the site MDF HP ProCurve 5406zl Ethernet switch.

18. Ensure that the sites connected via T-1 circuits are configured to use Point-to-Point (PPP) as the Open System Interconnection (OSI) layer 2 WAN protocol.

19. Ensure that all site LANs utilize the Internet Protocol (IP) and 802.1Q virtual LAN (VLAN) trunking to enable the appearance of any required site VLAN on any site switch port.

20. Ensure that the site 5406zl Ethernet switches and 29XX routers provide routing and access control list (ACL) based filtering as required. Static routes will be used since there is no need for a routing protocol because of the lack of redundant paths in the WAN.

21. Ensure that any wireless access points required in the district network are implemented using the Cisco Aironet 1140 series access point. If the Aironet 1140 is selected, the corresponding vendor part number is AIR-AP1141N-A-K9. This wireless access point provides support for 802.11a/g networks and a variety of wireless security protocols.

22. Install a network management system (NMS) as soon as the first new network elements are put to production use. The NMS will monitor network performance and automatically alert district staff members of a network outage. One system capable of effectively providing this type of network management support is the SNMPc Network Manager version 7.2 from Castle Rock Computing. This application runs on Microsoft Windows and will require Windows Server 2003 or 2008. FCMAT does not recommend installing this product on the Windows Vista or Windows 7 operating system platforms. The server hosting this application will also need an analog modem installed. The modem will enable alerts to the district staff as needed via cell phone text messages. E-mail alerts are also available without the modem. This software provides network monitoring as well as trend analysis, which is important when evaluating the performance of the network over time. This software requires that all network elements support simple network management protocol (SNMP) management. All the network elements included in this report provide SNMP management support. The SNMPc Network Manager application requires a yearly support contract renewal fee after the first year.

23. Ensure that an access control and syslog server is installed as soon as the first new network elements are put in production use. This server will control access to and provide central logging for all network elements. A modest workstation running Debian Linux can be used to provide these services. A workstation equipped with a 1.6 gigahertz single core processor, 1 gigabyte of memory, and 320 gigabytes of disk capacity would be sufficient to host access control and syslog services.

24. Ensure that the access control and syslog server is configured to automatically collect and save the configuration files of all network elements. This can be enabled by implementing an open source software package called RANCID. This software is available free of charge and can be found online at: http://www.shrubbery.net/rancid/.

25. Consider obtaining lifetime vendor support that includes next business day hardware replacement and software updates for equipment which provides this support option. It is an important cost factor that should be evaluated for feasibility when reviewing vendor hardware quotations. For instance, the HP equipment specified in this report normally includes this level of support in the purchase price of the equipment. However, other equipment manufacturers may assess a surcharge for this support level.

Appendices

A. District WAN and Site Plan

B. Cabling Documentation

C. Study Agreement