


**Upgrading LAN Infrastructure in Manufacturing Company
to Support Wireless Technology**

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ABSTRACT

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Building Materials Incorporated (BMI) is a leading manufacturer of building materials for the construction and remodeling industries. The company is committed to achieve the highest level of customer satisfaction, efficiency and quality products. In support of customer satisfaction initiative and operational efficiency, BMI will introduce new technologies within the manufacturing and warehouse environment. New technologies will include barcode printing/scanning devices and Radio Frequency (RF) wireless terminals within the manufacturing areas and the warehouses. These items will be used for recording finished goods

production, tracking inventory movement, and shipping of products to the customers.

Additionally, BMI will be upgrading the network hardware infrastructure to the latest Cisco hardware. Utilizing standardized Cisco equipment to support network infrastructure, the company ensures that the new applications will receive the quality of service they require. It also will allow deployment of featured business enablers such as wireless technology and Internet Protocol Telephony (IPT). This study will investigate site facility readiness, analyze current network environment, identify and document future network environment needed to support wireless terminals within the manufacturing areas and the warehouses. The outcome of this study is the recommendations, which BMI needs to take into consideration prior to deployment of wireless technology.

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Chapter I: Introduction

Background of the Problem

BMI is a leading manufacturer of building materials for the construction and remodeling industries. BMI products are used in everything: from major commercial developments and residential housing to simple home improvement projects. The family of products produced by BMI provides creative building solutions that set new standards for productivity and efficiency, helping contractors and architects to deliver high quality and innovative designs. The company is committed to the highest levels of customer satisfaction, efficiency, and quality products. To achieve its goal in customer satisfaction and operational efficiency, BMI is going to implement best-in-class supply chain and customer relationship processes. BMI will deliver superior service to customers while at the same time improving its bottom line.

In support of customer satisfaction initiative and operational efficiency, BMI will introduce the new technologies within the manufacturing and warehouse environment. These technologies will require a robust internetworking environment to support the 24x7 system processing requirements. The new technologies will include barcode printing, scanning devices, and Radio Frequency (RF) wireless terminals within the manufacturing areas and the warehouses. These items will be used for recording finished goods production, tracking inventory movement, and shipping of products to the customers. Additionally, BMI will be upgrading the network hardware infrastructure to the latest Cisco hardware.

The purpose of replacing the network equipment in each plant is to allow business enabling applications to be built upon a standardized, stable, and upgradeable network environment. With the standardization of a Cisco Catalyst switched infrastructure BMI is ensuring these applications receive the quality of service they need, as well as allowing the

deployment of future business enablers, such as Wireless, Internet Protocol Telephony (IPT), and Video. New equipment should be a solid platform to build upon for years to come.

Research Objectives

The objective of this study is 1) to investigate site facility readiness, 2) analyze current network environment, and 3) identify and document future network environment needed to support wireless terminals within the manufacturing areas and the warehouses.

Limitations of the Study

This study is limited to proposing the recommendations for a Local Area Network (LAN) upgrade. Upon completion of the site readiness survey and solution recommendations BMI will engage with a contractor for procurement, staging, installation, and troubleshooting of a new equipment, as well as creating final documentation following the installation.

Assumptions of the Study

An assumption has been made that all BMI's network infrastructure wiring is Institute of Electrical and Electronics Engineers (IEEE) certified and tested. To ensure consistency and scalability of the network infrastructure, single vendor equipment is to be used throughout the entire network. The network equipment vendor of choice is Cisco.

Methodology

A site survey methodology for this research is based on 1) a visual inspection of individual network closets, 2) completion of appropriate forms of documentation, 3) photographing current network racks and equipment, and 4) verifying that the distance between the location of wireless access points (APs) and the nearest network closets does not exceed allowable limits. BMI is responsible for identifying desired areas of wireless coverage and

locations of wireless APs placement. The researcher is responsible for a network site survey, analysis, and solution recommendations, which will be the outcome of this study.

Definition of Terms

The following terms are used throughout this study:

12U/15U/21U – A form factor of a rack that allows housing of 12/15/21 device units.

802.11 – A family of IEEE standards for wireless LANs that was designed to extend 802.3 (wired Ethernet) into the wireless domain.

Barcode scanner – A device specialized for reading bar codes and converting them into either the ASCII or EBCDIC digital character code.

Bandwidth – The amount of data that can be passed through the communication channel in a given period of time.

Basic Service Area (BSA) – A cell or area that contains a number of wireless stations.

Bus topology – A network topology in which devices use a common physical connection for communication. That means that the physical media is shared between devices.

Category 5 cable (Cat5) – An unshielded twisted pair type cable designed for high signal integrity. The actual standard defines specific electrical properties of the wire, but it is most commonly known as being rated for its Ethernet capability.

Crosstalk – Interference induced from one adjacent channel or circuit onto another.

Crossover cable – A network cable that crosses transmit and receive lines. It is used to interconnect devices such as hub to hub, switch to switch, router to router, pc to pc, and pc to router.

Ethernet – The most widely used LAN access method defined by the IEEE as the 802.3 standard.

Hub-and-spoke topology (Star) – A network topology where there is a central connection point to which multiple devices are connected.

Industrial, Scientific and Medical (ISM) band – A radio spectrum that can be used by anybody without a license. In recent years, this radio spectrum has also been used for license-free error-tolerant communication applications, such as wireless LAN. The most commonly used ISM bands are as follows: 900 MHz; 2.4 GHz; and 5.8GHz.

Industry Standard Architecture (ISA) – A standard bus (computer interconnection) architecture that is associated with the IBM AT motherboard.

Infrared (IR) – Invisible radiation in the part of the electromagnetic spectrum, which is characterized by wavelengths just longer than those of ordinary visible red light and shorter than those of microwaves or radio waves.

Institute of Electrical and Electronics Engineers (IEEE) - A non-profit technical professional association of 360,000 individual members in more than 150 countries. The IEEE fosters the development of standards that often become national and international standards.

Internet Protocol Telephony (IPT) – A technology that utilizes Internet Protocol (IP) of TCP/IP communications protocol suite to transport telephone calls over the Internet.

Local Area Network (LAN) – A group of computers and associated devices that share a common communication line or wireless link and typically share the resources of a single processor or server within a small geographic area (for example, within an office building).

Mbps – A data rate transmission in megabits per second.

NEMA 12 – National Electrical Manufacturers Association type 12 enclosures that are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping non-corrosive liquids.

Peripheral Component Interconnect (PCI) – An interconnection system between a microprocessor and attached devices in which expansion slots are spaced closely for high speed operation. Using PCI, a computer can support both new PCI cards while continuing to support Industry Standard Architecture (ISA) expansion cards (older standard).

Radio Frequency (RF) – A term that refers to alternating current (AC), which has the following characteristics: if the current input to an antenna, an electromagnetic (EM) field is generated suitable for wireless broadcasting and/or communications.

Registered Jack-45 (RJ-45) – A telephone connector that holds up to eight wires. RJ-45 plugs and sockets are used in Ethernet devices.

Ring topology – A network topology where devices are connected to one another in a shape of a closed loop, so that each device is connected directly to two other devices, one on either side of it.

Roaming – The ability of a communication device to be able to move from one cell or access point to another without losing the connection.

Straight Tip (ST) – A popular fiber optic twist-type connector originally developed by AT&T.

Unlicensed National Information Infrastructure (UNII) – Unlicensed RF band that covers the following range of frequencies: 5.15-5.35 GHz and 5.725-5.825 GHz

Walkthrough – A part of a site survey process, which is used to assess the current state of a surveyed location.

Wireless LAN (WLAN) – A local area network that transmits radio signals over the air typically in the 2.4GHz or 5GHz unlicensed frequency band.

Chapter II: Literature Review

Popularity of Wireless Technology

Manufacturing organizations throughout the world are struggling to keep in step with the aggressively dynamic computer industry. There are various tools, applications, devices, and other technological advancements that can increase productivity and efficiency, reduce production cost, and improve customer relations. One of such technological advancements is the wireless technology. The wireless data communication along with barcode scanning and centralized database system can significantly improve products expenditure at all stages of production and distribution. It allows to eliminate human errors in data entry and provides real time monitoring of inventory and production processes. The benefits of integrating wireless and barcoding into inventory management system are significant, and they cascade throughout company's supply chain (Lambert, 2003). According to IDC research (Keizer, 2004), the key driver for growing WLAN deployments is productivity. It has a score 6.4 on a scale 1 through 9. Second in line is improving customer service, which rated a median score of 5.5.

The wireless warehouse and logistics environment is generally comprised of three basic components: the wireless local area network (WLAN), the handheld processing unit equipped with barcode scanner, and the application software package necessary to process the data and integrate it with the business system. The discussion of barcode scanners, application packages, and integration logistics is beyond the scope of this study and therefore will not be covered. The main focus of this study is to research a site readiness for WLAN integration into an existing LAN and provide recommendations for LAN upgrade to support WLAN.

A LAN is the commonly used type of network for communications within a single plant in manufacturing environment. Introduction of a WLAN provides all the features and benefits of

traditional LAN technologies, such as Ethernet but without the limitations of wires or cables. WLANs redefine the way the industry views LANs. Connectivity no longer implies attachment. An infrastructure does not need to be buried in the ground or hidden behind the walls. An infrastructure can be moved and changed based on the needs of the organization. A WLAN, just like a LAN, requires a physical medium through which transmission signals pass. Instead of using twisted-pair or fiber-optic cable, WLANs use infrared (IR) light or RF. The use of RF is far more popular for its longer range, higher bandwidth, and wider coverage. WLANs use the 2.4-gigahertz (GHz) and 5-GHz frequency bands. These portions of the RF spectrum are reserved in most of the world for unlicensed devices. Wireless networking provides the freedom and flexibility to operate within the building and between buildings (Roshan and Leary, 2003).

Over the last seven years, WLANs have gained strong popularity in a number of vertical markets, including the health-care, retail, manufacturing, warehousing, and academic arenas. These industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real time information to centralized hosts for processing. Today, WLANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of business customers. According to META Group (2004) research, by the end of 2004, 30% of organizations would have transitioned WLAN trials into full production. Study indicates that WLAN adoption will accelerate over the next two years, with more than 50% of organizations deploying WLAN by 2006.

The study conducted by Synergy Research Group (2004) reports that worldwide sales of enterprise wireless LAN gears were worth \$320.7 M in Q3 2004, a jump of nearly 28% compared to last year. WLAN market leaders, according to the study, ranked as the following: Cisco Systems holds the top spot with nearly 43% market share; Symbol Technologies maintains

2nd spot with a 15.9% market share; Airespace has grabbed third place from Proxim with a 5.7% share; Proxim is tied for fourth place with 3Com (each company has a 4.4% piece of the corporate wireless market share).

Wireless Standards

Manufacturers of WLANs have a range of technologies to choose from when designing a WLAN solution. A widespread implementation of wireless technology forced IEEE to create wireless Ethernet standard. The first wireless Ethernet standard, IEEE 802.11, was adopted in 1997. Currently, this standard allows for transmission over following media:

- Infrared light
- Three types of radio transmission within the unlicensed 2.4-GHz frequency bands:
 - Frequency hopping spread spectrum (FHSS)
 - Direct sequence spread spectrum (DSSS) 802.11b
 - Orthogonal frequency-division multiplexing (OFDM) 802.11g
- One type of radio transmission within the unlicensed 5-GHz frequency bands:
 - Orthogonal frequency-division multiplexing (OFDM) 802.11a

Each media specification comes with its own set of advantages and limitations. As indicated above, there are two types of spread spectrum radio: FHSS and DSSS. Most wireless LAN systems use DSSS technology, a wideband radio frequency technique developed by the military for use in reliable, secure, and mission-critical communications systems. DSSS is designed to trade off bandwidth capacity for reliability, integrity, and security. In other words, more bandwidth is consumed than in the case of narrowband transmission. A narrowband radio system transmits and receives user information on a specific radio frequency. A narrowband

radio keeps the radio signal frequency as narrow as possible just to pass the information.

Undesirable crosstalk between communications channels is avoided by carefully coordinating different users on different channel frequencies. In a radio system, privacy and noninterference are accomplished by the use of separate radio frequencies. The radio receiver filters out all radio signals, except the ones on its designated frequency.

FHSS uses a narrowband carrier that changes frequency in a pattern known to both transmitter and receiver. Properly synchronized, the net effect is to maintain a single logical channel. Early implementations of 802.11 used FHSS. DSSS generates a redundant bit pattern for each bit to be transmitted. This bit pattern is called a chip or chipping code. The longer is the chip code, the greater the probability that the original data can be recovered and, of course, the more bandwidth is required. Even if one or more bits in the chip are damaged during transmission, statistical techniques embedded in the radio can recover the original data without the need for retransmission. DSSS and FHSS are the spread spectrum technologies used by WLANs, including 802.11b, which operates at 11Mbps.

OFDM is a multi-carrier transmission technique that has been recently recognized as an excellent method for high speed bi-directional wireless data communication. OFDM effectively splits a signal into several narrowband channels at different frequencies. These signals in turn are transmitted in parallel across that particular RF spectrum. OFDM limits the crosstalk or interference of transmitting channels. Also, OFDM facilitates longer distance capability; however, it requires more processing power in the radio. The IEEE 802.11a subcommittee has elected to use the OFDM transmission technique for their standard in the 5 GHz Unlicensed National Information Infrastructure (UNII) bands. OFDM is also used in the 2.4 GHz Industrial, Scientific, and Medical (ISM) band as the physical layer standard for the IEEE 802.11g standard.

The 802.11a and 802.11g standards operate at up to 54 Mbps. The 802.11g standard is designed to be backwards compatible with 802.11b. The 802.11b standard is most widely used for WLAN deployments; however, 802.11g is growing in popularity for its high speed and backward compatibility with 802.11b.

IR systems use a very high frequency to carry data. The frequency is just below visible light in the electromagnetic spectrum. IR wireless is used for short and medium range communications and control. Some systems operate in line-of-sight (LOS) mode; this means that there must be a visually unobstructed straight line through space between the transmitter (source) and receiver (destination). Other systems operate in diffuse mode, which also called scatter mode. This type of system can function when the source and destination are not directly visible to each other. However, both transmitter and receiver must be both in the same room.

In a typical WLAN configuration, a transmitter/receiver (transceiver) device, called an AP, connects to the wired network from a fixed location, using standard Ethernet cable. At a minimum, the AP receives, buffers, and transmits data between the WLAN and the wired network. A single AP can support a small group of users and can function within a range of less than one hundred to several hundred feet. The AP (or the antenna attached to the AP) is usually mounted high, however, it may be mounted essentially anywhere that is practical, as long as, the desired radio coverage is obtained. End users can access the WLAN through the wireless adapters, which are implemented as PC cards in notebook computers, ISA or PCI adapters in desktop computers, or fully integrated devices within hand-held computers. WLAN adapters provide an interface between the client network operating system (NOS) and the airwaves (via an antenna). The nature of the wireless connection is transparent to the NOS.

Wireless Site Readiness

The foundation of any network design is to understand the customer requirements. There are multiple factors that must be considered when implementing a site survey. Some of the major factors that have to be considered are applications and infrastructure that a client wants to implement. It is a very important that network engineer is completely aware of how a client wants to implement the WLAN. Every facility has different requirements, depending on the nature of the business. A good site survey will help the customer to determine how many APs will be required throughout the facility to provide the desired coverage. It will also determine the placement of the APs and detail the necessary information for installation. Additionally, a site survey will establish the feasibility of the desired coverage in the face of obstacles, such as wired connectivity limitations, radio hazards, and application requirements. This will allow the WLAN to be properly installed, and for the customer to have consistent, reliable wireless access (Alexander, 2004).

There are various operating and environmental conditions that have to be considered in order to provide maximum range, coverage, and infrastructure performance of WLAN.

According to Roshan and Leary (2003), they are the following:

- **Data Rates - Coverage is inversely proportional to data bit rates. The maximum radio range is achieved at the lowest workable data rate. There will be a decrease in receiver threshold as the radio data rate increases.**
- **Antenna Type and Placement - Proper antenna selection and installation are critical factors in maximizing radio range. As a general guide, range increases in proportion to antenna height and gain.**

- Physical Environments - Clear or open areas provide better radio range than closed or filled areas.
- Obstructions - A physical obstruction, such as shelving or a pillar, can hinder the coverage of the wireless system. It should be avoided to locate the computing device and antenna in a location where there is a barrier between the sending and receiving antennas.
- Building Materials - Radio penetration is greatly influenced by the building material used in construction. For example, drywall construction allows greater range than concrete blocks.
- LOS - A clear line of sight must be maintained between wireless bridge antennas. Any obstructions may impede the performance or prohibit the ability of the wireless bridge to transmit and receive data. Directional antennas should be placed at both ends at the appropriate elevation with maximum path clearance.

The topology of WLANs may take many forms just like with wired LANs. However, a term *topology* in the wireless terminology does not refer to architecture like bus, ring, or hub-and-spoke. It refers to the **Basic Service Area (BSA)**, which is comprised of cells. Each AP has an area of coverage referred to as a **cell**. In an installation, consisting of a single AP, this is a very simple concept. When multiple APs are installed, the cells must overlap, so that the wireless connection is never interrupted while roaming from the AP to AP. The main purpose of a site survey is to locate the proper placement for the APs and examine the cells to allow for proper overlap. Too much or too little overlap can cause disruption of the wireless connection to the client. Often times, a WLAN is implemented as an extension to wired LAN. In this case, the topology of the wired LAN will dictate the layout of the WLAN. For example, the distance

limitations of 100 m (328 ft) Category 5 (Cat5) cable run may not be sufficient to reach the recommended location of the AP in some areas. In such scenarios, the site survey engineer will have to be creative. There are many possible solutions to this problem, including the following:

- Wirelesses hop using a repeater talking back to a wired AP;
- A repeater or a hub can extend the Cat5 cable run;
- A fiber link with fiber to copper media converter can be used to provide connectivity to the distant areas.

It is a responsibility of a site survey engineer to find the best locations for the APs and the ways to connect the APs to the wired network based on the customer's requirements for desired wireless areas of coverage. Therefore, it is crucial that the engineer has an understanding of wired networks. This understanding should cover wired LAN topologies, standards, and components (Alexander, 2004). To properly assess customer's existing network infrastructure and evaluate desired area of wireless coverage, as well as blind spots in the facility, it is critical to conduct a site walkthrough. The customer should conduct the walkthrough and acknowledge any requirements or concerns. A site walkthrough also helps to locate any possible sources of radio frequency interference (RFI), electro-magnetic interference (EMI), environmental, or construction issues by looking for other antennas or high-voltage electrical motors. Some elements of the environment that define the possible coverage for the area include the following (Alexander, 2004):

- Other WLANs;
- High voltage electrical motors;
- Corrugated steel walls or ceilings;
- Amount of rebar in the concrete;

- Metal oxide window tinting;
- Inventory such as materials and supplies.

Taking all above into consideration, a site survey engineer can create a new site layout based on the drawings, identifying the coverage desired and issues found during the walkthrough. By providing the customer with a detailed site survey report, an Information Technology (IT) manager can turn specific installation portions over to a local contractor. The contractor can install any cabling needed to provide WLAN devices connectivity to the network. The contractors need a site survey that provides detailed information about where the APs are to be located, how they will be mounted, how they will be connected to the network, and where any cabling or power may need to be installed. At the same time, preparations can be made on the customer's network for the upcoming installation (Alexander, 2004). It is highly desirable to identify potential problems up front and discuss with the customer how these issues will be handled. This discovery can potentially save a lot of time and troubles during the installation. It is a good practice to begin a site survey with a pre-site survey document completed by the client. The pre-site survey document will help to determine what type of a survey needs to be conducted, how many days it can take, what equipment may be required, and what questions need to be asked during the walkthrough. A pre-site survey document is an introduction to the client's facility.

Chapter III: Methodology

Subject Selection and Description

BMI is one of the US largest manufacturers of construction materials. Geographical locations of its plants are highly dispersed. The total number of plants located in the United States is 77. To simplify data collection about each plant, a pre-site survey questionnaire form was redistributed among all 77 plants. It is beyond the scope of this study to provide recommendations for all 77 plants. Only one plant will be analyzed in this study, and recommendations for only LAN upgrade in this plant will be provided.

Instrumentation

The following equipment was used to conduct site survey: a digital camera, measuring wheel, and laptop computer. A template was created to organize data collection (Appendix C). The hard copies of this template (one template per one network closet) were used to collect data from each location.

Data Collection Procedures

The approach to a site survey consisted of three phases: site survey preparation, site requirements discovery, and conducting site survey. Each phase required detailed data collection and active customer participation. A site survey preparation began with collecting all the relative information about the customer and the site. A pre-site survey questionnaire form was designed to fulfill this purpose and capture the following information:

- The site information. It included site name, address, primary point of contact who is responsible for activities related to the project, his/her phone, fax number, e-mail address, and working hours.

- Current network information: equipment location, network diagram, IP addressing scheme, printer information, list of network devices (routers, switches, and hubs), LAN connectivity (cable infrastructure), routing protocols used, and any WLAN solutions currently deployed.
- The scope of work was determined to detail what network engineer will do to complete a proper job.

The site requirements discovery consisted of collecting facility documentation, such as a site map, desired wireless coverage map, and desired user areas and densities. In addition, the limitations, affecting equipment installation, were obtained. They included wireless area coverage restrictions and environmental concerns. It was determined that the duration of a site survey at the location selected for this study would take two to three days. It took two days to complete site survey. Actual site survey was performed with the following steps:

Day one

- Upon arrival on the site, a scaled copy of a facility blueprint was obtained. A scaled blueprint aided in creating realistically scaled network diagram of current and new plant layouts using Microsoft Visio application.
- The inspection of the facility began with walking through each network closet. Multiple pictures were taken at each network closet. Information indicated in Appendix A was recorded.
- Fiber and copper cable layouts were mapped on the drawing.

Day two

- Visiting designated locations of wireless APs. A wireless site survey was conducted by a third party contractor. The map of desired AP location was created.
- Measurements were taken from each designated AP location to the nearest network closets. Each network closet and the nearest corresponding AP were mapped on the drawing. Due to Cat5 cable length limitation, the distance between the AP and the network closet could not exceed 100 m (328 ft).

Data Analysis

Data analysis consisted of compiling information obtained from each individual network closet and cable network layout. This information was used to create a facility analysis document (Appendix D), and diagrams of Current Plant Layout (Appendix E), New Plant Layout (Appendix F), Current Network Layout (Appendix G), and New Network Layout (Appendix H). Personal experience and review of Cisco literature were used to provide recommendations for LAN upgrade.

Limitations and Assumptions

Limitation and assumptions of this study included the following:

- A WLAN site survey was conducted by a third party contractor.
- This study is focused on a LAN analysis only. It incorporates information regarding WLAN site survey obtained from a third party contractor.
- No real company name or IP addresses can be disclosed for security and privacy purposes.
- Data analysis and recommendations are provided for only one plant due to large number of plants located throughout the USA.

- No universal solution for company wide network upgrade exists. Each plant (site) should be surveyed and analyzed individually due to variety of network scenarios available at each site.
- An assumption has been made that the current Cat5 cable infrastructure complies with IEEE standard.
- The absence of originally documented fiber cable layout posed difficulties identifying fiber cable distribution and forced researcher to rely heavily on the knowledge of IT personal about fiber cable layout.

Summary

All necessary data was collected to perform network analysis. Efficient team work coordination allowed to complete data collection in two days. As it often happens, some little details were overlooked or missed. However, they were not ignored. Direct communication with the network administrator of surveyed site helped to find missing pieces of information and complete thorough facility analysis.

Chapter IV: Results

Data Analysis

The cable infrastructure is the foundation of any network. The study began with the analysis of the existing network cable infrastructure throughout the plant. The current logical fiber and copper cable layouts are displayed in Figures 3 and 5. There were two installations of fiber at this plant. The second fiber installation took place three years ago. It is unknown when the first fiber installation occurred. There is a single location in the plant where an old and new fiber runs meet. This location is Admin4. Also, there are two networks in the facility utilizing the same fiber infrastructure: LAN and Process Line Control (PLC) network. Both networks are completely independent and do not interfere (do not use the same fiber links), except for only one location (Admin15). This issue will be addressed later in the study. It is highly desirable to keep both networks separated. Based on data collected during a site survey, there are currently 20 network closets that are interconnected (Appendix E). Fourteen network closets are interconnected via a fiber cable. Five network closets are connected via a Cat5e cable to the corresponding backbone areas. A general term "network closet" is used to describe each location; however, not every location had a network closet or a data rack. An existing fiber cable distribution is displayed in Appendix A. Appendix A captures a fiber cable source and destination, number of strands available and strands required, as well as number of new strands of fiber required. It is recommended to pull more fiber than required for two reasons: cost effectiveness and link redundancy. Based on the information obtained during a site survey, company will need to install 20 wireless APs in various locations. According to the measurements between APs and nearest network closets, the optimum distribution of APs per nearest network closets is displayed in Appendix F. It was determined that there will be only

nine network closets to which the APs are connected. However, each location will be analyzed and upgraded based on its needs. A pair of Cat5 wires will need to be pulled from each data closet to the AP that it will support. Each pair of Cat5 wires should be terminated with RJ-45 network jacks. Appendix B lists new Cat5 cable requirements. Only one Cat5 cable out of two pulled to each AP will be connected to the AP. It is recommended to pull two cables because one cable represents a single point of failure, and it is more cost effective to pull two cables for the price of one. As it was discussed with the customer, the general rules for upgrading the network closet at each location should be the following:

- If an existing switch/hub is not a Cisco switch, it must be replaced.
- All hubs must be replaced.
- If a switch will be supporting an AP, then it must be a Cisco in-line power switch.
- If the existing switch has four or less available ports, then it should be upgraded or a new switch has to be added for scalability purposes.
- The patch panels should be installed at each location consistently with the current fiber layout.
- If a rack solution may be required, it should be recommended only if there is enough room to accommodate a rack.

The following findings reflect an existing state of each network closet (location) and recommendations:

Admin1. This location is a demarcation point. There are 48 strands of fiber running from Admin1 to Admin2. This location will use a fiber to copper media converter to support AP1 through the Main Fiber Distribution Closet (Admin2). The total number of network devices supported, including APs, is 54. An existing rack has no enclosure. The environmental

conditions are satisfactory and do not require an enclosed rack. There are no major upgrades required at this location.

Admin2. This location is a Main Fiber Distribution Closet. There are no network devices in this place. This location will serve as an intermediary point to connect AP1 to Admin1. A fiber to copper media converter will be used to connect AP1 to Main Fiber Distribution Closet. A power outlet will be required for the media converter. There is a need for two new Cat5e cable runs from this closet to AP1.

Admin3. Although there is no data rack in place, this location currently exists. The device is kept in the ceiling. It is difficult to access the device. A rack is required. The device at this location will not be replaced. It will support three APs (9, 10, and 11). The total number of network devices supported, including APs, is nine. Six new Cat5 cable runs will be pulled to connect to AP9, AP10, and AP11. The switch at this location is connected via two strands of fiber to Admin1.

Admin4. It is the location where an old and new fiber runs meet. The device at this location will not be replaced. A new fiber runs to this location from Admin1. An old fiber comes from Admin7. There are six strands of a new fiber and twelve strands of an old fiber coming into this location. A switch at this location will support AP13. There will be a need for two new Cat5 cable runs between AP13 and Admin4. The total number of network devices supported, including APs, is 18.

Admin5. Although there is no data rack in place, this location currently exists. The switch is housed in a wooden box. It is recommended to install an enclosed rack at this location. The device is connected to Admin4 via a single pair of a fiber cable. There is no need to replace a device at this location. The total number of network devices supported, including APs, is 10. An

existing switch will support AP12 and AP17; therefore four new Cat5 cable runs will be required (two for AP12 and two for AP17).

Admin6. This location has an old D-Link hub, which will require an upgrade to Cisco 3560 24 ports switch. There is no data rack in this place. The environmental conditions at this location require an enclosed rack to house the device. This location will support only one AP3, therefore two new Cat5 cable runs to AP3 will be required. The total number of network devices supported, including APs, is four. Admin6 is connected to Admin4 via a crossover cable. It is recommended to run three pairs of fiber from Admin4 to Admin6. A new fiber will allow to replace the crossover Ethernet cable. In addition, it is recommended to install ST fiber patch panel at this location. Current Cat5 crossover cable connection is less than 100 m and complies with the IEEE standards. It is recommended to upgrade this connection to a fiber, but it is not a mandatory. The customer has to make a decision whether or not they want to run fiber to this location.

Admin7. It is recommended to upgrade the existing data rack at this location to allow full access to the existing fiber patch panel. The fiber patch panel is not accessible in its current state. The network device at this location will support five APs (AP14, AP15, AP16, AP18, and AP19). Ten new Cat5 cable runs have to be pulled (two to each AP). The total number of network devices supported, including APs, is 20. It is recommended to upgrade an existing 24 ports switch to 48 ports switch for scalability purposes.

Admin8. This location has a data rack with no enclosure. The environmental conditions at this location allow keeping an existing data rack. A switch at this location will not be replaced. This is the location where an old fiber is originated. It has enough existing fiber to be reused. It

will support two APs (AP2 and AP8) and require two new Cat5 cable runs to each AP. The total number of network devices supported, including APs, is 18.

Admin9. A switch at this location is housed in the ceiling. Although there is a data rack in place, the copper patch panel is hanging loose. The rack should be replaced with an enclosure in a more accessible location. The switch in this room is connected via a fiber cable to Admin8 location, and the switch in Admin10 is connected to G0/1 (Gigabit interface 1) of this switch. The switch at this location will not be replaced. This device serves as the backbone for four switches located in Admin10, Admin18, Admin19, and Admin20. As indicated above, only switch at Admin10 has a fiber link to Admin 9. The other three locations are connected via a crossover Cat5 cable. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. However, it is recommended upgrading this copper links to a fiber. Also, it is recommended installing 12 ports fiber switch in this location to aggregate four switches: Admin9, Admin10, Admin18, and Admin19. Customer indicated that Admin20 location will be eliminated. The 12 ports fiber switch will then connect back to the existing 12 ports fiber switch in Admin8 location. A copper to fiber upgrade is recommended but not a mandatory. The customer has to make a decision whether or not they want to make an extra investment to upgrade the cable at this location. I believe that a copper to fiber cable upgrade is a long term investment from which client will benefit in the future. The location Admin9 will support four APs (AP4, AP5, AP6, and AP7). The total number of network devices supported, including APs, is 17. There are eight new Cat5 cable runs required (two to each AP).

Admin10. A switch at this location is connected via a fiber cable to Admin9. The device at this location will not be replaced. It will support AP20 and require two new Cat5 cable runs. The total number of network devices supported, including APs, is four. A device rack at this

location has no enclosure; however, environmental conditions allow to keep an existing rack in place. Admin10 switch is connected to G0/1 interface on Admin9 switch via a fiber cable.

Admin11. A switch at this location will not be replaced. Although there is a data rack in place, the device is not placed in the data rack. The rack is not deep enough to house the unit. It is recommended to upgrade the existing rack. The network device at this location is connected via a fiber cable to Admin1. This location will support no APs. The total number of network devices supported is seven.

Admin12. This location currently exists with no data rack. While the equipment in this area could benefit from an enclosed rack, there is not enough room to accommodate it. The network device at this location is connected via a fiber cable to Admin1. It will support no APs. The total number of network devices supported is six. Currently, there is no uninterruptible power supply (UPS) located here. The device at this location will not be replaced.

Admin13. A switch at this location is housed in a wooden box. There is no data rack in this place. It is recommended to install an enclosed rack to house the unit. The network device at this location is connected via a fiber cable to Admin1. There are only two strands of fiber coming into this location. Admin13 also is connected to Admin14 via a crossover Cat5 cable. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. However, it is recommended upgrading this copper link to a fiber. A new fiber can be cross connected from Admin14 into port G0/1 of Admin13 switch. Admin13 switch is utilized to its full capacity. All 24 ports are used. Therefore, it is recommended upgrading an existing switch to 48 ports switch for scalability purposes. There will be no APs installed at this location.

Admin14. Although here is no data rack in place, this location currently exists. The device is kept under a desk located in the corner. A rack is desirable. A room where the device is

housed is small. If the client decides not to install the rack (a rack may take up some working space), then a bigger piece of plywood is required to wall mount a new switch. A network device at this location is a hub; therefore, it will be upgraded to 24 ports Cisco switch. A hub is currently connected via a crossover Cat5 cable to Admin13 switch. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. However, it is recommended installing a new ST patch panel and running three new fiber pairs to Admin13 location to replace the Ethernet cable connection. A new switch will support no APs. The total number of network devices supported is eight.

Admin15. A device at this location is a hub. It serves as an intermediary point between Admin8 and Admin16 locations and provides network connectivity for only one workstation. This location will support no APs. The total number of network device supported is two. There is no data rack in this place. An existing hub is connected via a fiber cable to Admin8 and Admin16 locations. A copper to fiber media converter is used to connect to Admin16 location. A new 24 ports Cisco switch will be installed at this location, and it will eliminate a need for a copper to fiber media converter. There are only two strands of fiber that interconnect Admin8 and Admin15. This fiber belongs to PLC network and is currently shared with LAN. It is highly desirable to isolate LAN and PLC network. It is recommended installing a new ST patch panel and running three new fiber pairs to Admin8 location to separate LAN and PLC network.

Admin16. This location currently exists with no data rack. The device is kept in the ceiling. This location requires a rack. A switch at this location is connected via a fiber cable to Admin15 hub. A copper to fiber media converter is used to accommodate 100Mbps link on a hub at Admin15 location. This media converter will be eliminated when Admin15 location will have

a new switch installed. The device at this location will not be replaced. There will be no APs installed at this location. The total number of network devices supported is five.

Admin17. This location currently exists with no data rack. A network device at this location is connected via a crossover Cat5 cable to Admin8 switch. It is recommended installing a new ST patch panel and running three new fiber pairs to Admin8 location to replace the existing Ethernet cable. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. The new fiber link recommendation is not a mandatory. An enclosed rack is desirable to house the switch. The switch will not be replaced. It will not provide the connectivity to any APs. The total number of network devices supported is eight.

Admin18. This location currently exists without a data rack. The device is kept in the ceiling. It is impossible to access the device. A rack is required. The network device at this location is connected via a crossover Cat5 cable to Admin9 switch. The switch will not support any APs. The total number of network devices supported is 20. In near future, this location will provide network connectivity for three more users currently located in Admin20 area. The location Admin20 will be eliminated. Therefore, it is recommended upgrading an existing 24 ports switch to a new 48 ports switch. Also, it is recommended installing a new ST patch panel and running three new fiber pairs to Admin9 location to replace the existing Ethernet cable. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. The installation of a new fiber link is highly desirable but not a mandatory.

Admin19. A switch will not be replaced at this location. It currently supports 12 users. It will support no APs. There is no data rack. The area, where the equipment is kept, is very small. There are steel cabinets and steel walls surrounding the equipment at this location. It will be problematic installing a rack here; therefore it is not recommended. A switch is connected via a

crossover Cat5 cable to Admin9 switch. It is recommended installing a new ST patch panel and running three new fiber pairs to Admin9 location to replace the existing Ethernet crossover cable. Current Cat5 cable connection is less than 100 m and complies with the IEEE standards. Therefore, a new fiber link recommendation is not a mandatory.

Admin20. This location currently exists without a data rack. A hub is housed in the ceiling and connected to Admin9 via a crossover Cat5 cable. There are only three users at this location. The customer indicated that this location will be completely eliminated. The users will be connected to Admin18 switch. Therefore, no recommendation is necessary for this location.

The information above was presented to the client in format displayed in Appendix D. This format was used to present a summary of findings and recommendations along with a picture of the current state of each location and a snapshot of a new network plant layout. It also lists components required, such as type of fiber patch cables necessary to connect the new switches to the patch panels.

There are three type of switches that were recommended to the client based on a particular need: Cisco 3560 48 ports switch (WS-C3560-48PS-S), Cisco 3560 24 ports switch (WS-C3560-24PS-S), and Cisco 3570 12 ports switch (WS-C3750G-12S-S). A rack solution at each location was recommended based on a type of switch(s) and number of devices currently installed at each particular location. The majority of network closets have Cisco 3550 switches installed. These switches have larger dimensions than Cisco 3560 switches. Therefore, it is recommended to use two different models of Rittal racks. Each model has three different form factors to accommodate various numbers of device units: 12U, 15U, and 21U. Rittal racks are rated for NEMA-12 standard. Also, the facility analysis document included: 1) current IP network addressing, 2) current static IP address assignments, 3) current equipment list, 4) new

equipment list, and 5) summary table of areas requiring the enclosure. Four scaled drawings were presented to the client: Current Plant Layout (Appendix E), New Plant Layout (Appendix F), Current Network Layout (Appendix G), and New Network Layout (Appendix H).

Chapter V: Discussion

Limitations

The purpose of this study was to assess an existing network infrastructure at one of the BMI's plants and provide recommendations for LAN upgrade that would support WLAN solutions being deployed companywide. The company has 77 plants throughout the country. However, only one plant was analyzed in this study. It was beyond the scope of this study to provide analysis for all the plants. There are currently only five plants that undergone a site readiness assessment and upgrade. All five plants varied significantly in their existing network infrastructure and readiness for new technology deployment. Additionally, they all varied in size, product lines, and production volume.

Conclusions

The plant selected for this study was one of the largest in its production scale and number of active "network closets". It also required the largest number of APs to be installed compare to other plants. Currently, the surveyed plant has a very contemporary network in place. The total number of Cisco equipment currently installed in the plant represents 81 per cent. There is IPT technology utilized in several administrative areas of the plant. All Cisco switches in the plant have Power over Ethernet (PoE) capabilities. Only seven locations require equipment upgrade (Appendix H). One network closet (location) will be eliminated. There are 12 locations that require a rack solution. It is highly desirable to provide appropriate environmental conditions for the devices to extend their life time and reduce chances of failures. Overall network cable infrastructure is in satisfactory conditions. The existing crossover connections via Cat5 cable between internetwork devices located in remote areas comply with the IEEE standards and do not exceed limitation of 100 m (328 ft). It is recommended upgrading those links to a fiber, but it

is not a mandatory. However, it is a mandatory to upgrade a fiber link between Admin 8 and Admin15 locations. Since a single pair of a fiber in this area is shared between two networks (PLC and LAN), it is highly desirable to separate both. A new fiber run allocated for LAN data only will eliminate a single point of failure, as well as isolate PLC network from LAN. A new pair of Cat5 cable runs will be required between an AP and a corresponding network closet. There is currently no cable management practice in place, except for the three locations: Admin1, Admin7, and Admin10. Other locations have cables hanging loose. A good cable management will allow a network administrator to simplify troubleshooting. Overall state of the network is satisfactory.

Summarizing all above, it is clear that this particular site has to undergo some minor upgrades relative to its network size. It is currently utilizing large number of Cisco equipment with the newest features and ready for the integration of WLAN technology. This integration will extend functionality of the existing network to a higher level and help to improve company's performance, production and inventory processes, as well as customer satisfaction and loyalty.

References

- Alexander, B. (2004). *802.11 Wireless Network Site Surveying and Installation*. Indianapolis, IN: Cisco Press.
- Alexander, B., & Snow, S. (2002). *Secrets to Successful Wireless Deployment*. Retrieved March 5, 2005, from http://www.cisco.com/en/US/about/ac123/ac114/ac173/ac168/about_cisco_packet_feature09186a00800b443b.html
- Barnes, S. (2003). *M-Business: The Strategic Implications of Wireless Technologies*. Boston: Butterworth-Heinemann.
- Faigen, G., Fridman, B., & Emmett, A. (2002). *Wireless Data for the Enterprise: Making Sense of Wireless Business*. New York: McGraw-Hill Professional.
- Keizer, G. (2004). *IDC: Productivity Gains Reason No. 1 For Wireless*. Retrieved March 26, 2005, from <http://www.techweb.com/wire/story/TWB20040630S0007>
- Lambert, R.D. (2003). *Executive's Guide to the Wireless Workforce*. Hoboken, NJ: John Wiley & Sons, Inc.
- Martin, J. (2003). *Dramatic Growth of Wireless Networks*. Retrieved March 12, 2005, from http://www.cisco.com/en/US/about/ac123/iqmagazine/archives/nov_dec_2003/departments/net_index/dramatic_growth.html
- META Group. (2004). *Over 50% of Organizations Will Have WLAN Deployments by 2006*. Retrieved March 26, 2005, from http://www.channelminds.com/article.php3?id_article=2412
- Roshan, P., & Leary, J. (2003). *802.11 Wireless LAN Fundamentals*. Indianapolis, IN: Cisco Press.

Sankar, K., Sundaralingam, S., Balinsky, A., & Miller, D. (2004). *Cisco Wireless LAN Security*. Indianapolis, IN: Cisco Press.

Synergy Research Group. (2004). *Synergy: Switches Sizzle*. Retrieved March 12, 2005, from http://www.unstrung.com/document.asp?doc_id=63047

Schroeder, R., & Flynn, B. (2001). *High Performance Manufacturing: Global Perspectives*. New York: John Wiley & Sons, Inc.

TL Plastics Solves an Inventory Squeeze. (2004). Retrieved March 5, 2005, from http://www.cisco.com/en/US/netsol/ns339/ns444/ns450/networking_solutions_business_case0900aec800e4946.html

Wireless LAN Resource Guide. (2004). Retrieved April 9, 2005, from <http://www.cisco.com/en/US/netsol/ns340/ns394/ns348/netbr09186a0080227beb.html>

Appendix A: Fiber Distribution

<i>Source</i>	<i>Destination</i>	<i>Strands Available</i>	<i>Strands Required</i>	<i>New fiber required</i>
Admin1	Admin2	48 strands	14 strands	
Admin1	Admin11	6 strands	2 strands	
Admin2	Admin3	2 strands	2 strands	
Admin2	Admin12	2 strands	2 strands	
Admin2	Admin13	2 strands	2 strands	
Admin2	Admin4	6 strands	2 strands	
Admin8	Admin7	36 strands	6 strands	
Admin8	Admin15	0 strands (LAN is on 2 strands of PLC fiber)	2 strands	6 strands
Admin9	Admin8	6 strands	2 strands	
Admin7	Admin4	12 strands	2 strands	
Admin4	Admin5	2 strands	2 strands	
Admin4	Admin6	0 strands	2 strands	6 strands
Admin18	Admin9	0 strands	2 strands	6 strands
Admin19	Admin9	0 strands	2 strands	6 strands
Admin13	Admin14	0 strands	2 strands	6 strands
Admin15	Admin16	6 strands	2 strands	
Admin9	Admin10	6 strands	2 strands	

Appendix B: New Cat5 Cable Requirements

<i>Access Point</i>	<i>Supporting Data Closet</i>	<i>Wiring Needed</i>
Access Point 1	Admin1 (Admin2)	2 Cat5e
Access Point 2	Admin8	2 Cat5e
Access Point 3	Admin6	2 Cat5e
Access Point 4	Admin9	2 Cat5e
Access Point 5	Admin9	2 Cat5e
Access Point 6	Admin9	2 Cat5e
Access Point 7	Admin9	2 Cat5e
Access Point 8	Admin9	2 Cat5e
Access Point 9	Admin3	2 Cat5e
Access Point 10	Admin3	2 Cat5e
Access Point 11	Admin3	2 Cat5e
Access Point 12	Admin5	2 Cat5e
Access Point 13	Admin4	2 Cat5e
Access Point 14	Admin7	2 Cat5e
Access Point 15	Admin7	2 Cat5e
Access Point 16	Admin7	2 Cat5e
Access Point 17	Admin5	2 Cat5e
Access Point 18	Admin7	2 Cat5e
Access Point 19	Admin7	2 Cat5e
Access Point 20	Admin10	2 Cat5e

Appendix C: Template for data collection

LOCATION NAME							
Existing Network Devices							
Device	Module	Qty.	10/100Base-TX Total	In Use	Desc.	Other Total	In Use
Totals:			0	0			
Copper Patch Panels							
Panel Size (# of Ports)	# of Panels	Total					
Total:							
Fiber Connectors (strands, not pairs)							
Destination	Fiber Type	Connector	Total	Used			
Fiber Patch Cables							
Fiber Patch Type	Connectors	Qty.					
Power							
Power Source	NEMA Specification	Building Backup	Total	Used			
How is existing equipment installed/distributed?							
How much space is there for new equipment?							
What kind of cable management is in use?							
Are the patch panels labeled?							
How is the ventilation/cooling of the room?							
How is the room secured?							
Other comments:							

Appendix D: Example of Report Summary per Location

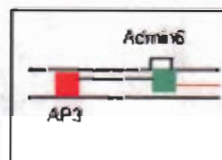
Site Name, Facility Analysis – Network**Admin6**

This location currently exists, although there is no data rack in place. It is connected to Admin4 via a crossover Cat5 cable. We recommend installing ST patch panel and running six strands of fiber to Admin4 to allow for the replacement of the crossover Ethernet cable. Current Cat5 crossover cable connection is less than 100m and complies with IEEE standards. Copper to fiber cable upgrade is recommended but not mandatory.

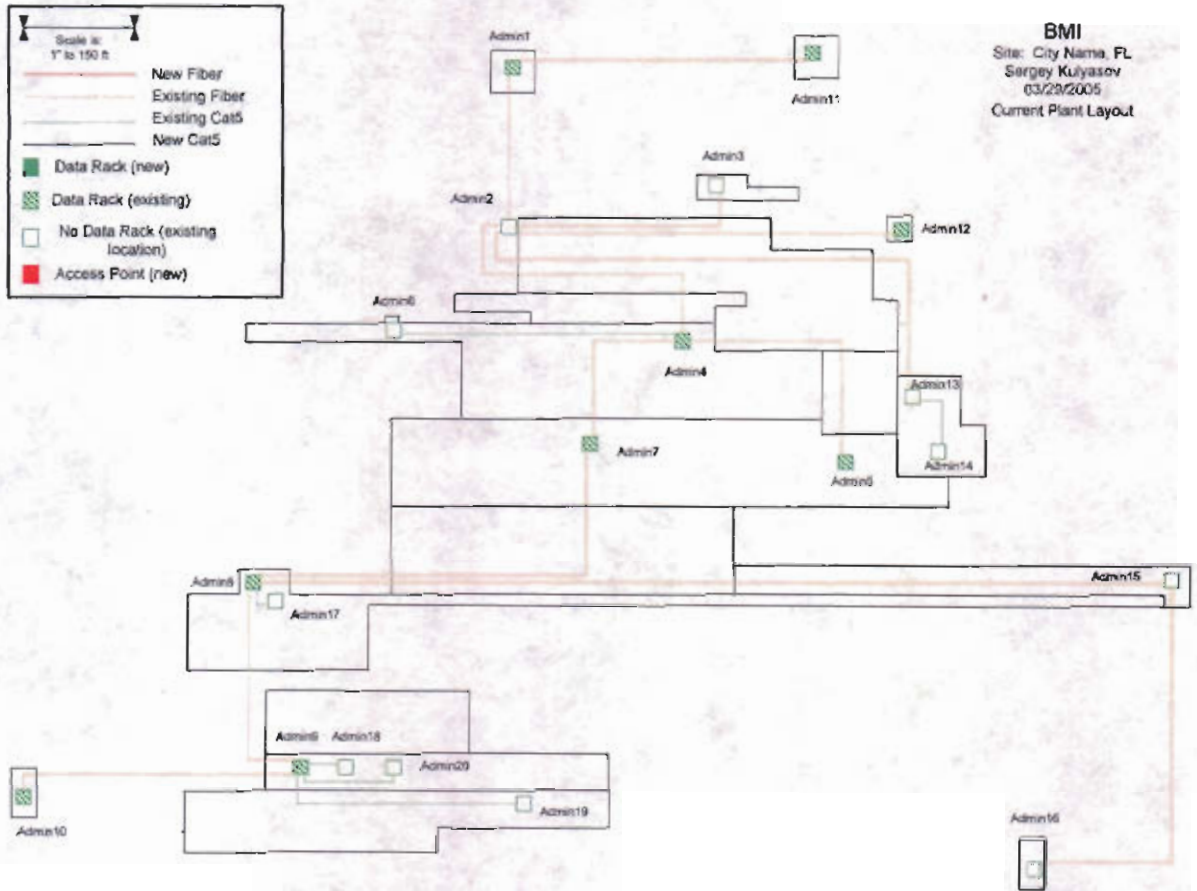
Service Required	
Access Points Supported	AP3
Total office network devices supported (including access points)	4
New Cat5e required	2 Cat5e cable runs to AP3
New Fiber required	6 strands to Admin4

Components Required:	
WS- X3560-24PS, 24port powered switch	1
Rittal Rack 12U Model 226 2605	1
Fiber Patch Cables	1 x LC-ST (3m)

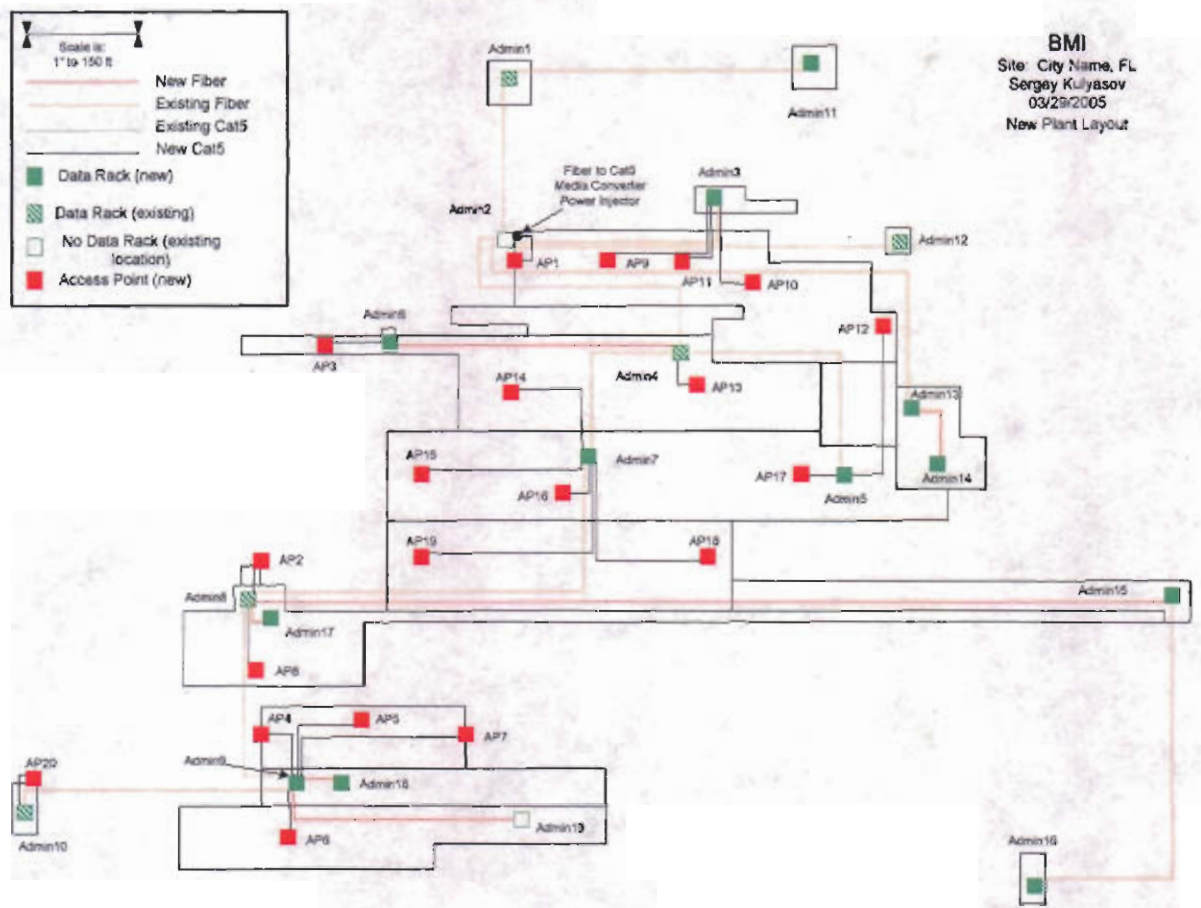
Figure 6. Current picture of Admin6 location.



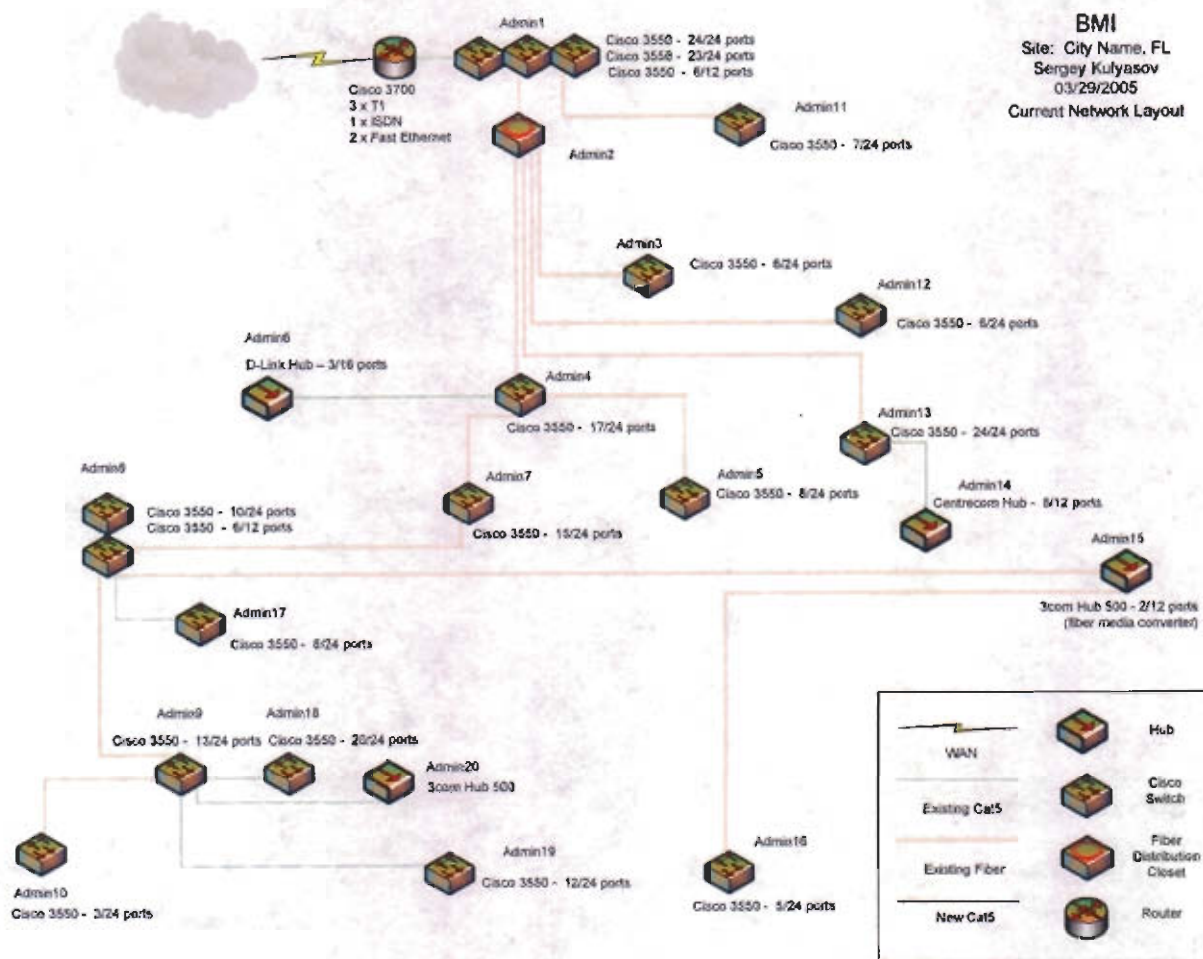
Appendix E: Current Plan Layout



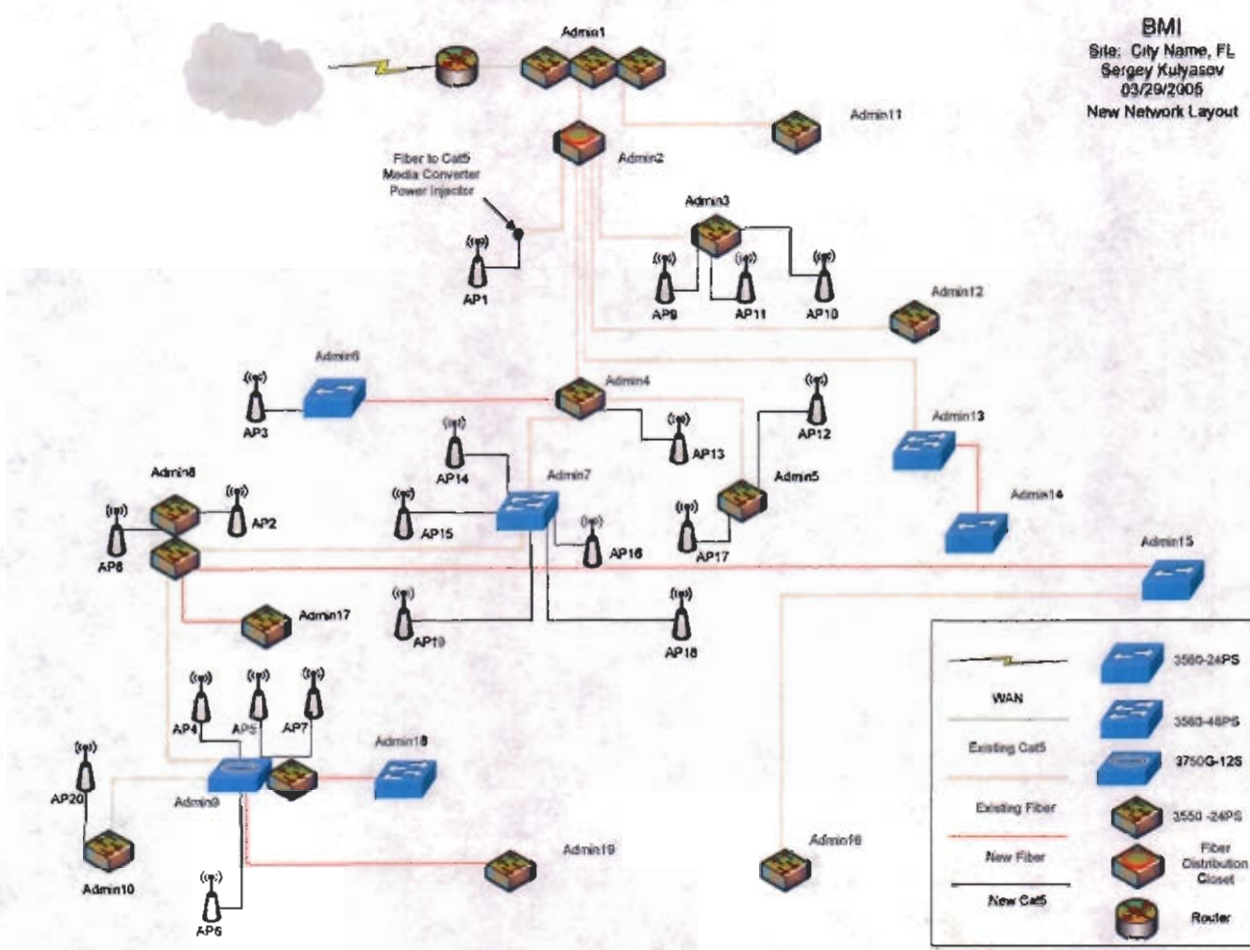
Appendix F: New Plan Layout



Appendix G: Current Network Layout



Appendix H: New Network Layout



BMI
 Site: City Name, FL
 Sergey Kulyasov
 03/29/2005
 New Network Layout