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Design, Development, and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy Case Study

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Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy Case Study

by

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Approval/Signature Page

We hereby certify that this dissertation, submitted by Tracey K. Cooley, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirements for the degree of Doctor of Philosophy.

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An Abstract of a Dissertation Submitted to Nova Southeastern University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study

by
Tracey K. Cooley

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Wireless Local Area Networks (WLANs) offer flexibility, mobility, and scalability to educational institutions. Students are increasingly expecting anywhere, anytime access to online resources. Secondary school administrators, who serve a similar population as the National Job Corps Program (NJCP), realize that student success in the 21st century workplace depends upon the student's ability to use new and emerging technologies, including wireless technology. Computer access anytime and anywhere is crucial to the success of students today.

Wireless technology has been broadly deployed at educational institutions, such as the Hartford Job Corps Academy (HJCA), but little is known about how these networks are deployed and used, specifically at a Job Corps center. HJCA deployed a WLAN in 2005. Information about the core aspects of the design and implementation of anytime, anywhere initiatives, such as wireless solutions in education, is needed to complement the current research. The NJCP does not have a model for standardizing, organizing, and maintaining wireless networks.

The goal of this investigation was to develop a model for planning, designing, and implementing a wireless solution for the Job Corps system. The case study findings from the investigation and the systems development life cycle (SDLC) provided the framework for structuring WLANs at other Job Corps centers. This framework also facilitated the investigation and a determination of the significance of the case study findings, and the analysis and development of the WLAN implementation model for the NJCP. The findings of the HJCA investigation from multiple sources are presented. Using the SDLC framework and the findings from the case study, the NJCP WLAN implementation model is presented. The NJCP WLAN implementation model may be used to facilitate the deployment of WLANs at government-operated, education and training facilities, such as the NJCP.

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Chapter 1

Introduction

Located in Hartford, Connecticut, the Hartford Job Corps Academy (HJCA) is one of the 122 Job Corps Centers (JCCs) funded in excess of $1 billion annually by the U.S. Department of Labor Education and Training Administration (DOL-ETA). Job Corps centers are located throughout the US and Puerto Rico. The Job Corps is administered under the provisions of the Workforce Investment Act of 1998. Individual JCCs are acquired by contractors through a competitive proposal and bidding process. More than 60,000 young adults enroll in the Job Corps each year (Mathematica Policy Research, Inc., 2001); the current enrollment is 40,290 (EIS, 2007). The centers offer continuous enrollment, and self-guided, open-entry, open-exit programs, which allow students to progress at their own pace through standards-based programs.

Since 2005, the HJCA has offered basic education, career technical training, health and dental services, career counseling, and job placement services that provide meaningful living and learning experiences for at-risk, economically disadvantaged young adults between the ages of 16 and 24. The HJCA is contracted for 200 students; this includes 136 residential and 64 non-residential students who can receive driver's licenses, general equivalency diplomas, high school diplomas, and career technical

education in business technology, hospitality, travel and tourism, health occupations, and manufacturing (A. Cardella, personal communication, October 2006).

In December 2005, the Job Corps Data Center (JCDC) began deploying the Job Corps Student Network (JCSN) nationwide. The JCSN supports access to educational and production software supported by the Microsoft™ Office Suite and the Internet. A WLAN provides Job Corps students with anytime and anywhere access to the Internet and learning resources. The HJCA WLAN also supports connectivity to the JCSN and has been fully operational since 2006. At other JCCs, wireless technology is used intermittently during meetings and conferences, on a short-term basis, to provide connectivity to the Internet and e-mail services.

The HJCA campus includes two educational buildings, an administrative building, and a maintenance building as well as a dormitory, cafeteria, daycare center, and a recreational facility. An optical fiber infrastructure enables connectivity among these buildings. An Ethernet LAN supporting 10BASE-T Ethernet is used for connections to desktop computers. The 10BASE-T Ethernet supports transmission rates of 10 Mbps (megabits per second). Wireline connectivity at HJCA is enabled with Category-6 (Cat-6) wiring. The network at HJCA is approximately 90% wireless. All student areas including the dormitory, the two educational buildings, and the recreational facility employ IEEE (Institute of Electrical and Electronic Engineers) 802.11g wireless solutions. The HJCA utilizes three T-1 lines. Each line supports access to the Internet at rates that reach 1.544 Mbps. This provides adequate bandwidth to meet staff, instructor, and student requirements.

Wireless technology is broadly deployed at educational institutions, such as HJCA, but little is known about how these networks are implemented and used (Kotz & Essien, 2005). Information about the core aspects of the design and implementation of initiatives, such as WLAN deployments throughout the JCCs, was needed to complement the current research (Penuel, 2006). The performance of the HJCA WLAN has not been evaluated prior to this inquiry; as a consequence, no implementation model for the other 121 JCCs to use for implementing wireless solutions exist; thereby, leading to haphazard use of wireless technologies.

Statement of the Problem Investigated and Goal Achieved

According to Moody and Schmidt (2004), secondary school administrators recognize that students must be able to use wireless technology and applications to be successful in the 21st century workplace. Moreover, technology skills and knowledge of users must be continually updated in order for them for function in the present-day, fast-paced business environment (Bose, 2004).

Demand for mobile learning (m-learning) with access to educational resources from any point on campus contributes to the importance of WLAN initiatives (Leung & Chan, 2003). M-learning is an approach to electronic learning (e-learning) that uses mobile devices to facilitate learning (Parsons, Ryu, & Cranshaw, 2006). Solutions use mobile devices such as notebook computers, PDAs (Personal Digital Assistants), handheld computers, and 3G (third generation) cellular phones, such as the Motorola V980™ and the Apple iPhone 3G™, that provide anywhere, anytime learning (Park, 2005). The advantages of m-learning include immediacy, expediency, interactivity,

flexibility, and the ability for students to remain connected and not constrained by specific time and place restrictions (Song & Fox, 2005).

According to Fong, Hui, and Lau (2004) and Caverly and MacDonald (2005), WLANs promote the development of new and improved teaching opportunities that enhance the overall learning experience. In Job Corps, center-wide WLAN implementations are rare (L. Estep, personal communication, July 2005), and as noted, factors compacting the effective planning, designing, and implementing a WLAN at JCCs had not been determined. In addition, the JCC staff members lacked the knowledge and expertise to effectively design and deploy WLAN implementations (G. Colvin, personal communication, January 2006).

Capabilities of wireless network solutions in enabling the electronic delivery of information to support education and/or training, and e-learning technologies, such as WLANs, must be further investigated through well-designed research projects as noted by Bose (2004). The author examined the planning, design, development, and implementation of the WLAN at HJCA and the role of this WLAN in facilitating access to the Internet, e-learning applications (Caverly & MacDonald, 2005), and instructional delivery. The goal of this investigation was to develop a model for WLAN implementation for the JC system based on the findings at HJCA. As a consequence, the author examined how HJCA instructors used the WLAN to facilitate teaching and learning. This case study was conducted in accordance with guidelines described by Yin (2003). Findings from this inquiry are described in accordance with the SDLC methodology described by Whitten, Bentley, and Dittman (2001). This framework facilitated the investigation, structured the organization and documentation of the case

study findings, and enabled the development of a WLAN implementation model for the NJCP.

All buildings on the HJCA campus, with exception of the maintenance and cafeteria buildings, are equipped with wireless access points (APs). Each wireless AP provides links to the JCSN, the Job Corps Administrative Network (JCAN), and the Internet. The JCAN is used solely by staff and instructors and the JCSN is for student use.

According to Sotillo (2003), wireless computing is a logical step in providing access to online education applications and resources. The HJCA WLAN offers the expected advantages of a WLAN such as ubiquitous coverage and flexibility in supporting collaborative learning projects and the integration of online applications into virtually every aspect of teaching, learning, and research (Sotillo).

Relevance and Significance for the Study

In older buildings, WLANs are more economical to implement than expanding wired networks (Walery, 2004). As an example, the Spring Independent School District of Houston, Texas selected a wireless solution because the costs of installing between 30 and 35 Ethernet lines at $200 per line to each classroom were prohibitive (Grant, 2005). An effective wireless implementation enables users to access learning resources at any time and from any place and eliminates the need to install a wireline infrastructure for information transmission (Kim, Holmes, & Mims, 2005). Cresskill Junior and Senior High School in New Jersey installed a WLAN to provide more than 800 students and faculty with mobile wireless access to the Internet and online educational resources (Cresskill, 2008). The Santa Clara Unified School District in Sunnyvale, California, is

installing an IEEE 802.11n WLAN to support 25 elementary, middle and high schools, as well as adult education facilities and district offices and over 16,000 users (Santa Clara, 2008).

The type of troubleshooting required with a wireless network is less labor intensive than a wireline network. Since the need for wiring is eliminated, installation, operational, and maintenance costs are reduced (Matsui, Monden, & Mizuno, 2006). Network performance can be disrupted by faulty wiring and damaged connectors in a wired environment as a consequence of errors in configuring hardware and software. In contrast, WLANs are widely used because of ease of administration and maintenance and low cost (Wang & Yow, 2006). According to Moody and Schmidt (2004), a WLAN is a mature technology that provides a positive set of advantages including cross-vendor interoperability, flexibility, mobility, and scalability, as well as interference-free communications over reasonable distances.

According to Chen and Kinshuk (2005), the use of wireless technology in schools has accelerated as a consequence of the popularity of the Internet and e-learning applications. According to Waters (2007), research conducted by Market Data Retrieval in 2005 indicated that 45 percent of K-12 schools used wireless technology. Job Corps is not keeping abreast with technology initiatives such as the use of WLANs that are used in the mainstream education system. Job Corps developed a vision for the 21st Century which reflects the importance of technology in education and job success (Job Corps National Office, 2006).

Each goal outlined in the Job Corps New Vision contains the following objective: identify technology infrastructure and support needs (Job Corps National Office, 2006).

Thus, the Job Corps' vision involves the implementation of technology and e-learning strategies at all 122 JCCs. Wireless solutions at all JCCs can play a pivotal role in achieving these goals and expanding the infrastructure of the entire Job Corps system. See Figure 1 for a map illustrating the location of JCCs throughout the US and Puerto Rico (Job Corps National Office, 2005).

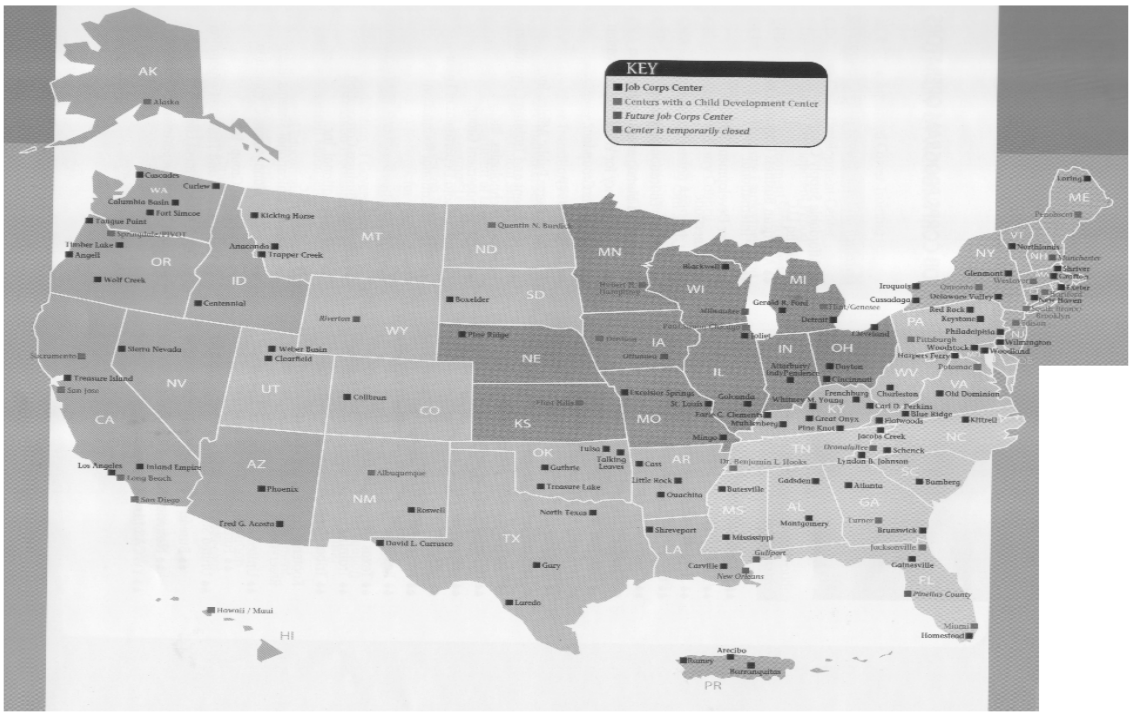


Figure 1. Map of JCCs Throughout the US and Puerto Rico

From "Job Corps Annual Report—PY05," by Job Corps National Office, p. 57

During 2009, the NJCP plans to develop and design a technology infrastructure that supports and enhances the learning experience of all JC students. A critical component of this infrastructure is wireless technology. Wireless deployment is expected to significantly enrich the quality of instruction by providing anytime and anywhere access to the Internet and JCSN e-learning resources.

Barriers and Issues

Security is a major challenge in a WLAN implementation, since WLANs are especially vulnerable to security incursions. According to Maple, Jacobs, and Reeve (2006), in the absence of WLAN security, unauthorized users can steal data or load malicious code onto the network. As a result, WLAN vulnerabilities and security strategies are examined in this investigation.

A popular procedure to enhance security is the use of 128-bit and 256-bit encryption (Moody & Schmidt, 2004). According to Getting (2006), encryption is the process of securing information transmitted over a network by using a code that encrypts and decrypts the data. A bit is a single value of either one or zero. With 128-bit encryption, the length of the key, a series of prime numbers, is 128 bits. Mathematically, there are 2,128 possible key combinations using 128-bit encryption; 256-bit encryption equates to 2,256 possible key combinations (Getting).

The U.S. DOL-ETA (2005) developed an extensive policy for assuring the integrity of the sensitive data that are transmitted via a WLAN. Importantly, the current Security Policy for Portable Electronic Devices and Wireless Technology (U.S. DOL-ETA) describes standards for securing wireless components. The standards in this policy must be in place prior to any full-scale WLAN implementation.

The U.S. DOL-ETA (2005) stipulates that wireless APs must not broadcast Service Set Identifiers (SSIDs). As noted by Chandra, Padmanabhan, and Zhang (2006), the SSID is the name of the WLAN that can be transmitted to unauthorized users who can then gain access to the network (Al Naamany, Al Shidani, & Bourdoucen, 2006). Additionally, the U.S. DOL-ETA guidelines stipulate that wireless APs must not

use the default SSID supplied by the vendor and SSIDs must be set to complex strings that do not identify the location or purpose of the access point and Direct Sequence Spread Spectrum (DSSS) technology must be used.

According to the U.S. DOL-ETA (2005), wireless APs that support IEEE 802.11 authentication must be configured to support this requirement and Tunnel Transport Layer Security (TTLS). Wireless APs must also be configured to support Wired Equivalency Privacy (WEP) to secure access the wireless network, and WEP encryption keys must be changed frequently. The aforementioned statements indicate an out-of-date requirement of WLAN implementation and were addressed during this investigation. Web management must be disabled or restricted to specific management Internet protocol (IP) addresses, and the Simple Network Management Protocol (SNMP) must be disabled or restricted to specific management IP addresses (U.S. DOL-ETA).

This HJCA WLAN implementation, as with all future JCC WLAN implementations, must comply with the guidelines, outlined above, of the Security Policy for Portable Electronic Devices and Wireless Technology established by the U.S. DOL-ETA. During the HJCA investigation, these guidelines were assessed in relation to the standards identified in the literature review.

Research Questions Investigated

According to Yin (2003), establishment of research questions for a case study is the most important step taken in an investigation. The research questions for this investigation were based on Gast (2005), and on seminal works in the field of wireless technology by Littman (2002), Geier (2002), Gast (2002), and Yin (2003). As noted, the performance of the current HJCA WLAN has not been evaluated and there was no model

for the other 121 JCCs to use for implementing wireless solutions. The systems development life cycle (SDLC) provides the framework for the development of a model for WLAN implementation at other Job Corps centers. According to Rogers (2003), potential adopters, the other JCCs, look to early adopters, the HJCA, for advice and information about an innovation, the implementation of a WLAN. Early adopters serve as a role model for other members of a system (Rogers).

The primary research questions investigated in this study were: How can JCCs effectively plan, design, develop, and implement WLANs to facilitate access to the Internet and e-learning resources? How can instructors use the WLAN to facilitate teaching and learning? The following research questions supported the primary research questions and were addressed in this investigation:

Planning Phase or Phase 1

- What were the key factors that supported the decision to implement the HJCA WLAN?
- What factors contributed to the selection of the wireless technology to employ?
- What were the implementation costs?
- How did career technical and academic instruction change with the wireless environment?
- How did student-to-student, instructor-to-student, and student-to-instructor interactivity change with the WLAN solution?

Analysis Phase or Phase 2

- What is the current network design at HJCA?
- How will the physical construction of the HJCA buildings impact WLAN operations?
- What information will be transmitted over the WLAN?
- What applications will be supported by the WLAN?
- How many users will access the WLAN at each JCC?
- Will the WLAN support voice, video, and data transmission?

Design Phase or Phase 3

- How was AP placement determined?
- Does the WLAN design comply with the wireless security standards defined by the U.S. DOL ETA?

Implementation Phase or Phase 4

- Are users with appropriate permissions able to access information using the HJCA WLAN from various locations?
- What modifications to the JCC WLAN design will be required based on the outcome of the HJCA evaluation?
- Has the HJCA WLAN implementation improved student and instructor access to resources?

Support Phase or Phase 5

- What training for instructors, students, and the network administrator will be required for the continued support and use of the HJCA WLAN?

Limitations and Delimitations of the Study

According to Gay and Airasian (2003), a limitation is an aspect of a study that may negatively affect the study but which cannot be controlled. This investigation had several limitations. The investigation was conducted at one point in time in 2008. The data reflected the opinions, WLAN usage, and user experience of staff and students at that point in time. Time was also a limitation in as much wireless applications and technologies continued to evolve during this research. These may affect the generalizability of the study findings to another point in time.

Another limitation was the demographics of the students, instructors, and staff at HJCA. Demographics include age, proficiency with technology, and educational background. Since student, instructor, and staff demographics vary by center, the generalizability of the findings from this case study at HJCA could vary slightly when the findings are applied in different JCCs. Since HJCA, like all JCCs, operates in accordance with standardized federal operating procedures and security protocols (DOL-ETA, 2005); this poses a significant delimitation to this study.

Definition of Terms

The following terms are central to this investigation:

10BASE-T Ethernet: IEEE 802.3 standard for Local Area Networks (LANs). IEEE 802.3-compliant LANs use twisted-pair wire and support transmission rates at 10 Mbps (Sharpened, 2007).

Authentication: The process of identifying a network user based on a username and password (Sandsmark, 2005b).

Bandwidth: Wireless devices operate in a certain frequency band. Each band has an associated bandwidth or the amount of frequency space in the band (Gast, 2005). The speed of wireless networks is constrained by the available amount of frequency space (bandwidth) (Gast, 2002).

Category 5/6 Wire (Cat-5/6): Consists of four twisted pairs of copper wire terminated by Registered Jack-45 (RJ45) connectors. Cat-5 wiring operates in frequencies up to 100 Megahertz (MHz) and speeds up to 1 Gbps. Cat-6 cabling supports Gigabit Ethernet LAN configurations (Networking Terms, 2008).

Complementary Code Keying (CCK): A modulation technique that works in conjunction with DSSS that transforms data blocks into complex codes in IEEE 802.11b WLANs (Gast, 2005).

Direct-Sequence Spread Spectrum (DSSS): A spread spectrum technology that spreads a signal over a wide frequency band for transmission. (Gast, 2005). DSSS enables transmission rates reaching 11 Mbps (Gast).

Distributed Coordination Function (DCF): An IEEE 802.11 quality of service (QoS) support function based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) that allows a wireless station to send data only after sensing a free transmission medium (Fan, Huang, & Tseng, 2006).

Encryption: A reversible transformation of data from plain text to cipher text as a means for protecting the data's confidentiality. (Tech Web, 2008). Encryption is seen as a major tool in the line of defense of WLANs (Li & Garuba, 2008). Encryption ensures the

integrity by enabling data to be transmitted between a wireless AP and a user's device (Sandsmark, 2005b).

Ethernet: Transmission rates vary between different types of Ethernet LANs (Littman, 2002), including Ethernet, Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet. There are two primary forms of Ethernet, 10Base-T and 100Base-T. A 10BaseT Ethernet connection supports a transmission rate of up to 10 Mbps via a copper wire (Sharpened, 2007). A 100BaseT Ethernet or Fast Ethernet connection supports transmission rates of up to 100 Mbps (Sharpened). Gigabit Ethernet supports data transmission rates up to 1 Gigabit per second (Gbps). A 10 Gigabit Ethernet supports transmission rates up to 10 Gbps (Tech Wire, 2008).

Extensible Authentication Protocol (EAP): An IEEE 802.11 protocol that allows transmission of security authentication data between a server, wireless AP, and a wireless client (Maple et al., 2006). Wi-Fi Protected Access (WPA) and Wi-Fi Protected Access 2 (WPA2) utilize EAP to ensure authentication (Maple et al.).

Frequency-Hopping Spread Spectrum (FHSS): A spread spectrum technology, FHSS modulates the data signal with a carrier signal that hops from frequency to frequency over a wide band of frequencies (Geier, 2002). FHSS supports secure operations by transmitting data over a range of frequencies (Davis, 2006).

IEEE Wireless Standards (IEEE 802.11): In 1997, IEEE (Institute of Electrical and Electronics Engineers) finalized the initial standard for WLANs. The IEEE 802.11 specification and its extensions, namely IEEE 802.11a/b/g/e/i/n, specify an over-the-air interface between a wireless client and a base station or access point. The IEEE 802.11 specification and its extensions describe operations at the both the Physical (PHY) Layer

or Layer 1 of the Open System Interconnection (OSI) Reference Model, and Media Access Control (MAC) Layer or Layer 2 of the OSI (Overview, 2007). The IEEE 802.11a extension uses Orthogonal Frequency Division Multiplexing (OFDM) spread spectrum technology supporting transmission rates of 6 to 54 Mbps (Megabits per second) in the 2.4 GHz (Gigahertz) frequency (Stephens, 2005 & Khan, Iniewski, Wang, Schlegel, & Myint, 2006). The IEEE 802.11b extension uses Direct Sequence Spread Spectrum (DSSS) with Complementary Code Keying (CCK) for supporting transmission rates of 5.5 to 11 Mbps in the 2.4 GHz frequency (Stephens & Khan et al.). DSSS is a spread spectrum technology that spreads a signal over a wide frequency band for transmission. (Gast, 2005). DSSS enables transmission rates reaching 11 Mbps (Gast). CCK is a modulation technique that works in conjunction with DSSS that transforms data blocks into complex codes in IEEE 802.11b WLANs (Gast). IEEE 802.11g uses DSSS with CCK, as well, supporting transmission rates of 6 to 54 Mbps in the 2.4 GHz frequency (Stephens & Khan et al.). IEEE 802.11n uses Multiple-input, Multiple-output (MIMO) spread spectrum supporting transmission rates of at least 100 Mbps in the 2.7 GHz and 5 GHz frequencies (Stephens & Khan et al.). All WLAN specifications support WEP and WPA security. In addition to these extensions, IEEE 802.11e provisions Quality of Service (QoS) and IEEE 802.11i addresses wireless network security. IEEE 802.11e defines two control functions to maintain transmission quality: the distributed coordination function (DCF) and the point coordination function (PCF). According to He, Sundararajan, Datta, Derke, and Mitchell (2005), IEEE 802.11i provides mutual authentication between a wireless AP and a user's device prior to connectivity to the WLAN.

Lightweight Extensible Authentication Protocol (LEAP): An implementation of EAP that supports dynamic WEP key generation and fixed password user authentication (Bhagyavati, Summers, & Dejoie, 2004).

Orthogonal Frequency Division Multiplexing (OFDM): A spread spectrum protocol that divides high-speed signals into multiple lower-speed sub signals thereby enabling transmissions at different frequencies in parallel (Geier, 2002).

Point Coordination Function (PCF): An IEEE 802.11 QoS support function that enables contention-free data transfer based on a priority mechanism (Gast, 2005). PCF enables time-bounded services that support the transmission of voice and video (Geier, 2002).

Protected Extensible Authentication Protocol (PEAP): An implementation of EAP that creates an encrypted Secure Sockets Layer/ Transport Layer Security (SSL/TLS) tunnel between the client and authentication server and serves as a secure protocol for WLANs (Landry & Richard, 2004).

Quality of Service (QoS): A guaranteed throughput level that ensures data transmission from one place to another and processed within a specified amount of time (Tech Wire, 2008). The IEEE 802.11e extension addresses WLAN QoS (Manitpornsut & Landfeldt, 2006).

Service Set Identifier (SSID): A name, consisting of 32 characters, that uniquely identifies a WLAN (Tech Wire, 2008). The default SSID for a wireless AP must be changed; otherwise, unauthorized users can access the WLAN. Additionally, the wireless AP's broadcast mode, which broadcasts the SSID, should be disabled (Park & Dicoi, 2003) to secure WLAN access.

Systems Development Lifecycle (SDLC): A five-phase methodology consisting of Phase 1 or the Planning Phase, Phase 2 or the Analysis Phase, Phase 3 or the Design Phase, Phase 4 or the Implementation Phase, and Phase 5 or the Support Phase (Whitten et al., 2001).

Thin Client (TC): A network computer that lacks a hard drive (Sharpened, 2007).

Transport Layer Security (TLS): A security protocol that provides privacy and data integrity assurances between client and server applications while communicating over the Internet (Tech Web, 2008).

Virtual Private Network (VPN): A network that is constructed using a public network, usually the Internet, to connect securely to a private network, such as a corporate network. Security mechanisms such as encryption and firewalls ensure that only authorized users can access the VPN (Sharpened, 2007).

Wi-Fi Protected Access (WPA): A security protocol for wireless 802.11 networks from the Wi-Fi Alliance. It was developed to provide enhanced security from WEP (Tech Web, 2008).

Wi-Fi Protected Access 2 (WPA2): Based on the ratified version of IEEE 802.11i (Gast, 2005), WPA2 provides stronger data protection and network access control than WPA. WPA2 also offers a high level of assurance that only authorized users access a wireless network (Maple et al., 2006).

Wired Equivalency Privacy (WEP): An IEEE 802.11 function that offers privacy of data transmission services similar to those enabled by a wireline network. WEP generates secret shared encryption keys on both the wireless AP and the wireless devices to eliminate disclosure of data and eavesdropping (Park & Dicoi, 2003; Geier, 2002).

Wireless Access Point (AP): A wireless AP is an interface between the wireless network and a wired network and performs wireless-to-wireline bridging functions (Geier, 2002; Gast, 2005).

Wireless Local Area Network (WLAN): A type of LAN that uses high-frequency radio waves rather than wires for enabling transmissions between nodes (Tech Web, 2008). WLANs offer several advantages over fixed, wireline networks, including ease and speed of implementation, maintenance, flexibility, and cost (Gast, 2005).

Summary

HJCA is located in Hartford, Connecticut and is one of 122 JCCs throughout the U.S. and Puerto Rico. HJCA offers education and training for young adults between the ages of 16 and 24. HJCA is contracted for 200 students.

In 2005, the JCDC began deployment of the JCSN. HJCA implemented a WLAN to support connectivity to the JCSN, the Internet, and other learning resources. All student areas at HJCA, including the dormitory, the two educational buildings, and the recreational facility employ IEEE 802.11g wireless solutions. Wireless technology is broadly deployed at educational institutions, such as HJCA, but little is known about how these networks are implemented and used (Kotz & Essien, 2005).

The performance of the HJCA WLAN had not been evaluated prior this inquiry; as a consequence, no model for implementing wireless solutions existed. Job Corps center-wide WLAN implementations are rare and, as noted, factors compacting the effective planning, designing, and implementing a WLAN at JCCS had not been determined. The goal of this investigation was to develop a model for WLAN implementation for the JC system based on the findings in the HJCA case study. The case

study was conducted in accordance with guidelines described by Yin (2003). Findings from this inquiry were described in accordance with the SDLC framework described by Whitten et al. (2001).

The NJCP had developed a New Vision for Job Corps, which included the implementation of technology and e-learning strategies at all 122 JCCs. Wireless solutions can play a pivotal role in achieving this goal.

Security of a WLAN presents considerable challenges to any implementation. At HJCA, security protocols defined by the U.S. DOL-ETA must be followed. These protocols were presented.

The primary research questions investigated in this study were: How can JCCs effectively plan, design, develop, and implement WLANs to facilitate access to the Internet and e-learning resources? How can instructors use the WLAN to facilitate teaching and learning? Seventeen (17) research questions supporting the primary research questions were presented and addressed in this investigation.

Limitations of this investigation included time of the investigation and wireless applications and technologies evolved during the research. Additionally, the demographics of the students, instructors, and staff were another limitation. These factors may affect the generalizability of the study findings to another point in time or another JCC. Since HJCA, like all JCCs, operates in accordance with standardized federal operating procedures and security protocols (DOL-ETA, 2005); this poses a significant delimitation to this study. The definitions of terms that were central to this investigation were presented. A review of the literature is presented in Chapter 2.

Chapter 2

Review of the Literature

The review of the literature provides the foundation for this investigation and a framework for the examination of recent advancements in the field. The topics examined include: (a) landmarks in the development of wireless technologies; (b) relevant wireless technologies; (c) key IEEE 802.11 wireless standard and its extensions; (d) wireless security challenges; (e) thin client technology; (f) virtual local area networks (VLANs); (g) mobile devices; and (h) WLAN implementation. The seminal works by Littman (2002), Geier (2002), and Gast (2002) provide background information for the HJCA investigation.

Landmarks in the development of wireless technologies are described. Wireless technologies relevant to this investigation including infrared, Bluetooth, and spread spectrum technologies, such as FHSS and DSSS, are described. The IEEE 802.11 specification and its extensions a, b, g, and n are introduced. In addition, IEEE 802.11i and IEEE 802.11e are also examined. Since the HJCA implementation uses thin client technology, the author also describes the capabilities of thin client technology.

Landmarks in the Development of Wireless Technologies

According to Wicks and Kemerling (2003), the feasibility of using wireless technology was demonstrated in 1895 with the Marconi radio broadcast. By 1920, radio

stations were established in major cities across the US. In 1971, the first WLAN was implemented in a research initiative called ALOHANET (Aloha Network), sponsored by Defense Advanced Research Projects Agency (DARPA) (History of Wireless, 2006).

During World War II, microwave technology operations in using short radio frequency (RF) spectrum in the upper range of the electromagnetic spectrum for enabling high-bandwidth applications were demonstrated (Littman, 2002). Russia's Sputnik I was the first satellite in space, followed by the US satellite, Explorer I. Satellite communication technology was proposed by Arthur C. Clark in 1945. Spread spectrum was patented in the early 1940s by Hedy Lamarr (Davis, 2006). The IEEE 802.11 Working Group, organized in September 1990, completed the IEEE 802.11 specification in late 1997 (Stephens, 2005). According to Gast (2005), early adopters of wireless technologies included companies such as logistics organizations United Parcel Services (UPS™) and Federal Express (FedEx™), hospitals, and educational institutions.

Relevant Wireless Technologies

Wireless technologies that are relevant to this investigation and future WLAN deployment at JC locations include infrared, Bluetooth, and spread spectrum. The capabilities, merits, and limitations of these technologies are therefore described.

Infrared Technology

The Infrared Data Association (IrDA) standard is available on laptops, 3G cellular phones, PDAs, and wireless personal area network (WPAN) configurations (Ailisto et al., 2006; Kawashima & Cair, 2005).

According to the IrDA standard, the maximum data rate is 16 Mbps and the operating range varies from .2 to 5 meters. A line-of-sight is required for transmissions between devices (Ailisto et al., 2006). According to Gast (2005), infrared transmissions are blocked by walls, partitions, and other construction. IEEE 802.11 WLANs use radio waves for transmission that can penetrate most office obstructions (Gast).

Bluetooth Technology

Bluetooth is a low-power, short-range wireless network protocol that uses frequency hopping spread spectrum (FHSS) technology (Gast, 2005; Scott, Sharp, Madhavapeddy, & Upton, 2005). This technology operates in license-free frequencies for instance, between the 2.4 and 2.4835 GHz spectral bands (Vaha-Sipila & Virtanen, 2005), and is commonly used in WPANs. The Bluetooth Baseband Specification describes point-to-point connection establishment as a procedure that involves device discovery and device connectivity (Scott et al., 2005).

In educational environments, Bluetooth technologies provide students and instructors with the option of accessing class-related material on handheld, wireless devices in WPAN configurations (Park, 2005). Bluetooth is used in educational settings to enable classroom response systems (Lichti, 2006). Purdue University, for example, deployed a Bluetooth-based classroom response system for communication instead of infrared. According to Lichti (2006), the major advantages of Bluetooth over infrared include eliminating the need for a student to point their response pads at a receiver due to the line-of-sight limitation of infrared technologies; increasing the number of students

who can use the system simultaneously; and enhancing the reliability of data transmission.

Spread Spectrum Technology

Spread spectrum transmissions spread a signal over a wider-than-normal range of frequencies to prevent jamming or signal interception (Davis, 2006). Wireless networks that employ frequency hopping spread spectrum (FHSS) and direct sequence spread spectrum (DSSS) technologies typically use the Orthogonal Frequency Division Multiplexing (OFDM) protocol (Davis). OFDM divides high-speed signals into multiple lower-speed sub signals thereby enabling transmissions at different frequencies (Geier, 2002).

In FHSS transmissions, the data signal modulates with a carrier signal that hops from frequency to frequency over a wide band of frequencies (Musa & Sadiku, 2006). By transmitting data over a range of frequencies, FHSS supports secure operations. According to Musa and Sadiku, FHSS provides transmission rates reaching 3 Mbps.

With DSSS transmission, a data signal is spread over a wide frequency band to increase the signal's resistance to interference (Gast, 2005). DSSS supports transmission rates that reach 11 Mbps (Lee, Marshall, & Zhou, 2006). The advantage to employing DSSS is that when some channels are blocked by interference or by other devices using those channels at the same time, the receiver can reconstruct the original bit from the portion of the transmission that successfully came through (Davis, 2006). According to Davis, DSSS significantly improves network reliability in comparison to FHSS.

Complementary code keying (CCK) is a modulation technique that works in conjunction with DSSS. According to Gast (2005), CCK encodes 4 bits per second (bps) onto an eight-chip spreading code. The mathematics underlying CCK encoding allows receivers to distinguish between different codes easily (Gast). Introduced in the first draft of the IEEE 802.11 specification, DSSS became popular with the introduction of the IEEE 802.11b extension (Stephens, 2005). In accordance with the U.S. DOL-ETA Security Policy for Portable Electronic Devices and Wireless Technology guidelines, the HJCA wireless network must employ DSSS (U.S. DOL, 2005).

The IEEE 802.11a/g WLANs use OFDM to achieve transmission rates of up to 54 Mbps (Dekleva, Shim, Vashney, & Knoerzer, 2007). OFDM divides an available channel into several subchannels and encodes a portion of the signal across each subchannel (Gast, 2005). In addition, OFDM enables transmissions at different frequencies (Gast). According to Lin, Pan, Shieh, and Shi (2006), OFDM has the highest frequency usage ratio and is easily implemented. Dekleva et al. indicate that OFDM is likely to be the protocol of choice for high bit rate LANs.

Key IEEE 802.11 Wireless Extensions

The IEEE 802.11 specification and its extensions, including IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, and most recently, IEEE 802.11n, IEEE 802.11i, and IEEE 802.11e, establish the framework for broadband fixed wireless access (FWA) LAN implementations (Khan et al., 2006). The IEEE 802.11 Working Group (WG) issued its first draft of the WLAN specification in 1997 (Stephens, 2005). WLANs operate at the Physical Layer (PHY) Layer or Layer 1 of the Open System Interconnection (OSI) Reference Model and the Data Link Layer (DLL) or Layer 2 (Fernandez, Jawhar,

Larrondo-Petrie, & VanHilst, 2004). The DLL is divided into the Media Access Control (MAC) Layer and the Logical Link Layer (LLC). WLANs operate at the MAC Layer of the DLL (Fernandez et al.). The OSI Reference Model is a set of protocols that attempt to define and standardize the data communications process (OSI Reference Model, 2008). It is comprised of seven layers: physical, data link, network, transport, session, presentation, and application (Geier, 2002).

IEEE 802.11a

Developed in 1999, IEEE 802.11a facilitates transmission of bandwidth-intensive voice, video, and data at rates up to 54 Mbps (Gast, 2005). According to Calafate, Manzoni, and Malumbres (2005), IEEE 802.11a operates in the 5 GHz RF band and uses the OFDM protocol. Park and Dicoi (2003) determined that IEEE 802.11a-compliant WLANs are not compatible with IEEE 802.11b-compliant WLANs.

IEEE 802.11b

Introduced in 1999, IEEE 802.11b facilitates broadband fixed wireless access (FWA) Ethernet LAN operations (Gast, 2005) and enables transmission rates reaching 11 Mbps. IEEE 802.11b WLANs operate in the unlicensed Industrial, Scientific, and Medical (ISM) band at 2.4 GHz (Calafate et al., 2005). The typical transmission rates and distances supported by IEEE 802.11b implementations are 100 to 150 feet at 11 Mps; 130 to 150 feet at 5.5 Mbps; and 250 to 350 feet at 2 Mbps (Kapp, 2004).

IEEE 802.11g

IEEE 802.11g-compliant WLANs operate in the 2.4 GHz frequencies (Calafate et al., 2005) while maintaining the high transmission rates provided by IEEE 802.11a-compliant WLANs (Gast, 2005). According to Gretarsson et al. (2005), IEEE 802.11g WLANs facilitate transmission rates reaching 54 Mbps. IEEE 802.11b WLANs and IEEE 802.11g WLANs operate in the same frequencies, therefore, IEEE 802.11g WLANs retain backward compatibility with IEEE 802.11b WLANs (Fuxjager, Valerio, & Ricciato, 2007; Gast, 2005). As with IEEE 802.11a, g and n employ the OFDM protocol (Sidhu, Singh, & Chhabra, 2007). In accordance with the U.S. DOL-ETA Security Policy for Portable Electronic Devices and Wireless Technology guidelines, the HJCA WLAN implementation must use IEEE 802.11g technology.

The maximum transmission rate of 54 Mbps enabled by IEEE 802.11g WLANs drops as the communication range increases. Additionally, Gretarsson et al. (2005) demonstrated that multiple IEEE 802.11g transmissions sent through a common wireless AP can cause channel contention that adversely impacts information throughput. Guaranteed transmission quality is directly affected by the number of wireless APs and their areas of coverage. To guarantee transmission quality, additional wireless APs may be needed to cover the intended service area (Wang & Yow, 2006).

IEEE 802.11e

Wireless network operations degrade as the number of network collisions increase (Villalon, Mico, Cuenca, & Orozco-Barbosa, 2005). As a consequence, IEEE 802.11e defines two control functions to maintain transmission quality: the distributed

coordination function (DCF) and the point coordination function (PCF). The DCF is based on carrier sense multiple access with collision avoidance (CSMA/CA). With DCF, a wireless node can send data only after sensing the availability of an available medium (Fan et al., 2006).

An IEEE 802.11 function, PCF provides contention-free data transfer based on a priority mechanism (Geier, 2002) that supports time-bounded services to support data, voice, and video transport. The PCF is typically not implemented at most access points (Dunn, Neufeld, Sheth, Grunwald, & Bennett, 2006), because PCF is unable to provide high capacity network utilization in combination with quality of service (QoS) assurances (Fan et al., 2006; Manitpornsut & Landfeldt, 2006). Abichar, Chang, and Quia (2006) indicated that DCF did not perform optimally as a consequence of the high collision rate among a large number of nodes. The IEEE 802.11e QoS WG supports development of a standard that addresses QoS at the MAC level in the wireless environment (Ansel, Ni, & Turletti, 2006). This WG intends to decrease end-to-end delay and allocate more bandwidth for multimedia applications that include voice and video streams.

IEEE 802.11e is expected to support the same QoS in WLANs that is provided by wireline Ethernet LAN solutions (Kapp, 2004). IEEE 108.11e describes a hybrid coordination function (HCF) protocol. According to Gast (2005), the HCF protocol enables nodes to maintain multiple service queues and balances access to the wireless medium in favor of applications that require QoS. In addition to being more flexible than DCF and PCF, Ansel et al. (2006) report that the HCF protocol improves QoS support in WLANs. According to Kocielnik (2006), the HCF protocol combines DCF and PCF features and allows users to apply priority to packets transmitted by setting the QoS

control field. This field is part of the MAC header (Calafate et al., 2005). With the HCF protocol, WLAN e-mail transmissions can be given a lower priority than VoIP transmissions. According to Kocielnik, contentions for bandwidth among transmissions are dominated by nodes with high priority.

Approaches for designing and testing QoS mechanisms are also examined in WLAN environments (Villalon et al., 2005). Calafate et al. (2005) reported that prioritizing the routing of WLAN packets significantly improves WLAN performance. Based on simulation tests involving IEEE 802.11e-compliant WLANs, Kocielnik (2006) indicated that the new HCF protocol improved performance by ensuring guaranteed QoS. Importantly, IEEE 802.11e provides QoS support for existing IEEE 802.11a/b/g WLANs while maintaining backwards compatibility with IEEE 802.11a/b/g-compliant WLANs (Xiao, 2006).

In cases where multiple users access a WLAN at a given time, some wireless APs may be overloaded, while others are under loaded. Bandwidth limitations adversely impact WLAN operations. The use of overloaded wireless APs results in throughput degradation (Jabir, Soudan, Krommenacker, & Divoux, 2006).

IEEE 802.11i

According to He et al. (2005), IEEE 802.11i provides mutual authentication between a wireless AP and a user's device prior to connectivity to the WLAN. The U.S. DOL-ETA (2005) issued the Security Policy for Portable Electronic Services and Wireless Technology for use in securing wireless implementations. However, the use of IEEE 802.11i is not a part of this policy.

The IEEE 802.11i Security WG mandates the use of protocols to standardize and enhance wireless encryption. IEEE 802.11i provisions enhanced security as well as supports the use of legacy protocols for backward compatibility to IEEE 802.11a/b/g-compliant WLANs (Al Naamany et al., 2006). The Extensible Authentication Protocol (EAP) is an IEEE 802.11 function standardized by the Internet Engineering Task Force (IETF) (Urien & Pujolle, 2008). EAP allows security authentication data to be passed between a server, a wireless AP, and the wireless client. Maple et al. (2006) report that EAP keeps the network port disabled until authentication is complete. The Protected Extensible Authentication Protocol (PEAP) and the Lightweight EAP (LEAP) are based on EAP.

The Protected EAP creates an encrypted Secure Sockets Layer/ Transport Layer Security (SSL/TLS) tunnel between the client and authentication server and is recognized as a secure protocol for WLANs (Landry & Richard, 2004). SSL/TLS also supports dynamic WEP key generation and fixed password user authentication (Bhagyavati et al., 2004). With fixed password authentication, the WLAN user creates an account password for authentication. According to U.S. DOL (2005) security guidelines, IEEE 802.11i is currently not used at HJCA. Strategies for using IEEE 802.11i are described in Chapter 5.

IEEE 802.11n

Popularly known as Wi-Fi, IEEE 802.11n is a recent extension to IEEE 802.11 (Khan et al., 2006). According to Stephens (2005), IEEE 802.11n defines modifications to both the Physical (PHY) Layer or Layer 1 and Media Access Control (MAC) Layer, or Layer 2 of the OSI Reference Model to provide substantially higher throughput than the

IEEE 802.11a and IEEE 802.11g extensions. In addition, IEEE 802.11n enables WLAN transmissions at 600 Mbps in an area that extends up to 100 meters (Sidhu et al., 2007). Higher transmission rates supported by IEEE 802.11n enhance network performance and enable multimedia applications (Abichar et al., 2006). Further, IEEE 802.11n is backwards compatible with IEEE 802.11a/b/g and operates in the 2.4 GHz and 5 GHz frequency bands (Khan et al.).

In Multiple-input, Multiple-output (MIMO), "multiple-in" means a WLAN device simultaneously ends two or more radio signals into multiple transmitting antennas (Yarali & Ahsant, 2007). "Multiple-out" refers to two or more radio signals coming from multiple receiving antennas. Simply stated, multiple antennas receive more signals and transmit more signals (Yarali & Ahsant). As a result, MIMO increases data rate and improves the robustness in wireless communications (Yarali & Ahsant). MIMO supports transmission rates of at least 100 Mbps in the 2.7 GHz and 5 GHz frequencies (Stephens, 2005 & Khan et al., 2006). Multiple-input multiple-output (MIMO) can be used with higher order modulation to extend the data rate and range of transmission. Khan et al. indicated that a MIMO-enabled IEEE 802.11n receiver is resilient to path loss. Additionally, an integrated design that combines MIMO and OFDM contributes to significant improvement in meeting QoS requirements over wireless networks (Tang & Zhang, 2005). Current and emerging IEEE 802.11n applications include Voice over IP (VoIP), streaming video and music, gaming, and large file transfers (Sidhu et al., 2007). In this investigation, the author describes the use of IEEE 802.11n hardware in future JC initiatives.

Wireless Security Challenges

Ensuring the security of a WLAN deployed at an U.S. DOL-operated facility, such as HJCA is essential. Accessibility to the WLAN must be secure and the WLAN must be used by authorized personnel only. The lack of a physical connection among users of a WLAN enables anyone within the network range to receive data with an appropriate receiver (Prodanovic & Simic, 2007). In the following sections, the author describes the capabilities of Wired Equivalency Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2, and Virtual Private Networks (VPNs) in supporting secure wireless applications and services.

Wired Equivalency Privacy (WEP)

A security protocol defined in IEEE 802.11b, WEP was intended to provide the same level of protection for WLANs as for wired local networks (Prodanovic & Simic). This protocol authenticates a workstation to a wireless AP, but does not include a mechanism to authenticate a wireless AP to the workstation (Sexton, 2007). The security policy for HJCA stipulates that wireless APs must be configured so that all clients are WEP enabled in order to ensure secure access to the wireless network. WEP encryption keys must be changed frequently (U.S. DOL, 2005). Since hackers can easily break WEP, additional security mechanisms must also be put into place (Al Naamany et al., 2006; Xi & Xin-xin, 2007). Thus, WEP is inadequate for meeting HJCA's WLAN security requirements (Sexton; Xi & Xin-xin). A series of articles were published in 2001 that described the vulnerabilities of WEP and the contradictions of the authentication method (Mejia-Nogales, Vidal-Beltrans, & Lopez-Bonilla, 2006). Hole, Erland, and Thorsheim

(2005) recommend the utilization of Wi-Fi Protected Access (WPA and WPA2) and VPNs as alternatives to WEP deployment.

Wi-Fi Protected Access (WPA)

WPA was a temporary solution for a safety improvement to WEP that did not require any upgrades or hardware replacements to existing WLANs (Prodanovic & Simic, 2007). Until the release of IEEE 802.11i for wireless security, WPA represented the most popular and useful solution to wireless security (Maple et al., 2006). WPA is designed to be a software upgrade to existing wireless devices and is compatible with the new IEEE 802.11i standard (Prodanovic & Simic). According to Prodanovic and Simic, WPA has several purposes: (a) to be a strong protective mechanism for wireless networks, (b) to be interoperable, (c) to replace WEP, (d) to enable existing Wi-Fi wireless devices to be upgraded with the new software solution, (e) to be applicable in small, as well as large, wireless networks, and (f) to be applicable immediately. Security protocols which specify security enhancements for authentication, access control, replay prevention, message integrity, message privacy and key distribution are necessary for secure WLAN implementations (Prodanovic & Simic).

Wi-Fi Protected Access 2 (WPA2)

Introduced in September, 2004, WPA2 provides stronger data protection and network access control than WPA, and a high level of assurance that only authorized users can access their wireless networks (Maple et al., 2006). WPA2 facilitates the use of AES (Advanced Encryption Standard) (Prodanovic & Simic, 2007). AES, also known as

the Rijindael Cipher, was developed by Joan Daemen and Vincent Rijmen. AES was adopted by the National Institute of Standards and Technology (NIST) in November, 2001 (Didla, Ault, & Bagchi, 2008; Haney, 2005). AES meets the US government's Federal Information Processing Standards (FIPS) (Li & Garuba, 2008); it became the standard for encryption to protect sensitive information by all US government organizations in May, 2006 (Didla et al.). AES is a symmetric-key block cipher with a block length of 128-bits and a flexible key length of 128, 192, or 256 bits (Didla et al.). The WPA2 authentication server requests a client's username and password before network access is allowed (Hytnen & Garcia, 2006).

Virtual Private Network (VPN)

A VPN is a secure virtual network that uses a combination of tunneling, encryption, authentication, and access control mechanisms to ensure data integrity (Bhagyavati et al., 2004). A VPN enables the interconnection of geographically-separated configurations such as the HJCA network with the Job Corps Data Center (JCDC) network located in Austin, Texas (Chapple, Chawla, & Striegel, 2007).

Entities use wireless VPNs that allow users to access the WLAN only if they are properly authenticated by a custom-generated encryption key that is generated automatically and changed periodically (Hanna, 2005). Wireless VPN access points are not used as part of the HJCA WLAN as a consequence of U.S. DOL-ETA security policy.

Thin Client Technology

At HJCA, thin clients are the primary wireless appliances used on the WLAN. In the thin client computing environment, the client computer acts solely as a display and input device. All WLAN operations are executed on a server (Goldwasser & Letscher, 2005; Kissler & Hoyt, 2005; Tolia, Andersen, & Satyanarayanan, 2006).

Thin client technology offers several advantages in an educational initiative. A thin client costs less than a personal computer (PC). Importantly, a thin client has an average lifespan of five years as opposed to the three-year lifespan of a PC (Ritschard, 2006). A thin client is a solid state device with no moving parts. As a consequence, technical maintenance of numerous thin clients can be maintained from a server (Kissler & Hoyt, 2005). Thin clients are less susceptible to viruses than PCs, do not include hard drives, and provide a higher level of security than PCs by reducing vulnerabilities to viruses, spyware and other malware (Ritschard).

Network administrators manage thin clients remotely from a central computer. By using Citrix™, an administrator can observe, monitor, measure, audit, report and archive information flowing throughout the network. Additionally, a network administrator administers configuration changes, virtually, for thin clients. Thin clients that are corrupted can easily be restored to the original state through an imaging process (G. Colvin, personal communication, November 2006). Imaging enables the conversion of settings, configurations, and applications into a single file that is readily implemented on thin clients (Lewis & Rodgers, 2005; Leamy, Smith, & Chen, 2006).

Virtual Local Area Networks (VLANs)

At HJCA, thin clients are deployed throughout the campus. These clients are connected to a Virtual Local Area Network (VLAN). The IEEE 802.1q specification defines how an Ethernet frame is tagged with a VLAN identifier (Matsui et al., 2006; Papaefstathiou & Papaefstathiou, 2006). The VLAN identifier is associated with a virtual work group (Matsui et al.). In an educational VLAN, network administrators organize students into functional groups and provide access to applications that are appropriate for that functional group (G. Colvin, personal communication, November 2006). The Job Corps' VLAN is used by JC students.

According to Yawelak and Viho (2006), VLANs streamline deployment and enhance security of the network infrastructure. A computer that is physically moved to another location can remain on the same VLAN without necessitating hardware reconfiguration (Yawelak & Viho). HJCA has two Job Corps Student Network (JCSN) servers housed in Austin, Texas. The JCSN is a scalable platform that enables students to access and share electronic information. The JCSN is segregated from the Job Corps Administrative Network (JCAN) in order to ensure system integrity for staff and student users. Within the JCSN, each student can access the Microsoft™ Office Professional Suite and the Microsoft™ Office E-Learning Library. Centralization of software distribution enables timely distribution of software upgrades and careful monitoring of WLAN operations and performance (Goldwasser & Letscher, 2005). Figure 2 illustrates the JCSN structure.

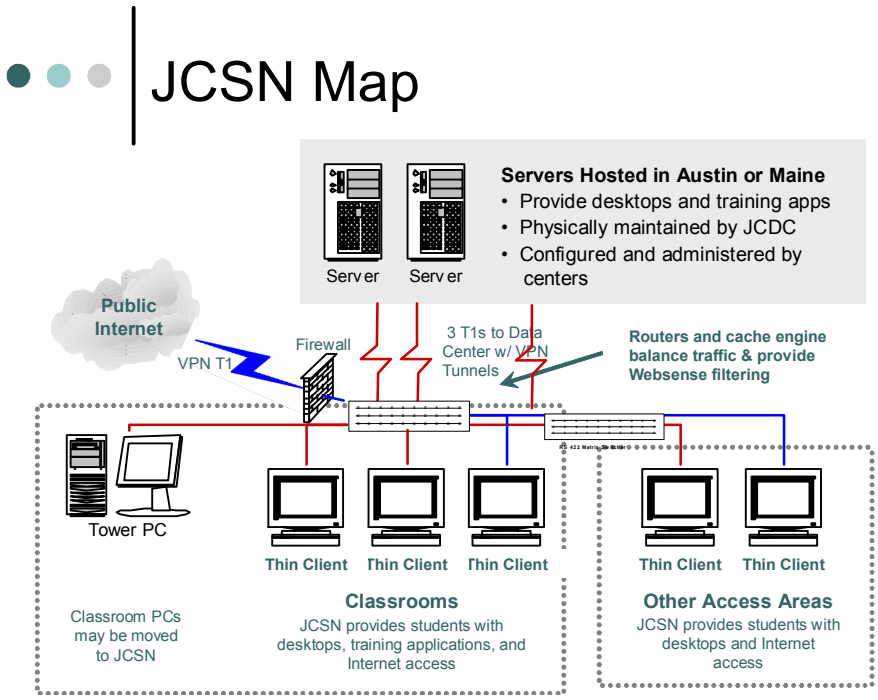


Figure 2. JCSN Structure

From G. Colvin, personal communication, November 2006. Reprinted from permission of the author.

Since Citrix™ offers centralized application management (Citrix, nd), the HJCA network administrator can load and upgrade software onto JCSN servers remotely. In addition, each HJCA student receives a user identification and password upon enrollment in order to access the JCSN. With Citrix™, a single sign-on to all applications is supported (Citrix, nd). Each student is allocated 100 MB (megabytes) of space while enrolled in JC in order to support a cohesive educational environment (Goldwasser & Letscher, 2005). With Citrix™ software, students can access their data from any computer connected to the VLAN. Students do not need to save work on an external Universal Serial Bus (USB) or maintain different computer accounts for different classes (Goldwasser & Letscher). All thin clients for student use are connected to the HJCA WLAN.

Mobile Devices

A WLAN enables the use of mobile devices for m-learning. Providing students with ubiquitous access to wirelessly connected computers has the potential to transform learning environments and improve student learning outcomes (Penuel, 2006). The use of mobile devices such as PDAs, laptops, and cellular phones for teaching and learning is not supported by the NJCP or the HJCA WLAN. The future of WLAN deployment in the NJCP presents many possibilities. With the planned introduction of the SABA™ learning management system (LMS) in 2009 at JCCs, enhanced communications and mobile technology will offer new options to reshape instruction and enable new activities in classrooms and informal learning (Verdejo, Celorrio, Lorenzo, & Sastre, 2006). As a platform for managing various aspects of teaching and learning, an LMS can support e-mail, instant messaging, discussion forums, chat; and file upload and download; and file sharing (Beck, 2005).

According to Liang, Liu, Wang, and Chan (2005), one student with one mobile device, or 1:1 computing, will be the future and long-term trend in computer use in education. With a 1:1 educational computing implementation paradigm; every student with a mobile device can participate in various learning activities (Liang et al.). Several possible applications for PDAs in the JC learning environment exist. For example, a classroom response system (CRS) is a software application that can be loaded onto a PDA. The instructor can pose short questions or multiple-choice questions and the students use the handheld devices to send back answers (Wattinger et al., 2006). A PDA can also be used to download short readings or articles for a student's use. In addition, students equipped with PDAs in the classroom can collaborate with other students on

learning projects using tools such as discussion boards and chat (Wattinger et al.). Handheld devices can also be used by instructors to post data on students' progress in the LMS.

WLAN Implementation

For this investigation, the SDLC (Whitten et al., 2001) provided the framework for WLAN implementation at all JCCs based on the in-place HJCA WLAN case study findings. Additional implementation guidelines in the literature complemented and supported the SDLC.

During the Planning Phase, or Phase 1, of the SDLC, Landry and Richard (2004) recommend that WLANs implementers research and become familiar with IEEE 802.11 and its extensions. Additionally, hardware for the WLAN implementation is evaluated and cost/budget analyses are completed during the Planning Phase.

During the Analysis Phase, Phase 2, and the Design Phase, Phase 3, wireless APs are configured and installed and security protocols are identified. A site survey should be conducted to evaluate WLAN coverage. A site survey also provides the means to map needs to areas in a building (Owen & Farsaii, 2006). During the implementation of the HJCA WLAN, no site survey was conducted; therefore, as part of the HJCA investigation, a site survey was attempted. Since wireless devices connect the access points through channels, care is needed to place the wireless APs to eliminate signal overlap and interference (Owen & Farsaii). Additionally, wireless APs are vulnerable to physical attacks. For example, an individual can reset the wireless AP causing a switch to default settings (Al Naamany et al., 2006). If one wireless AP uses the same channel assigned to a neighboring wireless AP, WLAN performance is significantly degraded by

co-channel interference (Choi, Park, & Kim, 2005); thereby, necessitating reconfiguration. In the IEEE 802.11 specification, multiple orthogonal (the use of different frequencies to transmit a set of data) frequency channels are defined (Wang & Yow, 2006). To reduce interference and maximize spectrum use, Wang and Yow suggest that neighboring wireless APs should operate on orthogonal channels. Based on the site survey, additional equipment and/or reconfiguration of wireless APs may be required. At HJCA, the WLAN security guidelines are outlined in the U.S. DOL ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology as previously discussed.

In 2006, the HJCA experienced problems with its WLAN implementation from interference caused by an adjacent government WLAN installation (J. MacDonald, personal communication, October 2006). As noted by Manitpornsut and Landfeldt (2006), WLANs are limited in terms of frequencies available for transmissions. As a consequence, using the same frequencies in close proximity results in interference. Since the implementation of the HJCA WLAN, the effectiveness of the current WLAN has not been evaluated. The author examined the effectiveness of this WLAN in this investigation.

High School WLAN Implementation

In this investigation, the author examined WLAN deployments in high school settings since JC serves a demographically similar population. JC students range in age from 16 to 24 years. As noted, the JC provides residential education and training programs with funding provided through the U.S. DOL. By contrast, public high schools

are non-residential educational institutions with funding provided through the U.S. Department of Education (U.S. DOE). All JCCs are required to report on a student's success in terms of career technical training achievement, literacy and numeracy gains, as well as general equivalency diploma (GED) and/or high school diploma (HSD) attainment. In addition, employment data, such as placement wage, job training match, and wage at six months and 12 months of employment, are reported.

The following material illustrates various WLAN implementations in public educational settings. The Spring Independent School District of Houston, Texas opted for a wireless solution because the costs of installing 30 to 35 Ethernet lines to each classroom were not feasible or economical. At $200 per line, the cost was prohibitive (Grant, 2005). The Fairfax County Public School System (FCPS) in Virginia implemented high-speed wireless network connectivity in every school in the system. This configuration enabled customized instruction for all students (Cisco, 2005).

The Mount Vernon City School District in New York deployed wireless technology for learner enrichment as well (Sandsmark, 2005a). The Colorado Adams County School District 50 in Colorado invested in a wireless network that covers 32 buildings, 11,000 students, and more than 1,200 teachers and support staff (Ramaswami, 2007). This wireless network consists of 258 wireless APs (Ramaswami).

The Manteca Unified School District, one of the largest public school districts in California, implemented a wireless network with thin clients as the primary wireless appliance (Milner, 2005). The Loomis Chaffee School in Windsor, Connecticut deployed a WLAN providing Internet access to 800 students and 200 faculty and staff. The goal of

this implementation was to increase student flexibility by allowing any space on campus to be used as a classroom (Mitchell, 2006).

Graychase (2008) discusses various implementations of WLANs in school districts across the US. The Talampais Union High School District in California offers wireless access in every classroom; previous efforts were ad-hoc, with staff members providing wireless access points as needed to solve specific access issues (Graychase). At Oak Ridge High School in Tennessee, 170 wireless APs were installed providing wireless coverage across classrooms, administrative areas, and outdoors space for 1500 students and teachers (Graychase). The material presented in this section illustrates that public school systems are embracing wireless technology while the NJCP is significantly behind in the implementation and use of this technology.

Summary of What Is Known and Unknown about WLANs

The problem examined in this dissertation was how to effectively plan, design, develop, and implement a WLAN at HJCA to facilitate access to the Internet and e-learning resources. The goal of this investigation was to develop a model for a WLAN implementation for the JC system based on findings from the HJCA case study. In 1971, the first WLAN was implemented in a research project called ALOHANET (Aloha Network) (History of Wireless, 2006).

Ensuring security has been and will continue to be a challenge for educational entities that implement WLANs. WEP was the first logical solution to secure WLANs, but experienced many problems, which were overcame with the introduction of IEEE 802.11i (Al Naamany et al., 2006). The U.S. DOL ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology

outlined security protocols for JCC WLAN implementation. Written in 2005, the security protocols are outdated and require revision. The HJCA WLAN was implemented in 2005 based on these out-of-date protocols; hence, the need for this investigation.

Existing wireless standards include: IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11e, IEEE 802.11i, and IEEE 802.11n. The HJCA WLAN is IEEE 802.11g-compliant; strategies for employing IEEE 802.11e, IEEE 802.11i, and IEEE 802.11n are not used at JCCs. Wireless technologies and standards continue to be designed and developed; as a system, Job Corps needs to be abreast of advances in and the uses of wireless technology.

The Contribution this Study Makes to the Field

Additional information on the design, implementation, and performance of WLANs in education is needed to complement the current research (Penuel, 2006). The author of this study used the HJCA case study findings to develop a model for planning, designing, and implementing a WLAN for use by JCCs. The model for WLAN implementation provides JC with a network solution that supports the goals and objectives of the NJCP vision for the Job Corps of the 21st Century.

Chapter 3

Methodology

In this chapter, the methodology used in this investigation is presented and the distinctive features of the SDLC are examined. Research methods employed, research questions with propositions, the unit of analysis, instrumentation, format for presenting results, criteria for interpreting the findings, and resource requirements are examined. A discussion of validity and reliability is also presented.

Research Methods Employed

The author used the case study strategy described by Yin (2003) in this HJCA inquiry. A case study is conducted in a real-world context and used for the purposes of demonstration and learning in the field of education (Scholz, Lang, Wiek, Walter, & Stauffacher, 2006). A case study enables examination of contemporary events when the relevant behaviors cannot be manipulated. The author developed case study questions and propositions. Additionally, the author identified the unit of analysis and determined the criteria for interpreting the findings.

The framework for the case study was based on guidelines described by Yin (2003) and the systems development life cycle (SDLC) described by Whitten et al. (2001). This framework was used to facilitate the investigation, organize and document case study findings, and analyze and develop the NJCP WLAN implementation model.

Systems Development Life Cycle (SDLC)

According to Whitten et al. (2001), the SDLC model consists of five phases that include: Phase 1 or the Planning Phase, Phase 2 or the Analysis Phase, Phase 3 or the Design Phase, Phase 4 or the Implementation Phase, and Phase 5 or the Support Phase. In this investigation, the SDLC paradigm supported the development of the model for WLAN deployment throughout the National Job Corps Program (NJCP) based on the HJCA case study findings.

Ideally, prior to deployment of the HJCA WLAN, the scope of the implementation would have been defined, identification of the wireless technologies to be used, and description of the applications to be supported by the HJCA WLAN should have been determined. This was not the case. Planning for a WLAN implementation is critically important (Gast, 2005). As a consequence of the obtained historical data, the planning of the HJCA WLAN may have been haphazardly completed.

In the Analysis Phase, the author analyzed the current HJCA WLAN and determined related problems, the impact of building construction on the WLAN, and WLAN user requirements (Whitten et al., 2001). In addition, the performance of the WLAN implementation was determined by factors, such as, WLAN planning, user requirements and satisfaction, and security guidelines, as specified in accordance with Whitten et al. guidelines.

In the Design Phase, wireless AP placement was defined (Geier, 2002) to determine that adequate WLAN coverage was established. The author also identified the security protocols in terms of the use of IEEE 802.11i and the U.S. DOL ETA Security Policy for Portable Electronic Devices and Wireless Technology.

In the Implementation Phase, the author made recommendations on how the HJCA WLAN should be modified in accordance with the results of the Analysis and Design Phases. An evaluation of the design, implementation, and use of the HJCA WLAN was subsequently conducted. As described in Appendix A, online questionnaires were administered to the student and instructor user groups. The author conducted a face-to-face interview with the HJCA Network Administrator; additionally, a telephone interview was conducted with the NJCP Division Chief of Information and Technology Support.

In the support phase, training requirements for the HJCA Network Administrator and instructors and students were identified through the use of questionnaires and interviews. The need for ongoing technical support for users and maintenance was also determined, as discussed (Whitten et al., 2001).

Propositions

The author established propositions for each research question presented in Chapter 1. According to Yin (2003), propositions direct attention to factors that should be examined within the scope of a study. Propositions for this investigation were based upon the literature. The data collection instruments used in this investigation are presented in Appendix A.

Planning Phase or Phase 1

Proposition 1. The research question to be answered was: What were the key factors that supported the decision to implement the HJCA WLAN? According to Gast (2005), the key factors to consider when deploying a WLAN should include: user experience, costs, coverage area, user density, user population, physical considerations,

application characteristics, and security requirements. The HJCA WLAN should offer the expected advantages of a WLAN such as ubiquitous coverage and flexibility in supporting teaching and learning (Sotillo, 2003). These factors were examined in this investigation. The findings based on research question (RQ) one provided historical data relevant to this investigation.

Proposition 2. The research question to be answered was: What factors contributed to the selection of the wireless technology to be employed? At HJCA, IEEE 802.11g-compatible equipment was employed. Transmission rates that were supported reached 54 Mbps (Gast, 2005). The HJCA WLAN should support instructional resources, software applications, and Internet access. The WLAN technologies, wireless APs and thin clients should be JCDC-approved and configured. The findings based on RQ 2 provided a framework for understanding the factors contributing to the decision for deploying IEEE 802.11g.

Proposition 3. The research question to be answered was: What were the costs of this implementation? As a new JC center, HJCA implemented the WLAN and thin client technology to optimize cost savings because wireless implementations are typically more cost effective than wireline networks. When identifying expenditures, implementation and operational support costs should be considered (Gast, 2005). These include implementation costs such as the costs of the hardware, software, and labor associated with the implementation; and operational support costs such as electricity for hardware, network administration, maintenance, and training. Identifying the costs related to the HJCA WLAN implementation is vital to the future WLAN deployment at other JCCs. The findings based on RQ three provided historical data relevant to this investigation.

Proposition 4. The research question to be answered was: How did career technical and academic instruction change with the wireless environment? According to Lakas, Shuaib, and Boulmalf (2006), e-learning is defined as the use of technology in the teaching and learning process. E-learning is an emerging approach to education that facilitates new instructional methods. One instructional method includes collaborative, problem-based learning (PBL). Students work in groups to study complex, real-world problems. As an instructional method, PBL is easily facilitated in a WLAN environment (Wattinger et al., 2006). Connectivity to the Internet via the WLAN allows students to use Web-based sharing technologies, such as discussion forums, bulletin board systems, e-mail, instant messaging, and chat, to facilitate collaboration (Hsiu-Ping & Wei-Jane, 2005). According to Fong et al. (2004) and Caverly and MacDonald (2005), WLANs should promote the development of new and improved teaching opportunities that enhance the overall learning experience. The findings based on RQ four provided data on the use of the in-place HJCA WLAN.

Proposition 5. The research question to be answered was: How did student-to-student, instructor-to-student, and student-to-instructor interactivity change with the WLAN solution? Interactivity in the classroom should be enhanced within the WLAN environment. For successful e-learning, Bose (2004) suggested that there are three types of necessary interactions: student-content, student-instructor, and student-student. The biggest challenge with WLANs implementation is encouraging instructors to embrace the technology and use the technology to enhance student learning (Milner, 2005). The findings based on RQ five provided data on the use of the in-place HJCA WLAN.

Analysis Phase or Phase 2

Proposition 6. The research question to be answered was: What is the current network design at HJCA? The current network design at HJCA includes the use of thin clients that enable student, instructor, and staff access WLAN resources (J. MacDonald, personal communication, October 2006). Thin clients are the primary wireless appliances used on the WLAN. In the thin client computing environment, the client computer acts solely as a display and input device; all WLAN operations should be executed on a server (Goldwasser & Letscher, 2005; Kissler & Hoyt, 2005; Tolia et al., 2006). Wireless APs are strategically placed throughout student areas such as dormitories, recreation facilities, and the two training buildings. The fiber optic backbone interconnects the buildings and a 10BASE-T Ethernet is utilized for desktop connections (J. MacDonald). The findings based on RQ six provided data on the design of the current HJCA WLAN.

Proposition 7. The research question to be answered was: How will the physical construction of the HJCA buildings impact WLAN operations? A site survey provides the means to map needs to areas in a building (Owen & Farsaii, 2006). During the implementation of the HJCA WLAN, no site survey was conducted; therefore, as part of the HJCA investigation a site survey was completed. Physical construction of a building with metal, for example, can interfere with WLAN performance. Additionally, walls, doors, and windows can interfere with radio signals (Gast, 2005). The author used NetStumbler®, a free, open-source software tool, which can find locations with poor coverage in the HJCA WLAN. In addition, NetStumbler® can detect unauthorized wireless APs, as well as detecting and resolving RF interferences from nearby devices (Clincy & Krithi, 2005). The findings based on the HJCA WLAN site survey provided

data on the impacts of the physical construction on the performance of the current HJCA WLAN.

Proposition 8. The research question to be answered was: What types of information are transmitted over the WLAN? Information transmitted over the HJCA WLAN should include: text, images, streaming video, and streaming audio. Since WLANs are primarily designed for data applications, efficient multimedia communication over WLANs can be challenging (Choudhury, Gibson, Sheriff, & Belding-Royer, 2006). This information will be accessed via the Internet on T1 lines and the JCSN. The findings based on RQ eight provided data on the use of the in-place HJCA WLAN.

Proposition 9. The research question to be answered was: What applications will be supported by the WLAN? The applications supported by the wireless network should include Internet access, Microsoft™ Office suite, and designated electronic educational resources such as typewriting tutors, resume writing software, and academic and career technical software. The findings based on RQ nine provided data on the use of the in-place HJCA WLAN.

Proposition 10. The research question to be answered was: How many users will have access to the WLAN at each JCC? The WLAN implementation at HJCA should support 200 student and instructor users (A. Cardella, personal communication, October 2006). The findings based on RQ 10 provided data on the number of users who access the HJCA WLAN.

Proposition 11. The research question to be answered was: Will the WLAN support voice, video, and data transmission? The HJCA WLAN should support voice,

video, and data transmissions (Choudhury et al., 2006). In the future, the WLAN should support access to and the use of an LMS. The findings based on RQ 11 provided data on the types of information available to instructors, student, and staff who are accessed through the HJCA WLAN.

Design Phase or Phase 3

Proposition 12. The research question to be answered was: How was AP placement determined? Because wireless devices connect the access points through channels, wireless APs should be placed to avoid signal overlap and interference (Owen & Farsaii, 2006). Additionally, wireless APs are vulnerable to physical attacks because an individual can physically reset the wireless AP and cause a switch to default settings (Al Naamany et al., 2006); wireless APs should be placed in areas that are not accessible by students or instructors. The performance of a WLAN can be significantly degraded from channel interference caused by one wireless AP using the same channel assigned to a neighboring wireless AP (Wang & Yow, 2006). This may require reconfiguration. To reduce interference and maximize the usage of the spectrum, neighboring APs should operate at orthogonal channels (Wang & Yow). Wireless APs have a coverage area of up to 300 feet (Clincy & Krithi, 2006)

Geier (2002) recommends positioning the wireless APs above office partitions and away from metal objects such as furniture, fans, and doors. Additionally, Geier suggests that the wireless APs should be installed in a central location, such as the center of a large room or corridor. Wireless AP placement was analyzed through a site survey as part of this investigation.

Proposition 13. The research question to be answered was: Does the HJCA WLAN design comply with the wireless security standards defined by the U.S. DOL-ETA?

As noted, various security protocols can be employed in a WLAN implementation including: WPA, WPA2, VPN, EAP, and PEAP. The HJCA WLAN should meet or exceed the WLAN security protocols outlined in the U.S. DOL Education and Training Administration (ETA) 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology. This policy describes standards for securing wireless components and support users. The standards in this policy must be in place prior to any full-scale WLAN implementation.

The U.S. DOL-ETA (2005) stipulates that wireless APs must not broadcast Service Set Identifier (SSID). U.S. DOL-ETA guidelines stipulate that wireless APs must not use the default SSID supplied by the vendor and SSIDs must be set to complex strings that do not identify the location or purpose of the access point and Direct Sequence Spread Spectrum (DSSS) technology must be used. Additionally, wireless APs that support IEEE 802.11 authentication must be configured to support this requirement and Tunnel Transport Layer Security (TTLS). Wireless APs must also be configured to support Wired Equivalency Privacy (WEP) to secure access the wireless network, and WEP encryption keys must be changed frequently. Web management must be disabled or restricted to specific management Internet protocol (IP) addresses, and the Simple Network Management Protocol (SNMP) must be disabled or restricted to specific management IP addresses (U.S. DOL-ETA).

According to He et al. (2005), IEEE 802.11i supports mutual authentication between a wireless AP and a user's device prior to connectivity to the WLAN. The U.S. DOL-ETA (2005) issued the Security Policy for Portable Electronic Services and Wireless Technology for use in securing wireless implementations. However, the use of the IEEE 802.11i is not a part of this policy. Defining an appropriate wireless security policy is an important faction to achieve overall WLAN security (Al Naamany et al., 2006). Strategies for using IEEE 802.11i were determined in this investigation.

Implementation Phase or Phase 4

Proposition 14. The research question to be answered was: Are users with appropriate permissions able to access information with the HJCA WLAN from various locations? Currently, HJCA does not utilize or support the use of mobile devices such as laptops, PDAs, and cellular phones to access the WLAN. Users should be able to access the WLAN from the dormitories, academic and career technical classrooms, and the recreation facility. A site survey was conducted as part of this investigation. The findings based on the HJCA WLAN site survey provided data on the HJCA WLAN coverage.

Proposition 15. The research question to be answered was: What modifications to the JCC WLAN design will be required based on the outcome of the HJCA evaluation?

Based on the results from the site survey, modifications to the WLAN design may involve reconfiguring wireless APs, and relocating wireless APs for enhanced coverage. Implementing security protocols to meet and/or exceed the U.S. DOL ETA security standards were examined.

Proposition 16. The research question to be answered was: Has the HJCA WLAN implementation improved student and instructor access to resources? According to Chen and Kinshuk (2005), the use of wireless technology in schools has accelerated as a consequence of the popularity of the Internet and e-learning applications. A WLAN implementation should improve access to e-learning resources that include resources on the Internet and the JCSN. The findings based on RQ 16 provided data on how the HJCA WLAN facilitates access to teaching and learning resources.

Support Phase or Phase 5

Proposition 17. The research question to be answered was: What training for instructors, students, and the network administrator will be required for the continued support and use of the HJCA WLAN? Instructors will require additional training on using the WLAN for teaching and learning, and the JC students will require training on using the WLAN to access online resources. According to Penuel (2006), instructors who spend nine hours or more in educational technology professional development activities were more likely than instructors who spent less time to feel well or very-well prepared to use computers and Internet for instruction. The network administrator will also require training on accessing relevant Internet-based resources and monitoring the development and availability of new and emerging WLAN technologies, applications, and enhancements.

Unit of Analysis

The HJCA investigation was an embedded case study design with one unit of analysis. As defined by Yin (2003), a unit of analysis defines what the "case" is in the

case study. The HJCA was the unit of analysis for this case study. Selection of the appropriate unit of analysis was based on the research questions. Yin purports that a common err in case studies is that the data collection sources may be individual people, such as the network administrator, instructors, students, and the Division Chief for Job Corps' Division of Information Technology and Support for the HJCA investigation; whereas the unit of analysis may be organizational, such as HJCA.

Instrumentation

Yin (2003) recommends using multiple sources of evidence when conducting case studies. An advantage of using multiple sources of evidence is the process of data source triangulation. Data source triangulation is the convergence of several different sources of information to support a finding or conclusion (Yin). The more a case study relies on different types of evidence that triangulate on the same finding, the stronger it will be (Yin, 2004). Figure 3 represents the convergence of evidence (Yin) in the HJCA case study.

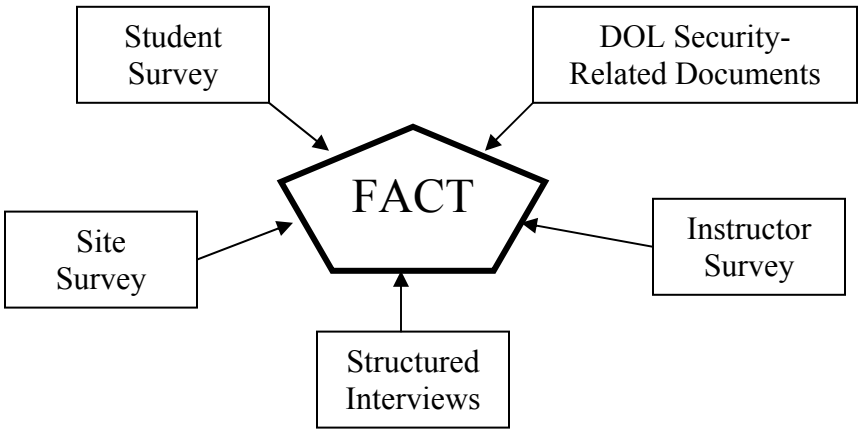


Figure 3. Convergence of Evidence

At noted in Figure 3, the author utilized interviews, questionnaires, printed documents, and a WLAN site survey as sources of evidence; also the author used

qualitative and quantitative research methodologies. Qualitative data, gathered through interviews, observations and printed documents, enabled exploration of complex research areas (Gay & Airasian, 2003). Interviews were essential sources of case study information (Yin, 2003). According to Gay and Airasian, qualitative research focuses on real-world situations such as the investigation at HJCA. Furthermore, descriptive data in the form of interview notes and field notes were the basis for analysis and interpretation (Gay & Airasian).

Quantitative research was conducted through the use of questionnaires. When constructing questionnaire items, Gay and Airasian (2003) recommend that the author knows what information needs to be collected from the questionnaires. Also, the author must understand why the information is being collected. Questionnaire items were written in a clear and concise manner. Ambiguous terms were clearly defined or explained. The author used short, brief, and clear questions that required little reading. All questions were written in positive terms and organized from general to specific. The questionnaires were organized to focus items on a single topic or idea. Sufficient space for open-ended questions was provided (Gay & Airasian).

As described in Appendix A, questions were developed for each proposition based on the literature reviewed in this investigation and the criteria set forth by Gay and Airasian (2003). Additionally, questions in the student and instructor questionnaires were based on questions that were initially validated by Morgenstern (2004). Since the participants in the Morgenstern case study were college-level, additional reliability and validity was necessary. The surveys were designed and administered through Survey

Monkey®, a Web-based survey service. Survey participants were given ample time to complete the online survey.

Reliability and Validity

Reliability is the degree to which a test consistently measures whatever it is measuring (Gay & Airasian, 2003). A panel of experts in the field of educational research reviewed the study questionnaires. The questionnaires were distributed via e-mail for suggestions and recommendations. Suggestions and recommendations made by the panel of experts were reflected in the questionnaires. Reliability was established by this panel of experts. The panel of experts also validated the content of the interview questionnaires completed by network administrator and the Division Chief for the Job Corps Division of Information Technology and Support. The panel of experts included: Dr. Marlene Groman, recent graduate of Nova Southeastern University and Dr. Kurt Steuck, Education Consultant, MTC Technologies, Inc.

Gay and Airasian (2003) recommend pretesting survey instruments to establish survey validity. Validity is concerned with the appropriateness of the interpretation of the findings. A pretest was conducted with the instructor and student questionnaires. Three or four individuals, similar to the research participants, helped to identify problems (Gay & Airasian) with the questionnaires. Seven students and three instructors at the Penobscot Job Corps Academy, in Bangor, Maine participated in the questionnaire pretest. These individuals were demographically similar to the research participants. Modifications to the student and instructor questionnaires were made based on the feedback from the participants. Definitions for the terms aggregate, PDA, and thin client were added to the student questionnaire. Question 4 of the instructor questionnaire and Question 5 of the

student questionnaire were modified for clarification. Additional space was added to questions 17 and 18 of the instructor questionnaire. The scale used in questions 5 and 12 was modified on the student and instructor questionnaires. Questionnaire reliability and validity were established in the pretest.

Formats for Presenting Results

Data analysis consists of examining, categorizing, tabulating, testing or otherwise recombining both quantitative and qualitative evidence to address the initial propositions of the investigation (Yin, 2003). Descriptive statistics such as number of respondents, overall response rate, response rate for each item, total sample size, percentage of returns, and measures of central tendency were determined. Measures of central tendency included the mode and median (Gay & Airasian, 2003). A transcript of the interview with the network administrator and the Job Corps National Office, Division of Information Technology and Support Division Chief was prepared by the author.

Criteria for Interpreting Findings

The case study design should indicate what is to be done after the data have been collected; as indicated by the criteria for interpreting the findings (Yin, 2003). The goal of this investigation was to develop a model for a WLAN implementation for the JC system based on a case study of HJCA. Using the SDLC model as the framework and the findings from the case study, the NJCP WLAN implementation model was designed and presented. Each phase of the SDLC used to determine the NJCP WLAN implementation model is described in this segment.

Planning Phase of the NJCP WLAN Implementation Model

The author conducted an interview with the network administrator to determine the factors which supported the decision to implement the WLAN at HJCA and the cost of the implementation. In addition, an interview with the Division Chief for the Job Corps Division of Information Technology and Support was conducted to learn about the future expectations of WLAN deployment throughout JC and the effectiveness of WLAN technology in meeting the Job Corps new goals and objectives. By evaluating findings from the instructor questionnaires, the author identified changes that could enhance career technical and academic classroom instruction delivery in the wireless environment. Results from instructor and student questionnaires that were related to student-to-student, instructor-to-student, and student-to-student interactivity were also evaluated.

Analysis Phase of the NJCP WLAN Implementation Model

In the interview with the network administrator, the author determined the network design of the HJCA WLAN, the merits and limitations of this wireless solution, and the number of users, students, staff, and instructors, supported by the WLAN. Through the use of student and instructor questionnaires, the types of information transmitted over the WLAN, the applications used, and the types of information accessed were determined. Additionally, through the use of student and instructor questionnaires, user experience in a WLAN environment was determined.

Design Phase of the NJCP WLAN Implementation Model

The interview with the network administrator provided data on wireless AP placement, the effects of the physical construction of the HJCA buildings on the WLAN, and types of wireless security protocols employed. The results of the site survey are presented.

Implementation Phase of the NJCP WLAN Implementation Model

Data from student and staff questionnaires revealed what information is accessed, where the WLAN is accessed, and the use of the WLAN in the classroom.

Support Phase of the NJCP WLAN Implementation Model

The interview with the network administrator, the instructor questionnaire, and the student questionnaire revealed the training required for the continued support and use of a WLAN.

Resource Requirements

The case study research was conducted at the Hartford Job Corps Academy. To complete this research, letters requesting consent to conduct the research were prepared and distributed to the HJCA Director, the contractor, and the National Office of Job Corps (See Appendix B). As described in Appendix C, written approvals were obtained from the Academy Director, the contractor, and the U.S. Department of Labor National Office of Job Corps to conduct the investigation.

For 18 months, the author served as the Director of Learning at Penobscot Job Corps Academy in Bangor, Maine. In this capacity, the author managed all education and

training programs at the center. In October 2005, the contract was awarded to Career Systems Development, Inc. and the author was appointed as the Academic Manager responsible for the High School Diploma Program, the General Equivalency Diploma Program, driver's education, reading and math classrooms, and special education. The author worked as an eLearning Specialist for the National Office of Job Corps through a contract with Coffey Consulting, LLC for three years. Currently, the author is employed by the State of Maine Department of Education as an Education Consultant for Career and Technical Education.

The author brings to this study an extensive background in education and core knowledge in the use of wireless technologies and applications. The author has taught adults for over ten years and worked in the field of higher education for five years.

Summary

The author examined the planning, design, development, and implementation of the WLAN at HJCA. The goal of this investigation was to develop a model for WLAN implementation for the JC system based on the findings at HJCA. The framework for the case study was based on guidelines described by Yin (2003) and the systems development life cycle (SDLC) described by Whitten et al. (2001).

In this chapter, the author presented the research methods employed, research questions with propositions, unit of analysis, instrumentation, formats for presenting results, criteria for interpreting the findings, and resource requirements. A discussion of validity and reliability related to this investigation was also presented.

Chapter 4

Results

This chapter presents the results of the HJCA investigation. This investigation is an embedded case study design with the HJCA as the unit of analysis for the case study. The quantitative findings obtained from the sampled groups, students and instructors, are presented. The findings from the interviews conducted with the Network Administrator and the Division Chief for the Job Corps Division of Information Technology and Support are also presented.

Findings

The case study methodology (Yin, 2003) was utilized in the HJCA investigation. The author developed research questions and propositions based on a review of the literature. The data collection instruments addressed each of these propositions. The systems development life cycle (SDLC) provided the descriptive framework for organizing and documenting the HJCA case study findings (Whitten et al., 2001).

During the summer 2008, data were collected from HJCA students, instructors, and the Network Administrator, as well as the Division Chief for the Job Corps Division of Information Technology and Support at the National Office of Job Corps. Instrumentation used for data collection was approved by the university's Institutional Review Board (IRB) (See Appendix D). Prior to participation in the study, all

participants received an IRB Participation Letter (See Appendix E). Of the 117 currently enrolled students at HJCA, 43 (37%) students 18 years and older completed the online survey. Of the 11 full-time instructors employed at HJCA, 7 (64%) completed the online survey. The Network Administrator and the Division Chief for the Job Corps Division of Information Technology and Support were interviewed by the author. The findings, organized with the SDLC framework, are presented below.

Planning Phase, or Phase 1, of the HJCA WLAN

Five research questions were related to the Planning Phase of the HJCA WLAN implementation. The five research questions and the related propositions are described below, along with the data analysis.

Research Question 1. What were the key factors supporting the decision to implement the HJCA WLAN?

Proposition 1. According to Gast (2005), the key factors to consider when deploying a WLAN should include: user experience, costs, coverage area, user density, user population, physical considerations, application characteristics, and security requirements. The HJCA WLAN should offer the expected advantages of a WLAN such as ubiquitous coverage and flexibility in supporting teaching and learning (Sotillo, 2003).

Research Question 2. What factors contributed to the selection of the wireless technology to be employed?

Proposition 2. At HJCA, IEEE 802.11g-compatible equipment facilitated transmission rates reaching 54 Mbps (Gast, 2005). The HJCA WLAN should support

instructional resources, software applications, and Internet access. WLAN technologies, wireless APs and thin clients should be JCDC-approved and configured.

Research Question 3. What were the costs of this implementation?

Proposition 3. As a new JC center, HJCA implemented the WLAN and thin client technology to optimize cost savings because wireless implementations are typically more cost effective than wireline networks. When identifying expenditures, implementation and operational support costs should be considered (Gast, 2005). These include implementation costs such as the costs of the hardware, software, and labor associated with the implementation; and operational support costs such as electricity for hardware, network administration, maintenance, and training.

Research Question 4. How did career technical and academic instruction change with the wireless environment?

Proposition 4. According to Lakas et al. (2006), e-learning is defined as the use of technology in the teaching and learning process. E-learning is an emerging approach to education that facilitates the use of new instructional methods, such as, collaborative, problem-based learning (PBL). Students work in groups to study complex, real-world problems. As an instructional method, PBL is easily facilitated in a WLAN environment (Wattinger et al., 2006). Connectivity to the Internet via the WLAN allows students to use Web-based sharing technologies, such as discussion forums, bulletin board systems, e-mail, instant messaging, and chat (Hsiu-Ping & Wei-Jane, 2005). According to Fong et al. (2004) and Caverly and MacDonald (2005), WLANs can also promote the development of new and improved teaching opportunities that enhance the overall learning experience.

Research Question 5. How did student-to-student, instructor-to-student, and student-to-instructor interactivity change with the WLAN solution?

Proposition 5. Interactivity in the classroom should be enhanced within the WLAN environment. For successful e-learning, Bose (2004) suggested that there are three types of necessary interactions: student-content, student-instructor, and student-student. The biggest challenge with WLANs implementation is encouraging instructors to embrace the technology and use the technology to enhance student learning (Milner, 2005).

Data Analysis: HJCA WLAN Planning Phase

The author expected that during the Planning Phase of the HJCA WLAN implementation, the scope of the implementation would be defined and the wireless technologies to be used would be identified. Additionally, the instructional applications supported by the HJCA WLAN would be determined. The planning of the HJCA WLAN may have been haphazardly completed; therefore, it was necessary for the author to obtain the historical data related to the Planning Phase of the HJCA WLAN.

The HJCA WLAN was implemented in 2005 during the construction of the facility. HJCA employed IEEE 802.11g-compatible wireless equipment. It was reported that IEEE 802.11g supported a faster connection speed at the time of implementation. Since the time of implementation, there have been no upgrades to the HJCA WLAN, such as, upgrading to IEEE 802.11n-compatible equipment.

At the time of planning for the HJCA WLAN implementation, no site survey was conducted to determine optimal placement of wireless APs and to maximize network

coverage. It was reported that the majority of wireless APs is located in the education building where the most of the thin clients are housed. Additionally, the education building needed to accommodate the most students. It was expected that students would be able to access the HJCA WLAN in all student areas including the dormitory, the two educational buildings, and the recreation facility. Table 1 reports the locations whereby the students reported having access to the HJCA WLAN. The academic classrooms were the locations whereby most (63%) of the students reported having access to the HJCA WLAN.

Table 1

HJCA WLAN Access Locations (students)

HJCA WLAN Access Locations	N	Response Percent
Academic classroom	27	63%
Career technical classroom	23	54%
Dormitory	22	51%
Career preparation classroom	12	28%
Career transition classroom	9	21%
Recreation facility	3	7%
Administration building	2	5%
Other (please specify)	2	5%

The academic classrooms were the locations in which most (57%) of the instructors reported having access to the HJCA WLAN, as well. Table 2 reports the locations where the instructors reported having access to the HJCA WLAN.

Table 2

HJCA WLAN Access Locations (instructors)

HJCA WLAN Access Locations	N	Response Percent
Academic classroom	4	57%
Career technical classroom	3	43%
Office	2	29%
Career preparation classroom	1	14%

Wireless technology was chosen for the network implementation because of cost effectiveness and scalability. The costs of the HJCA WLAN implementation were not determined. The implementation occurred over four years ago. The goal of this investigation was to develop a model for WLAN implementation for the JC system based on the findings at HJCA. To base the NJCP WLAN Implementation Model on HJCA WLAN 2004 prices would be unreasonable; therefore, obtaining current costs will be an important step in the Planning Phase of the NJCP WLAN Implementation Model as presented in Chapter 5.

It is important to develop an understanding of WLAN users' computer skills during implementation planning. User computer skills may be indicative of the user's comfort level with technology, in general. During the HJCA case study, demographic information about the students and instructors was collected. Table 3 illustrates that of the 43 students, 29 (67%) rated their computer skills as Average and 11 (26%) of the students rated their computer skills as Above Average. Of the 7 instructors, 2 (29%) rated their computer skills as Average, 4 (57%) rated their computer skills as Above Average, and 1 (14%) instructor respondent rated their computer skills as Expert (See Table 3).

Table 3

HJCA Student and Instructor Computer Skills

Computer Skills Rating	N	Response Percent
Student		
Never used a computer	0	0%
Below average	3	7%
Average	29	67%
Above average	11	26%
Expert	0	0%
Instructor		
Never used a computer	0	0%
Below average	0	0%
Average	2	29%
Above average	4	57%
Expert	1	14%

The author expected that interactivity in the classroom would be enhanced by the WLAN environment. At HJCA, instructors were asked to comment on how the use of the wireless network enhanced teaching and learning at HJCA. Instructors reported that wireless is the latest technology and students are given the opportunity to adapt to and learn this technology. Two instructors related that the use of a WLAN to accessibility to the Internet with the use of various Web sites for academic preparation and virtual high school resources. Two instructors commented that there was an assumption of enhancing learning; they viewed the use of new technologies to enable learning more than enhance

the learning experience. No instructors reported using Web-based tools such as blogs, wikis, discussion forums, bulletin board systems, e-mail, instant messaging, and chat to facilitate collaboration in the classroom. Additionally, the HJCA instructors did not indicate that the WLAN facilitated interactivity among students in the classroom. One instructor stated that there are pros to using a wireless network, but there are also too many cons, for instance, the use of the thin clients limits what the students can actually accomplish via the Internet.

Analysis Phase, or Phase 2, of the HJCA WLAN

Six research questions were related to the Analysis Phase of the HJCA WLAN implementation. The six research questions, the related propositions, and the data analysis are presented below.

Research Question 6. What is the current network design at HJCA?

Proposition 6. The current network design at HJCA includes the use of thin clients that enable student, instructor, and staff access WLAN resources (J. MacDonald, personal communication, October 2006). Thin clients are the primary wireless appliances used on the WLAN. In the thin client computing environment, the client computer acts solely as a display and input device; all WLAN operations should be executed on a server (Goldwasser & Letscher, 2005; Kissler & Hoyt, 2005; Tolia et al., 2006). Wireless APs are strategically placed throughout student areas such as dormitories, recreation facilities, and the two training buildings. The fiber optic backbone interconnects the buildings and a 10BASE-T Ethernet is utilized for desktop connections (J. MacDonald).

Research Question 7. How will the physical construction of the HJCA buildings impact WLAN operations?

Proposition 7. A site survey provides the means to map needs to areas in a building (Owen & Farsaii, 2006). During the implementation of the HJCA WLAN, no site survey was conducted; therefore, this investigation included a site survey. Physical construction of a building with metal, for example, can interfere with WLAN performance. Additionally, walls, doors, and windows can interfere with radio signals (Gast, 2005). The author will use NetStumbler®, a free, open-source software tool, which can find locations with poor coverage in the HJCA WLAN. In addition, NetStumberl® can detect unauthorized wireless APs, as well as detecting and resolving RF interferences from nearby devices (Clincy & Krithi, 2005).

Research Question 8. What types of information will be transmitted over the WLAN?

Proposition 8. Information that will be transmitted over the HJCA WLAN should include: text, images, streaming video, and streaming audio. Since WLANs are primarily designed for data applications, efficient multimedia communication over WLANs can be challenging (Choudhury et al., 2006). This information will be accessed via the Internet on T1 lines and the JCSN.

Research Question 9. What applications will be supported by the WLAN?

Proposition 9. The applications supported by the wireless network should include Internet access, Microsoft™ Office suite, and designated electronic educational resources such as typewriting tutors, resume writing software, and academic and career technical software.

Research Question 10. How many users will have access to the WLAN at each JCC?

Proposition 10. The WLAN implementation at HJCA should support 200 student and instructor users (A. Cardella, personal communication, October 2006).

Research Question 11. Will the WLAN support voice, video, and data transmission?

Proposition 11. The HJCA WLAN should support voice, video, and data transmissions (Choudhury et al., 2006). In the future, the WLAN should support access to and the use of an LMS.

Data Analysis: HJCA WLAN Analysis Phase

In the Analysis Phase, the current HJCA WLAN and related problems, the effects of building construction, for example, construction with metal beams, on the performance of the WLAN, and WLAN user requirements are defined. The current network at HJCA includes the use of thin clients that enable student, instructor, and staff access to WLAN resources. Thin clients are the primary wireless appliance used on the HJCA WLAN. Wireless APs are strategically placed throughout student areas such as dormitories, recreation facilities, and the two training buildings. A fiber optic backbone interconnects the buildings and a 10BASE-T Ethernet connection supports desktop applications. Additionally, HJCA has three T1 lines servicing the facility. The HJCA WLAN supports approximately 250 users, including staff, instructors, and students.

A site survey using NetStumbler® was attempted as part of the HJCA investigation. NetStumbler® is free, downloadable software that monitors and assesses security threats for WLANs (Clincy & Sitaram, 2006). NetStumbler® has many uses, including: verifying that the WLAN operates as intended, finding locations with poor

coverage, detecting other networks that may cause interference, and detecting unauthorized "rogue" access points (Clincy & Sitaram). NetStumbler® was chosen for the site survey because it is a free, open-source program; however, it was unable to detect wireless APs that were not enabled to broadcast an SSID. Although a site survey was not permitted, the Network Administrator reported that there were no issues with the physical construction of the buildings at HJCA as it relates to the performance of the WLAN.

It was expected that the information transmitted over the WLAN would include: text, images, streaming video, and streaming audio. At HJCA, this information will be accessed via the Internet on T1 lines and the JCSN. According to the instructors and students, the HJCA WLAN supported voice, video, and data transmissions and enabled transmissions of video, audio, and e-mail delivery. The types of applications supported by the HJCA WLAN include: e-mail; Microsoft™ Word, Excel, PowerPoint, and Access; and Internet Explorer. Students reported using the HJCA WLAN to access the Internet and obtain information a few times week (16%); almost every day (26%); and several times a day (26%). Additionally, students reported using the HJCA WLAN to complete work in Microsoft™ Word a few times a week (21%); almost every day (16%); and several times a day (9%). Students reported using the HJCA WLAN to create and send e-mail a few times a week (23%); almost every day (12%); and several times a day (7%). Microsoft™ Excel was used a few times a week (12%); almost every day (16%); and several times a day (2%). These top four student uses of the HJCA WLAN are represented in Table 4.

Table 4

Top Four Uses of the HJCA WLAN (students)

Uses of the HJCA WLAN	A few times a week (N)	%	Almost every day (N)	%	Several times a day (N)	%
Use the Internet to research information	7	16%	11	26%	11	26%
Use Microsoft™ Word to complete work	9	21%	7	16%	4	9%
Create and send e-mail	10	23%	5	12%	3	7%
Use Microsoft™ Excel to complete work	5	12%	7	16%	2	5%

The instructor data was similar to the student data, in that the top four uses were the same for the instructors as for the students. Instructors reported using the HJCA WLAN to access the Internet to conduct research a few times week (14%); almost every day (29%); and several times a day (29%). Additionally, the instructors reported using the HJCA WLAN to complete work in Microsoft™ Word almost every day (29%) and several times a day (71%). Instructors also reported using the HJCA WLAN to create and send e-mail almost every day (14%) and several times a day (57%). They used Microsoft™ Excel a few times a week (14%); almost every day (14%); and several times a day (29%). These top four instructor uses of the HJCA WLAN are represented in Table 5.

Table 5

Top Four Uses of the HJCA WLAN (instructors)

Uses of the HJCA WLAN	A few times a week (N)	%	Almost every day (N)	%	Several times a day (N)	%
Use Microsoft™ Word to complete work	0	0%	2	29%	5	71%
Create and send e-mail	0	0%	1	14%	4	57%
Use the Internet to research information	1	14%	2	29%	2	29%
Use Microsoft™ Excel to complete work	1	14%	1	14%	2	29%

Design Phase, or Phase 3, of the HJCA WLAN

Two research questions were related to the Design Phase of the HJCA WLAN implementation. The two research questions, the related propositions, and the data analysis are presented below.

Research Question 12. How was AP placement determined?

Proposition 12. Because wireless devices connect the access points through channels, wireless APs should be placed to avoid signal overlap and interference (Owen & Farsaii, 2006). Additionally, wireless APs are vulnerable to physical attacks whereby an individual physically resets the wireless AP causing a switch to default settings (Al Naamany et al., 2006); wireless APs should be placed in areas that are not accessible by students or instructors. The performance of a WLAN can be significantly degraded from channel interference caused by one wireless AP using the same channel assigned to a neighboring wireless AP (Wang & Yow, 2006). This may require reconfiguration. To

reduce interference and maximize the usage of the spectrum, neighboring APs should operate at orthogonal channels (Wang & Yow). Wireless APs have a coverage area of up to 300 feet (Clincy & Krithi, 2006).

Geier (2002) recommends positioning the wireless APs above office partitions and away from metal objects such as furniture, fans, and doors. Additionally, Geier suggests that the wireless APs should be installed in a central location, such as the center of a large room or corridor.

Research Question 13. Does the HJCA WLAN design comply with the wireless security standards defined by the U.S. DOL-ETA?

Proposition 13. As noted, various security protocols can be employed in a WLAN implementation including: WPA, WPA2, VPN, EAP, and PEAP. The HJCA WLAN should meet or exceed the WLAN security protocols outlined in the U.S. DOL ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology as previously discussed. According to He et al. (2005), IEEE 802.11i provides mutual authentication between a wireless AP and a user's device prior to connectivity to the WLAN. The U.S. DOL-ETA (2005) issued the Security Policy for Portable Electronic Services and Wireless Technology for use in securing wireless implementations. However, the use of the IEEE 802.11i is not a part of this policy. Defining an appropriate wireless security policy is an important faction to achieve overall WLAN security (Al Naamany et al., 2006).

Data Analysis: HJCA WLAN Design Phase

In the Design Phase, wireless AP placement and security protocols were examined. The author expected that wireless APs would be installed in a central location, such as the center of a large room or corridor; subsequently, it was reported that wireless APs were installed in the ceilings throughout most of the buildings. This approach safeguards the integrity of the wireless APs.

Defining an appropriate security policy for WLAN implementation is of the utmost importance during the Design Phase. Various security strategies can be employed in a WLAN implementation including: WPA, WPA2, VPN, EAP, and PEAP. The HJCA WLAN complies with the WLAN security guidelines outlined in the U.S. DOL ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology.

As an additional security measure, the Network Administrator uses MAC filtering when dedicating wireless devices to a particular wireless AP. If a wireless device is not configured to a particular wireless AP, then the device is unable to connect to the WLAN. MAC filtering is one option to control access to the WLAN; unknown computers will be denied access if the computer's MAC address is not on an authorized list (McKimmy, 2005).

The HJCA WLAN does not employ IEEE 802.11i. The U.S. DOL ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology does not require the use of IEEE 802.11i.

Implementation Phase, or Phase 4, of the HJCA WLAN

Three research questions related to the Implementation Phase of the HJCA WLAN implementation. The three research questions, the related propositions, and data analysis related to the Implementation Phase in the material that follows.

Research Question 14. Are users with appropriate permissions able to access information with the HJCA WLAN from various locations?

Proposition 14. HJCA does not utilize or support the use of mobile devices such as laptops, PDAs, and cellular phones to access the WLAN. Users should be able to access the WLAN from the dormitories, academic and career technical classrooms, and the recreation facility.

Research Question 15: What modifications to the JCC WLAN design will be required based on the outcome of the HJCA evaluation?

Proposition 15. Based on the results from the site survey, modifications to the WLAN design may involve reconfiguring wireless APs, and relocating wireless APs for enhanced coverage. Implementing security protocols to meet and/or exceed the U.S. DOL ETA security standards were examined.

Research Question 16. Has the HJCA WLAN implementation improved student and instructor access to resources?

Proposition 16. According to Chen and Kinshuk (2005), the use of wireless technology in schools has accelerated as a consequence of the popularity of the Internet and e-learning applications. A WLAN implementation should improve access to e-learning resources including resources on the Internet and the JCSN.

Data Analysis: HJCA WLAN Implementation Phase

In the Implementation Phase, the author presented recommendations for HJCA WLAN modifications and enhancements. An evaluation of the design, implementation, and use of the HJCA WLAN was conducted. The author expected that users would be able to access the WLAN from the HJCA dormitories, academic and career technical classrooms, and the recreation facility.

As previously outlined in Tables 1 and 2, instructors and students can access the HJCA WLAN from various locations on campus. The author found that the use of mobile devices such as laptops, PDAs, and cellular phones for WLAN access was not permitted at HJCA; nonetheless, students and instructors indicated the ownership of such mobile devices (See Table 6 and Table 7).

Table 6

Mobile Device Ownership (students)

Mobile Device Ownership	N	Response Percent
Yes	20	47%
No	23	54%

Nearly 50% of the student respondents indicated that they owned a handheld device, such as a cellular phone or PDA. One student indicated ownership of a Blackberry®.

Table 7

Mobile Device Ownership (instructors)

Mobile Device Ownership	N	Response Percent
Yes	4	57%
No	3	43%

Based on findings from the HJCA WLAN investigation, the author determined that modifications to the WLAN design may involve reconfiguring and relocating wireless APs for enhanced coverage. There was no indication that the wireless APs needed to be relocated or reconfigured to enhance coverage.

It was expected that the HJCA WLAN implementation would improve access to e-learning resources, including the Internet and JCSN resources. As noted, the HJCA WLAN improved access to Internet based, e-learning resources, mainly the use of the Internet for research. The students, as well as the instructors, indicated varying levels of satisfaction with the performance of the HJCA WLAN. Table 8 indicates the student and instructor satisfaction levels with the performance of the HJCA WLAN. Approximately 40%, or 18 students, indicated that they were somewhat dissatisfied and very dissatisfied with the level of performance of the HJCA WLAN. Approximately 28%, or 2 of the instructors, were very dissatisfied with level of performance of the HJCA WLAN.

Table 8

Satisfaction Level with the Performance of the HJCA WLAN (students and instructors)

Satisfaction Level	N	Response Percent
Students		
Somewhat dissatisfied	13	30%
Somewhat satisfied	12	28%
Satisfied	9	21%
Very dissatisfied	5	12%
Very satisfied	4	9%
Instructors		
Very dissatisfied	2	29%
Somewhat dissatisfied	0	0%
Somewhat satisfied	3	43%
Satisfied	1	14%
Very satisfied	1	14%

Both students and instructors were asked about the major complaints they had with the HJCA WLAN. Table 9 outlines the major student complaints. Loss of connection and limited bandwidth were the top two major complaints from the student respondents. Other complaints included slow connection to the Internet and the thin clients "freeze," in that, the thin client stops operating.

Table 9

Major Complaints with the HJCA WLAN (students)

Major Complaints	N	Response Percent
Loss of connection	26	61%
Limited bandwidth (data transmission problems with the amount of data that can be received and sent)	22	51%
Lack of printing capabilities	12	28%
Inadequate number of thin clients available	11	26%
Other (please specify)	5	12%

Table 10 depicts the major complaints by instructors in using the HJCA WLAN. Problems include lack of printing capabilities, loss of connection and limited bandwidth. One instructor indicated that the HJCA WLAN limited what could actually be accomplished. For example, lack of bandwidth limited the extent to which files could be uploaded and downloaded.

Table 10

Major Complaints with the HJCA WLAN (instructors)

Major Complaints	N	Response Percent
Lack of printing capabilities	5	71%
Limited bandwidth (data transmission problems with the amount of data that can be received and sent)	2	29%
Loss of connection	3	43%
Other (please specify)	2	29%
Inadequate number of thin clients available	1	14%
Security problems	1	14%

Support Phase, or Phase 5, of the HJCA WLAN

One research question dealt with the Support Phase of the HJCA WLAN implementation. The research question, the related proposition, and the data analysis are presented in the material that follows.

Research Question 17. What training for instructors, students, and the network administrator will be required for the continued support and use of the HJCA WLAN?

Proposition 17. Instructors will require additional training on using the WLAN for teaching and learning, and the JC students will require training on using the WLAN to access online resources. According to Penuel (2006), instructors who spend nine hours or more in educational technology professional development activities were more likely than instructors who spent less time to feel well or very-well prepared to use computers and Internet for instruction. The network administrator also requires training on accessing relevant Internet-based resources and monitoring the development and availability of new and emerging WLAN technologies, applications, and enhancements.

Data Analysis: Support Phase of the HJCA WLAN

In the Support Phase, training requirements for the HJCA Network Administrator and HJCA instructors and students were identified through the use of questionnaires and interviews. The author found that instructors required additional training on using the WLAN for teaching and instruction, and the JC students required training on using the WLAN in accessing online resources. The Network Administrator also required training on monitoring the development and availability of new and emerging WLAN technologies, applications, and enhancements.

Five (71%) of the seven instructors indicated that they had received training on how to use the wireless network. The types of training they reported were face-to-face with the Network Administrator and hands-on (do-it-yourself) training. The Network Administrator's training consisted of on-the-job training. The students were also asked to report the training they received on the use of the HJCA WLAN. Table 11 reflects their comments.

Table 11

Top 5 Types of Training Received on the Use of the HJCA Wireless Network (students)

Types of Training	N	Response Percent
No Training Received	11	26%
Microsoft™ Office through Career Technical Training	11	26%
Not Applicable	6	14%
Keyboarding	2	5%
Resume, cover letters	2	5%

Summary of Results

The HJCA WLAN, with IEEE 802.11g-compatible equipment, was implemented in 2005. The HJCA WLAN currently supports approximately 250 users, including staff, instructors, and students. Although a site survey was not conducted at the time of implementation, the HJCA Network Administrator reported that there was no performance issues associated with the physical construction of the buildings or placement of the wireless APs. Additionally, the HJCA Network Administrator reported

that there have been no updates in the HJCA WLAN since implementation, including the upgrade to IEEE 802.11n-compatible equipment.

The HJCA WLAN supports various types of applications including e-mail, Microsoft™ Word, Excel, PowerPoint, Access, and Internet Explorer. Students reported they could access the HJCA WLAN in training classrooms, the dormitory, the recreation building, and the administrative building.

The HJCA WLAN complies with the wireless security standards defined by the U.S. DOL-ETA. For additional security measures, the Network Administrator uses MAC filtering. The HJCA WLAN does not employ IEEE 802.11i.

Of the 117 currently enrolled students at HJCA, 43 (37%) 18+ year olds and seven (63.6%) of the eleven full-time instructors completed online surveys. Interviews with the HJCA Network Administrator and the NJCP Division Chief for the Job Corps Division of Information Technology and Support were conducted by the author.

Instructors reported that Web-based tools such as blogs, wikis, discussion forums, bulletin board systems, e-mail, instant messaging, and chat, to facilitate collaboration in the classroom were not utilized. The HJCA instructors did not report using the WLAN to facilitate interactivity within the classroom. Nearly 50% of the student respondents indicated that they owned a handheld device, such as a cellular phone or PDA. The four primary uses of the HJCA WLAN, as reported by students and instructors, are using the Internet to research information, completing work in Microsoft™ Word, creating and sending e-mail, and completing work in Microsoft™ Excel.

Students and instructors indicated varying levels of satisfaction with the performance of the HJCA WLAN. Loss of connection and limited bandwidth were the

top two major complaints from the students. Lack of printing capabilities, loss of connection, and limited bandwidth were the top three major complaints from instructors.

Finally, students and instructors were asked to comment on their overall experiences using the HJCA WLAN. The top six student comments are reflected in Table 12. Instructor comments are included in Table 13.

Table 12

Top Six Student Experiences Using the HJCA WLAN

Student Comments	N	Response Percent
It's a good network	13	30%
Not applicable	6	14%
The network blocks access to various Web sites required to complete training.	5	12%
Connection is lost	4	9%
The network is slow	3	7%
Not enough access to thin clients	3	7%

Table 13

Instructor Experiences Using HJCA WLAN

Instructor Comments
In some cases unable to install/run certain educational software.
I get frustrated at times because of the limitations.
I use the basic daily functions and do SIMON (Staff Instruction Management Online) Training when asked.
Microsoft™ applications are out of date, 2003 for Word, Excel, etc. Most files sent to me are not able to be opened because hardly anyone would think that a public agency would be using such out dated versions of common applications, most private concerns and other public agencies have updated versions of Microsoft™ products at a minimum of bi-annual updates.
I have a very easy time with the network due to my advantageous location. I know it is far less popular with other people, and yet it serves its purpose well in my experience.
Satisfied.
I have found that the system shuts down a lot.

In Chapter 5, the author presents the conclusions, implications, recommendations, and summary for the HJCA investigation. As noted, the SDLC methodology provided the framework for the NJCP WLAN Implementation Model, which is presented in Chapter 5, as well.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

This chapter presents the conclusions, recommendations, implications, and recommendations and summary from the Hartford Job Corps Academy (HJCA) WLAN case study.

Conclusions

Colleges and universities were among the earliest adopters of wireless technologies (Waters, 2007). In 2005, 45 percent of K-12 public schools reported implementing wireless networks (Waters). The use of wireless networks on Job Corps Centers (JCC) is ad-hoc, at best. The National Job Corps Program is not keeping pace with its public school or college counterparts, who are providing learning opportunities to students using up-to-date technology and innovative instructional methods. In Job Corps, center-wide WLAN implementations are rare and, as a consequence, models for planning, designing, and implementing WLANs at JCCs are not available.

The goal of this investigation was to develop a model for WLAN implementation for the Job Corps (JC) system. The author posed two primary research questions, “How can JCCs use a model to effectively plan, design, develop, and implement a WLAN to facilitate access to the Internet and e-learning resources?” and “How can instructors use the WLAN to facilitate teaching and learning?” An additional seventeen (17) research

questions and propositions were developed to support the primary research questions. A case study was conducted at HJCA. The SDLC framework (Whitten, Bentley, & Dittman, 2001), in conjunction with case study findings, facilitated the investigation and enabled the analysis and development of the NJCP WLAN implementation model.

The first primary research question of this investigation was "How can JCCs use a model to effectively plan, design, develop, and implement a WLAN to facilitate access to the Internet and e-learning resources?" In addressing this research question, the NJCP WLAN implementation model is based on the HJCA findings and support from the literature (Landry & Richard, 2004; Gast 2002, 2005; Owen & Farsaii, 2006; and Geier, 2002). Using the SDLC framework with the corresponding five phases: (1) Planning, (2) Analysis, (3) Design, (4) Implementation, and (5) Support (Whitten, Bentley, & Dittman), the author presents the NJCP WLAN Implementation Model in the material that follows.

Planning Phase, or Phase 1, of the NJCP WLAN Implementation Model

During the Planning Phase, the NJCP facility should designate members for a WLAN implementation team. The implementation team should be lead by an individual who is knowledgeable in WLAN technologies (Owen & Farsaii, 2006). The team members should consist of representatives from the various user groups (Gast, 2005), including students and instructors. Based on the findings of the HJCA case study, user groups consisting of instructors, students, and staff of the HJCA WLAN were not participants of the implementation team. The users can provide valuable insight throughout the WLAN implementation process. During the Planning Phase, the team

should define the scope of the implementation, determine a budget and schedule for the implementation, determine instructional applications that can be supported in the WLAN environment, and establish costs associated with the WLAN implementation (Gast 2002, 2005; Geier, 2002).

In defining the scope of the implementation, the team should determine the type of wireless technology to be employed. Based on the case study findings, future NJCP WLAN implementations are expected to support instructional applications such as e-mail, Internet access, Microsoft™ Office applications, and a learning management system (LMS), such as SABA Learning™. The author recommends that IEEE 802.11n-compatible equipment be used for future NJCP WLAN implementations higher transmission rates than IEEE 802.11g. IEEE 802.11n increases the data rate of WLANs to 600 Mbps and the range of transmission up to 100 meters (Sidhu et al., 2007). Higher transmission rates enhance network performance and enable multimedia applications (Abichar et al., 2006).

The implementation team should identify the instructional applications that can be supported in the WLAN environment. Based on the HJCA findings, the author determined that instructors use the HJCA WLAN to access the Internet to access various Web sites for research and connectivity to virtual high school resources.

Figure 4 illustrates the Planning Phase for the NJCP WLAN Implementation Model.

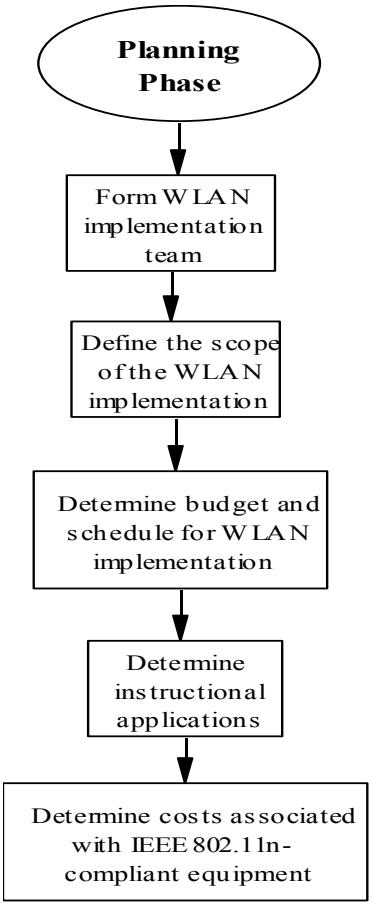


Figure 4. Planning Phase: NJCP WLAN Implementation Model

Adapted from Gast 2002, 2005; Geier, 2002; Landry & Richard, 2004; and Owen & Farsaii, 2006.

Analysis Phase, or Phase 2, of the NJCP WLAN Implementation Model

In the Analysis Phase, the WLAN implementation team determines optimal wireless AP placement by conducting a site survey. A site survey provides the means to map wireless coverage to areas in a building (Owen & Farsaii, 2006). Wireless devices connect to the access points; placement of the wireless APs is critical to avoid signal overlap and interference (Owen & Farsaii). Additionally, wireless APs are vulnerable to physical attacks whereby an individual physically resets the wireless AP causing a switch to default settings (Al Naamany et al., 2006). HJCA experienced success with the

placement of wireless APs in the ceilings of the buildings, namely, the education buildings, dormitories, and recreational facility. Based on the case study findings, this approach provided optimal WLAN coverage and physical safety of the wireless APs.

The number of users of the WLAN is established in the Analysis Phase, as well. HJCA's WLAN supports 250 users, including students and staff. HJCA is considered an average size JCC, student enrollment at various JCCs throughout the NJCP range from 150-1800 students (Job Corps, 2005).

Based on the case study findings, future NJCP WLAN implementations are expected to support applications such as e-mail, Internet access, Microsoft™ Office applications, and a learning management system (LMS), such as SABA Learning™. Future implementations should support voice, video, and data transmissions. Figure 5 illustrates the Analysis Phase for the NJCP WLAN Implementation Model.

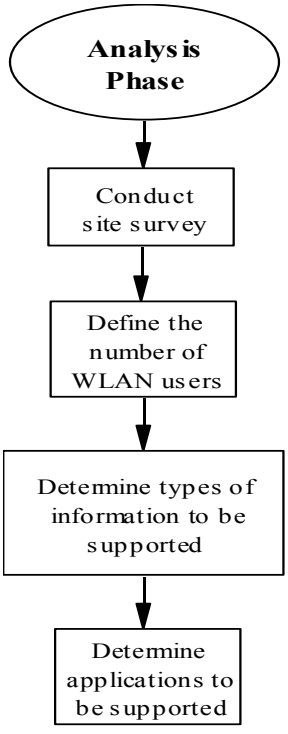


Figure 5. Analysis Phase: NJCP WLAN Implementation Model

Adapted from Gast 2002, 2005; Geier, 2002; Landry & Richard, 2004; and Owen & Farsaii, 2006.

Design Phase, or Phase 3, of the NJCP WLAN Implementation Model

During the Design Phase, the WLAN implementation team should review the results of the site survey conducted in the Analysis Phase and reconfigure wireless AP placement. The most important step taken during the Design Phase is the definition of an appropriate security policy for the WLAN implementation.

The U.S. DOL ETA's (2005) Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology describes minimal WLAN security protocols for NJCP WLAN implementations. It was reported that federal policy governing the use of wireless technology is significantly lagging. Importantly, the NJCP is unable to develop and adopt its own wireless security policy, because it is governed by this overarching federal policy.

HJCA's Network Administrator employed the use of MAC filtering for additional security. The author recommends that future NJCP WLAN implementations support the use of IEEE 802.11i. IEEE 802.11i addresses three main security areas: authentication, key management, and data transfer privacy (Li & Garuba, 2008). According to U.S. DOL (2005) security guidelines, IEEE 802.11i is currently not used in the NJCP, but should be used in future NJCP WLAN implementations.

Figure 6 illustrates the Design Phase for the NJCP WLAN Implementation Model.

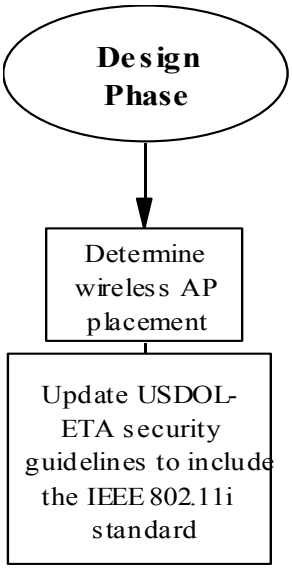


Figure 6. Design Phase: NJCP WLAN Implementation Model

Adapted from Gast 2002, 2005; Geier, 2002; Landry & Richard, 2004; and Owen & Farsaii, 2006.

Implementation Phase, or Phase 4, of the NJCP WLAN Implementation Model

The WLAN implementation team should determine if users with appropriate permissions are able to access WLAN data from various locations at the facility. The implementation team should determine if the WLAN is performing as intended; additionally, the WLAN should improve access to e-learning resources. If determined that modifications to the WLAN design are required, the modifications should be defined and implemented. Figure 7 illustrates the Implementation Phase for the NJCP WLAN Implementation Model.

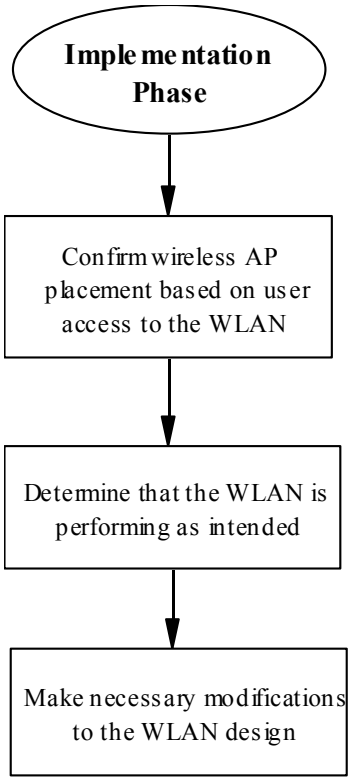


Figure 7. Implementation Phase: NJCP WLAN Implementation Model

Adapted from Gast 2002, 2005; Geier, 2002; Landry & Richard, 2004; and Owen & Farsaii, 2006.

Support Phase, or Phase 5, of the NJCP WLAN Implementation Model

In the support phase, the WLAN implementation team should define the training requirements for the facility's Network Administrator, and instructors and students users. The HJCA Network Administrator received no formal training on wireless technologies and implementation. With new WLAN implementation in the NJCP, network administrators should be offered formal WLAN implementation training.

The biggest challenge with WLAN implementation is encouraging instructors to use the technology to enhance student learning (Milner, 2005). Instructors require additional training on WLAN implementation for teaching and learning. Importantly, the JC students require training on how to use the WLAN in order to access online resources. According to Penuel (2006), instructors who spend nine hours or more in educational

technology professional development activities were more likely than instructors who spent less time to feel well or very-well prepared to use computers and the Internet for instruction. Formal training for instructors and students is a prerequisite for effective WLAN utilization in the classroom. Figure 8 illustrates the Support Phase for the NJCP WLAN Implementation Model.

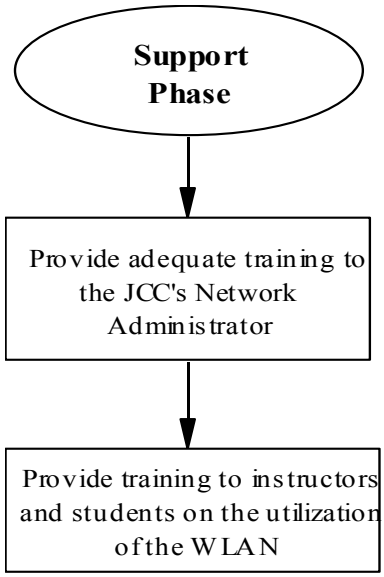


Figure 8. Support Phase: NJCP WLAN Implementation Model

Adapted from Gast 2002, 2005; Geier, 2002; Landry & Richard, 2004; and Owen & Farsaii, 2006.

The second primary research question for the HJCA investigation was: "How will instructors use the WLAN to facilitate teaching and learning?" No instructors reported using Web-based tools such as blogs, wikis, discussion forums, bulletin board systems, e-mail, instant messaging, and chat, to facilitate collaboration and interactivity in the classroom. Mobile devices, such as PDAs, laptops, and cellular phones are considered to be the next generation of computers for use in educational settings (Sa & Carrico, 2006). The use of these mobile devices are not permissible by the U.S. DOL-ETA Security Guidelines (U.S. DOL-ETA, 2005), and are not yet supported by the HJCA WLAN.

However, future WLAN deployment in the NJCP presents many instructional possibilities using mobile technology.

E-learning, or the use of technology in the teaching and learning process (Lakas et al., 2006), facilitates utilization of an array of instructional applications. According to Fong et al. (2004) and Caverly and MacDonald (2005), WLAN applications also promote the use of new and improved teaching strategies that enhance the student's learning experience. Today's youth are coming to expect more active ways of seeking knowledge (Palloff & Pratt, 2007). As noted by Palloff and Pratt, WLAN implementation can support a wide range of e-learning applications, e-collaborations, participation, and instructional simulations. Future NJCP WLAN implementations should provide instructors the opportunity to enhance teaching and learning by incorporating active learning techniques such as working collaboratively on assignments, participating in online small-group discussions and projects, role playing, and using simulations (Palloff & Pratt).

The WLAN can enhance interactivity in the classroom through the use of a classroom response system (CRS) or an audience response system (ARS). The instructor poses questions, typically with a Microsoft PowerPoint™ interface; the students then select their choice using a response keypad; the results are aggregately displayed (Medina et al., 2008). The use of CRS or ARS promotes active learning in the classroom by encouraging student reflection about course content (Medina et al; Sonntag, 2007). CRSs and ARSs allow for immediate and anonymous feedback from students (Sonntag). Connectivity to the Internet via the WLAN also allows students to use Web-based

applications, such as discussion forums, bulletin board systems, e-mail, instant messaging, and chat to facilitate collaboration (Hsiu-Ping & Wei-Jane, 2005).

The use of mobile technology could offer new options to reshape and enable new activities within the Job Corps classrooms and after hours learning (Verdejo et al., 2006). According to Liang et al. (2005), one student with one mobile device, or 1:1 computing, is an emerging trend in educational computing. The 1:1 educational computing model means that every student, equipped with a computing device can participate in various learning activities (Liang et al.). A WLAN facilitates the use of mobile devices for mobile learning. Providing students with ubiquitous access to wirelessly connected computers has the potential to transform learning environments and improve student learning outcomes (Penuel, 2006).

Implications

This case study involved the investigation of a WLAN implementation at the Hartford Job Corps Academy. The case study findings support the use of wireless technologies at other Job Corps facilities. The SDLC methodology was used in conjunction with the findings to design for the NJCP WLAN Implementation Model, as previously presented.

The author has contributed to the body of knowledge and research by presenting a model that can be deployed at a government-operated, education and training facility, such as the NJCP. The author highlighted options for enhancing wireless security guidelines as outlined in the U.S. DOL- ETA's 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology. Additionally, the author presented a recommendation for enhancing wireless network performance by

employing IEEE 802.11n-compatible equipment and using IEEE 802.11i in future NJCP WLAN implementations. The author provided options for instructional uses for future NJCP WLANs.

Implications for Future Research

Additional research is needed in the use of WLANs in the Job Corps instructional setting and the effect on student learning. This investigation concentrated primarily on a model to implement WLANs in the NJCP; it did not provide an in depth investigation into the instructional use of WLANs in the Job Corps classroom.

Recommendations

Based on the HJCA case study findings, it is recommended that the U.S. DOL ETA update the 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology to include the use of IEEE 802.11n-compliant wireless equipment and provisions for the use of IEEE 802.11i. Additional attention should be given to staff and student training regarding the use of WLANs within the Job Corps facility.

The students, as well as the instructors, indicated varying levels of satisfaction with the performance of the HJCA WLAN. Loss of connection and limited bandwidth were the top two major complaints from the students. Lack of printing capabilities, loss of connection and limited bandwidth were the top three major complaints from the instructors. These issues require additional research to specifically troubleshoot the causes for these complaints.

Summary

The goal of this investigation was to develop a model for WLAN implementation within the JC system based on case study findings from the Hartford Job Corps Academy (HJCA). Located in Hartford, Connecticut, the HJCA is one of the 122 Job Corps Centers (JCCs) located in the US and Puerto Rico. The HJCA is contracted to enroll 200 students who can receive driver's licenses, general equivalency diplomas, high school diplomas, and career technical education in business technology, hospitality, travel and tourism, health occupations, and manufacturing.

In 2005, HJCA implemented a WLAN to support connectivity to the JCSN, the Internet, and other learning resources. The performance of the HJCA WLAN had not been evaluated prior this investigation. Within Job Corps, center-wide WLAN implementations are rare, and models for planning, designing, and implementing a WLAN at JCCs are not available. In addition, the staff of the JCCs appeared to lack the knowledge and expertise needed to effectively design and deploy a WLAN implementation.

The primary research questions for the HJCA investigation were: How can JCCs effectively plan, design, develop, and implement WLANs to facilitate access to the Internet and e-learning resources? and How can instructors use the WLAN to facilitate teaching and learning? The author formulated research questions to support the primary research questions; the following research questions were also addressed in this investigation:

Planning Phase or Phase 1

- What were the key factors that supported the decision to implement the HJCA WLAN?
- What factors contributed to the selection of the wireless technology to employ?
- What were the implementation costs?
- How did career technical and academic instruction change with the wireless environment?
- How did student-to-student, instructor-to-student, and student-to-instructor interactivity change with the WLAN solution?

Analysis Phase or Phase 2

- What is the current network design at HJCA?
- How will the physical construction of the HJCA buildings impact WLAN operations?
- What information will be transmitted over the WLAN?
- What applications will be supported by the WLAN?
- How many users will access the WLAN at each JCC?
- Will the WLAN support voice, video, and data transmission?

Design Phase or Phase 3

- How was AP placement determined?
- Does the WLAN design comply with the wireless security standards defined by the U.S. DOL ETA?

Implementation Phase or Phase 4

- Are users with appropriate permissions able to access information using the HJCA WLAN from various locations?
- What modifications to the JCC WLAN design will be required based on the outcome of the HJCA evaluation?
- Has the HJCA WLAN implementation improved student and instructor access to resources?

Support Phase or Phase 5

- What training for instructors, students, and the network administrator will be required for the continued support and use of the HJCA WLAN?

Limitations and delimitations of the investigation were defined. Time was identified as a significant limitation because the investigation was conducted at one point in time. Additionally, wireless applications and technologies continued to evolve during the conduct of this research. Another limitation was the demographics of the students, instructors, and staff at HJCA. These limitations may affect the generalizability of the findings from this case study at HJCA when applied to different JCCs. Since HJCA, like all JCCs, operates in accordance with standardized federal operating procedures and

security protocols; this poses a significant delimitation to this study. Terminology that was central to this investigation was defined and presented in Chapter 1.

Review of the literature was presented in Chapter 2. This review provided the foundation for this investigation. The author examined (a) landmarks in the development of wireless technologies; (b) wireless technologies; (c) key IEEE 802.11 wireless specification and its extensions; (d) wireless security challenges; (e) thin client technology; (f) virtual local area networks (VLANs); (g) mobile technology; and (h) WLAN implementations.

Landmarks in the development of wireless technologies included a brief history of wireless technology beginning in 1895 when Marconi invented the radio. Wireless technologies relevant to this investigation included infrared, Bluetooth, and spread spectrum technologies. The capabilities, merits, and limitations of these technologies were presented.

The IEEE 802.11 specification and its extensions, specifically, a, b, e, i, g, and n were described. Since the HJCA implementation used thin clients, the author discussed related technology. Although the HJCA did not support mobile technology, mobile devices were described in Chapter 2, along with other WLAN implementations.

Chapter 3 included a description of the methodology used in this investigation. The SDLC (Whitten et al., 2001) was introduced and defined. Research methods employed, research questions with propositions, unit of analysis, instrumentation, formats for presenting results, criteria for interpreting the findings, and resource requirements were presented.

This investigation used an embedded case study design with one unit of analysis, the HJCA. The author delineated the validity and reliability of the instrumentation used in this investigation for interviews and questionnaires, and also utilized printed documents as sources of evidence.

Quantitative research was conducted through the use of questionnaires. Questions were developed for each proposition based on the literature reviewed in this investigation and the criteria set forth by Gay and Airasian (2003). The questionnaires were designed and administered through Survey Monkey®, a Web-based survey service. Qualitative data were gathered through interviews with the HJCA Network Administrator and the Job Corps National Office, Division of Information Technology and Support Division Chief.

The quantitative findings obtained from the sampled groups of students and instructors were presented in Chapter 4. The findings from the interviews conducted with the HJCA Network Administrator and the Division Chief for the Job Corps Division of Information Technology and Support were presented, as well. Of the 117 currently enrolled students at HJCA, 43 (37%) 18+ year olds completed the online survey. Seven (63.6%) of the eleven full-time instructors completed the online survey.

As noted, the HJCA WLAN was implemented in 2005 employing IEEE 802.11g-compitable equipment. Although a site survey was not conducted at that time, the network administrator reported that there were no issues with the physical construction of the buildings or placement of the wireless APs at HJCA as it relates to the performance of the WLAN. There have been no updates to the HJCA WLAN since implementation, including the upgrade to IEEE 802.11n-compatible equipment.

The HJCA WLAN supports various applications including e-mail, Microsoft™ Office applications, and access to the Internet. The HJCA WLAN currently supports approximately 250 users that include staff, instructors, and students. Students were able to access the HJCA WLAN in training classrooms, dormitory, and the recreation and administrative buildings.

The HJCA WLAN complies with the wireless security standards defined by the U.S. DOL-ETA. These wireless security standards do not include the use of the IEEE 802.11i specification.

At HJCA, no instructors reported using Web-based tools such as blogs, wikis, discussion forums, bulletin board systems, e-mail, instant messaging, and chat to facilitate collaboration in the classroom. The HJCA instructors did not report using the WLAN to facilitate interactivity within the classroom. Nearly 50% of the students indicated that they owned a handheld device, such as a cellular phone or PDA. The four primary uses of the HJCA WLAN, as reported by students and instructors, were using the Internet to research information, completing work in Microsoft™ Word, creating and sending e-mail, and completing work in Microsoft™ Excel. Students and instructors reported varying levels of satisfaction with the performance of HJCA WLAN.

Chapter 5 included the study's conclusions, implications, and recommendations for the HJCA investigation. As noted, the goal of this investigation was to develop a model for WLAN implementation for the JC system based on case study findings at the HJCA. HJCA is one of the 122 Job Corps Centers (JCCs) located throughout the US and Puerto Rico. The SDLC provided the framework for the NJCP WLAN Implementation

Model (Whitten et al., 2001). Figure 9 illustrates the NJCP WLAN Implementation Model.

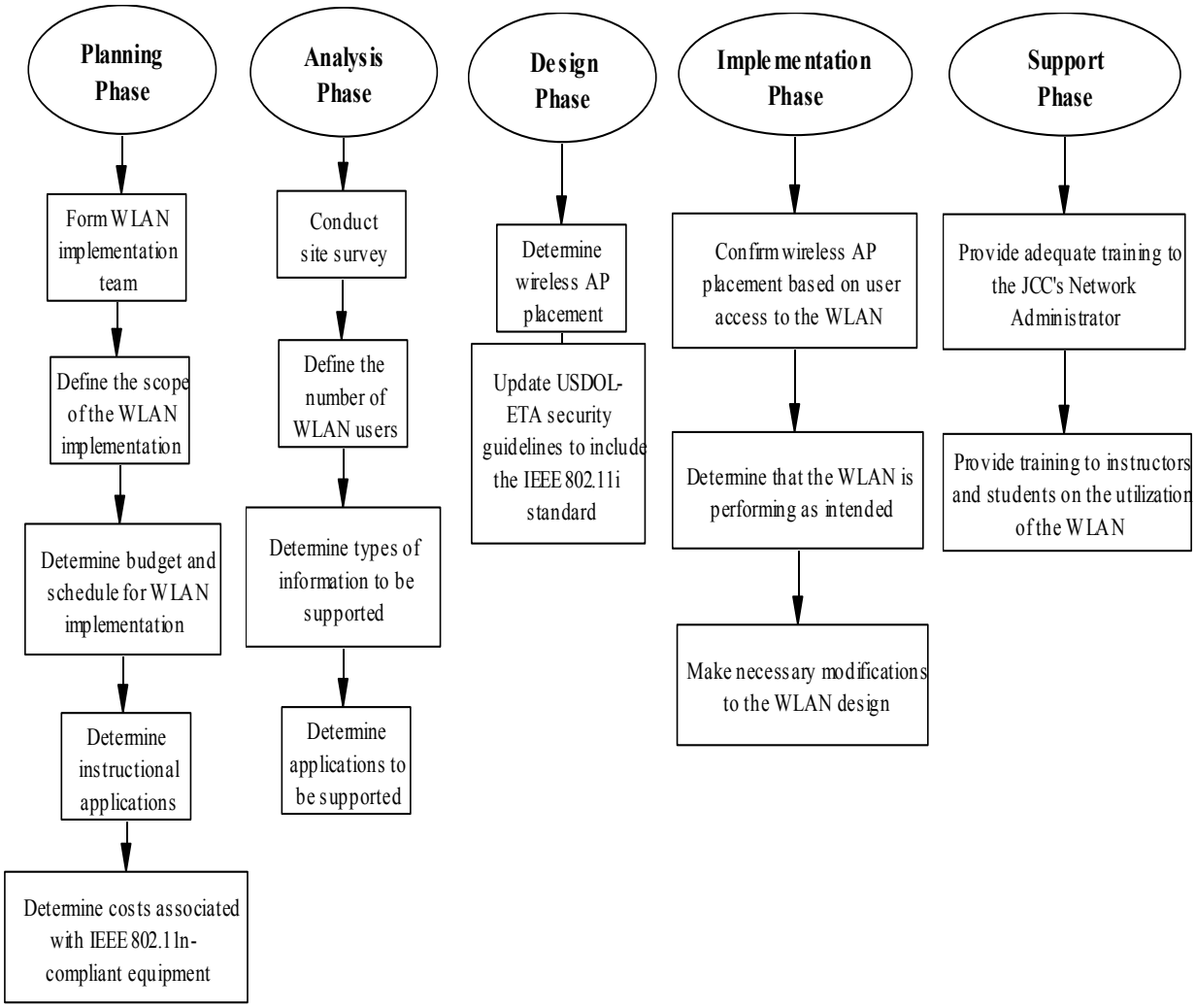


Figure 9. NJCP WLAN Implementation Model

Adapted from Landry & Richard, 2004; Gast 2002, 2005; Owen & Farsaii, 2006; and Geier, 2002.

The students, as well as the instructors, indicated varying levels of satisfaction with the performance of the HJCA WLAN. Loss of connection and limited bandwidth, lack of printing capabilities, loss of connection and limited bandwidth were the major complaints from the students and instructors. These issues will require additional research to specifically troubleshoot the causes for these complaints. Additionally, research is also

needed to document the use of WLANs in the Job Corps instructional setting and the effect on student learning.

In conclusion, the Division Chief for Information Technology and Special Support Programs reported that the NJCP plans to use wireless technology extensively in the future. Currently, the implementation of new WLANs throughout the NJCP is limited by federal policy that governs such deployments. Based on the HJCA case study findings, it is recommended that the U.S. DOL ETA update the 2005 Computer Security Handbook: Security Policy for Portable Electronic Devices and Wireless Technology to include the use of IEEE 802.11n-compliant wireless equipment and provisions for the use of IEEE 802.11i. Additional attention should be given to staff and student training regarding the use of WLANs within the Job Corps facility.

Appendix A

Instrumentation

Student Questionnaire

Instructions: To assist in the design, development, and use of wireless networks in the Job Corps Program, you are asked to complete the following questionnaire. The questions are about you, your general computer use and your use of the wireless network at Hartford Job Corps Academy. Individual responses will be anonymous and will **not** be reported. All data will be tabulated and reported as a whole. This questionnaire should not take any longer than 30 minutes to complete.

Demographic Information

1. Please indicate your gender:
   __ Female
   __ Male

2. Are you currently enrolled in career technical training?
   __ Yes
   __ No

   If yes, which career technical training are you currently enrolled in at Hartford Job Corps Academy?
   ___ Manufacturing
   ___ Hospitality, Travel, & Tourism
   ___ Business Office Technology
   ___ Certified Nurse's Assistant
   ___ Unknown/uncertain
   ___ Other (please specify): _____

3. Please check the age group to which you belong:
   ___ 18-20
   ___ 21-24
   ___ Older than 24 years

4. How long have you been enrolled at Hartford Job Corps Academy?
   ___ Less than 1 month
   ___ 1-6 months
   ___ 7-12 months
   ___ 13-18 months
   ___ 19-24 months
   ___ More than 24 months

General Computer Use

5. How would you rate your computer skills?
   ___ Never used a computer
   ___ Below average
   ___ Average
   ___ Above average
   ___ Expert

6. Using the following scale: not at all (1), a few times a month (2), a few times a week (3), almost every day (4), and several times a day (5), over the past month, on average, circle how often you used a computer for the following:

	Not at all	**A few times a month**	**A few times a week**	**Almost every day**	**Several times a day**
Create and send email	**1**	**2**	**3**	**4**	**5**
Use an Instant Messenger (IM) service	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Word to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Excel to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) PowerPoint to create a presentation	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Access to create a database	**1**	**2**	**3**	**4**	**5**
Play streaming video	**1**	**2**	**3**	**4**	**5**
Play streaming music	**1**	**2**	**3**	**4**	**5**
Use the Internet to research information	**1**	**2**	**3**	**4**	**5**
Create a webpage and/or website	**1**	**2**	**3**	**4**	**5**
Create and/or participate in a blog (a blog is short for weblog. A weblog is a journal that is frequently updated and intended for general public use.	**1**	**2**	**3**	**4**	**5**

7. Do you own a computer?
   ___ Yes
   ___ No

   If yes, what type of computer do you own?
   ___ Desktop
   ___ Laptop
   ___ Notebook

8. A personal digital assistant (PDA) is a handheld device that functions as a Web browser, personal organizer, and cellular telephone. Do you own a PDA or other handheld appliance such as a cellular phone?
   ___ Yes (please indicate): _____
   ___ No

9. On average, how many hours a week do you use a computer for personal use?
   ___ More than 40 hours
   ___ 20-40 hours
   ___ 10-19 hours
   ___ 5-9 hours
   ___ Less than 5 hours
   ___ I do not use the computer for personal use

10. On average, how many hours a week do you use a computer for school assignments?
    ___ More than 40 hours
    ___ 20-40 hours
    ___ 10-19 hours
    ___ 5-9 hours
    ___ Less than 5 hours
    ___ I do not use the computer for school use

Using the Wireless Network at Hartford Job Corps Academy (HJCA)

11. A thin client is a network computer that lacks a hard drive. HJCA uses thin clients as the primary computing device. How often do you use access information using a thin client on the HJCA wireless network?
    ___ More than 40 hours
    ___ 20-40 hours
    ___ 10-19 hours
    ___ 5-9 hours
    ___ Less than 5 hours
    ___ I do not use the thin clients

12. Using the following scale: not at all (1), a few times a month (2), a few times a week (3), almost every day (4), and several times a day (5), over the past month, on average, circle how often you used the wireless network using a thin client for the following:

	Not at all	**A few times a month**	**A few times a week**	**Almost every day**	**Several times a day**
Create and send email	**1**	**2**	**3**	**4**	**5**
Use an Instant Messenger (IM) service	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Word to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Excel to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) PowerPoint to create a presentation	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Access to create a database	**1**	**2**	**3**	**4**	**5**
Play streaming video	**1**	**2**	**3**	**4**	**5**
Play streaming music	**1**	**2**	**3**	**4**	**5**
Use the Internet to research information	**1**	**2**	**3**	**4**	**5**
Create a webpage and/or website	**1**	**2**	**3**	**4**	**5**
Create and/or participate in a blog (a blog is short for weblog. A weblog is a journal that is frequently updated and intended for general public use.	**1**	**2**	**3**	**4**	**5**

13. Which statement best describes your satisfaction with the performance (transmission rate and time to access applications) of the wireless network at HJCA?
    ___ Very dissatisfied
    ___ Somewhat dissatisfied
    ___ Somewhat satisfied
    ___ Satisfied
    ___ Very satisfied

14. Please check all the locations on campus where you access the HJCA wireless network.
    ___ Academic classroom
    ___ Career technical classroom
    ___ Career preparation classroom
    ___ Career transition classroom
    ___ Dormitory
    ___ Recreation facility
    ___ Administration building
    ___ Other: Please Specify: _____

15. What are the major problems you have with the wireless network at HJCA? (Check all that apply)
    ___ Limited bandwidth (data transmission problems with the amount of data that can be received and sent)
    ___ Inadequate number of thin clients available
    ___ Loss of connection
    ___ Lack of printing capabilities
    ___ Other: Please Specify: _____

Please comment on your experiences using the wireless network at HJCA.

16. What type of training did you receive on the use of the HJCA wireless network?

Instructor Questionnaire

Instructions: To assist in the design, development, and use of wireless networks in the Job Corps Program, you are asked to complete the following questionnaire. The questions are about you, your general computer use and your use of the wireless network at Hartford Job Corps Academy. Individual responses are anonymous and will **not** be reported. All data will be tabulated and reported as a whole. This questionnaire should not take any longer than 30 minutes to complete.

Demographic Information

1. Please indicate your gender:
   __ Female
   __ Male

2. What subject area(s) do you teach in at Hartford Job Corps Academy? Please check all that apply.
   ___ Manufacturing
   ___ Hospitality, Travel, & Tourism
   ___ Business Office Technology
   ___ Certified Nurse's Assistant
   ___ GED
   ___ High School Diploma
   ___ Reading
   ___ Math
   ___ Career Preparation, including Information Technology
   ___ Career Transition

3. How long have you been an instructor at Hartford Job Corps Academy?
   ___ Less than 1 month
   ___ 1-12 months
   ___ 13-24 months
   ___ More than 24 months

General Computer Use

4. How would you rate your computer skills?
   ___ Never used a computer
   ___ Below average
   ___ Average
   ___ Above average
   ___ Expert

5. Using the following scale: not at all (1), a few times a month (2), a few times a week (3), almost every day (4), and several times a day (5), over the past month, on average, circle how often you used a computer for the following:

	Not at all	**A few times a month**	**A few times a week**	**Almost every day**	**Several times a day**
Create and send email	**1**	**2**	**3**	**4**	**5**
Use an Instant Messenger (IM) service	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Word to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Excel to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) PowerPoint to create a presentation	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Access to create a database	**1**	**2**	**3**	**4**	**5**
Play streaming video	**1**	**2**	**3**	**4**	**5**
Play streaming music	**1**	**2**	**3**	**4**	**5**
Use the Internet to research information	**1**	**2**	**3**	**4**	**5**
Create a webpage and/or website	**1**	**2**	**3**	**4**	**5**
Create and/or participate in a blog (a blog is short for weblog. A weblog is a journal that is frequently updated and intended for general public use.	**1**	**2**	**3**	**4**	**5**

6. Do you own a computer?
   ___ Yes
   ___ No

   If yes, what type of computer do you own?
   ___ Desktop
   ___ Laptop
   ___ Notebook

7. A personal digital assistant (PDA) is a handheld device that functions as a Web browser, personal organizer, and cellular telephone. Do you own a PDA or other handheld appliance such as a cellular phone?
   ___ Yes (please indicate): _____
   ___ No

8. On average, how many hours a week do you use a computer for personal use?
   ___ More than 40 hours
   ___ 20-40 hours
   ___ 10-19 hours
   ___ 5-9 hours
   ___ Less than 5 hours
   ___ I do not use the computer for personal use

9. On average, how many hours a week do you use a computer for work-related use?
   ___ More than 40 hours
   ___ 20-40 hours
   ___ 10-19 hours
   ___ 5-9 hours
   ___ Less than 5 hours
   ___ I do not use the computer for school use

Using the Wireless Network at Hartford Job Corps Academy (HJCA)

10. A thin client is a network computer that lacks a hard drive. HJCA uses thin clients as the primary computing device. How often do you access information using a thin client or computer on the HJCA wireless network?
    ___ More than 40 hours
    ___ 20-40 hours
    ___ 10-19 hours
    ___ 5-9 hours
    ___ Less than 5 hours
    ___ I do not use the thin client or computer

11. Using the following scale: not at all (1), a few times a month (2), a few times a week (3), almost every day (4), and several times a day (5), over the past month, on average, circle how often you accessed the HJCA WLAN using a thin client or computer for the following:

	Not at all	**A few times a month**	**A few times a week**	**Almost every day**	**Several times a day**
Create and send email	**1**	**2**	**3**	**4**	**5**
Use an Instant Messenger (IM) service	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Word to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Excel to complete work	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) PowerPoint to create a presentation	**1**	**2**	**3**	**4**	**5**
Use MS (Microsoft) Access to create a database	**1**	**2**	**3**	**4**	**5**
Play streaming video	**1**	**2**	**3**	**4**	**5**
Play streaming music	**1**	**2**	**3**	**4**	**5**
Use the Internet to research information	**1**	**2**	**3**	**4**	**5**
Create a webpage and/or website	**1**	**2**	**3**	**4**	**5**
Create and/or participate in a blog (a blog is short for weblog. A weblog is a journal that is frequently updated and intended for general public use.	**1**	**2**	**3**	**4**	**5**

12. Which statement best describes your satisfaction with the performance (transmission rate and time to access applications) of the wireless network at HJCA?
    ___ Very dissatisfied
    ___ Somewhat dissatisfied
    ___ Somewhat satisfied
    ___ Satisfied
    ___ Very satisfied

13. Please check all the locations on campus where you access the wireless network.
___ Academic classroom
___ Office
___ Career technical classroom
___ Career preparation classroom
___ Career transition classroom
___ Dormitory
___ Recreation facility
___ Administration building
___ Other: Please Specify: _____

14. In your opinion, what are the major complaints you have with the wireless network at HJCA? (Check all that apply)

___ Limited bandwidth (data transmission problems with the amount of data that can be received and sent)
___ In adequate number of thin clients available
___ Loss of connectivity
___ Lack of printing capabilities
___ Security problems
___ Other: Please Specify: _____

15. Did you receive training on how to use the wireless network to enhance student learning? If yes, please indicate the type of training you received.

___ Yes, Please indicate type of training.
___ No

16. Please comment on how the use of the wireless network has enhanced teaching and learning at HJCA.

17. Please comment on your experiences using the wireless network at HJCA.

Network Administrator
Interview Questionnaire

Planning Phase or Phase 1

1. What were the key factors supporting the decision to implement the HJCA WLAN?

2. What factors contributed to the selection of the wireless technology to employ?

3. What were the implementation costs?

Analysis Phase or Phase 2

4. What is the current network design at HJCA?

5. How does the physical construction of the HJCA buildings impact WLAN operations?

Design Phase or Phase 3

6. How was AP placement determined? How does the construction of the HJCA buildings impact this determination?

7. Does the WLAN design meet the security and wireless protocols defined by the U.S. DOL ETA?

8. How many users have access to the WLAN?

Implementation Phase or Phase 4

9. What types of information will be transmitted by the users?

10. What security protocols were implemented?

11. Has the WLAN implementation improved student and staff access to e-learning resources?

Support Phase or Phase 5

12. What training is required for the continued support and use of the WLAN for instructors? Students? You?

Division of Information Technology and Support, Division Chief
Interview Questionnaire

1. What are the future plans for WLAN deployment throughout the JC system?

2. How will WLAN deployment be used in designing, planning, and implementing Job Corps' new vision?

Appendix B

Letters Requesting Consent to Conduct Research

November 6, 2006

Ms. Valaida Randolph
President/CEO
Education Management Corporation
221 Laurel Road, Suite 100
Voorhees, NJ 08043

Dear Ms. Randolph

I am currently working on my dissertation for a PhD in Computing Technology in Education through Nova Southeastern University in Fort Lauderdale, Florida. The title of my dissertation is "Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study".

My research will encompass five distinct phases, based on the Systems Development Lifecycle (SDLC). These phases are Planning, Analysis, Design, Implementation, and Support. The goal of the research is to develop a model for a WLAN implementation for Job Corps Centers nationwide and in Puerto Rico.

Next spring, I will be administering several surveys to the students, staff, and system administrator regarding the use of the WLAN. All surveys are anonymous and approved by Nova Southeastern University's Institutional Review Board (IRB). This data will be reported in my final dissertation report on an aggregate basis.

Along with your approval to conduct this research, I will be receiving approval from the Job Corps National Office, Regional Office, the Job Corps Data Center, and the Academy Director. Please sign the attached Consent Form to Conduct Research. Thank you so much for your support.

Sincerely

Tracey K. Cooley

November 6, 2006

Ms. Anita Cardella
Academy Director
Hartford Job Corps Academy
100 William "Shorty" Campbell Street
Hartford, CT 06106

Dear Ms. Cardella

I am currently working on my dissertation for a PhD in Computing Technology in Education through Nova Southeastern University in Fort Lauderdale, Florida. The title of my dissertation is "Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study".

My research will encompass five distinct phases, based on the Systems Development Lifecycle (SDLC). These phases are Planning, Analysis, Design, Implementation, and Support. The goal of the research is to develop a model for a WLAN implementation for Job Corps Centers nationwide and in Puerto Rico.

Next spring, I will be administering several surveys to the students, staff, and system administrator regarding the use of the WLAN. All surveys are anonymous and approved by Nova Southeastern University's Institutional Review Board (IRB). This data will be reported in my final dissertation report on an aggregate basis.

Along with your approval to conduct this research, I will be receiving approval from the Job Corps National Office, Regional Office, the Job Corps Data Center, and Education Management Corporation. Please sign the attached Consent Form to Conduct Research. Thank you so much for your support.

Sincerely

Tracey K. Cooley

November 6, 2006

Edward Benton, Division Chief
Information Technology and Special Support Programs
Job Corps National Office
200 Constitution Ave, NW
Washington, DC 20210

Dear Mr. Benton

I am currently working on my dissertation for a PhD in Computing Technology in Education through Nova Southeastern University in Fort Lauderdale, Florida. The title of my dissertation is "Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study".

My research will encompass five distinct phases, based on the Systems Development Lifecycle (SDLC). These phases are Planning, Analysis, Design, Implementation, and Support. The goal of the research is to develop a model for a WLAN implementation for Job Corps Centers nationwide and in Puerto Rico.

Next spring, I will be administering several surveys to the students, staff, and system administrator regarding the use of the WLAN. All surveys are anonymous and approved by Nova Southeastern University's Institutional Review Board (IRB). This data will be reported in my final dissertation report on an aggregate basis.

Along with your approval to conduct this research, I will be receiving approval from the Regional Office, Academy Director, Education Management Corporation, and the Job Corps Data Center. Please sign the attached Consent Form to Conduct Research. Thank you so much for your support.

Sincerely

Tracey K. Cooley

Appendix C

Consents to Conduct Research

Consent Form to Conduct Research

Location: Hartford Job Corps Academy

I, Edward Benton, on behalf of the Job Corps National Office, approve research to be conducted at Hartford Job Corps Academy. The research is being conducted by PhD candidate, Tracey K. Cooley, to investigate the "Design, Development and Implementation of a Wireless Local Area Network (WLAN)".

The researcher, Tracey Cooley, will not discuss, disclose, release, reproduce or otherwise provide or make available the data, or any portion thereof, to any non-Government person or entity without prior written approval from the Job Corps National Office.

Edward V. Benton II

Edward Benton, Division Chief
Information Technology and Program Support

2/15/2007

Date

Consent Form to Conduct Research

Location: Hartford Job Corps Academy

I, Valaida Randolf, on behalf of Education Management Corporation, approve research to be conducted at the Hartford Job Corps Academy. The research is being conducted by a PhD candidate, Tracey K. Cooley, to investigate the "Design, Development and Implementation of a Wireless Local Area Network (WLAN)".

Valaida Randolf, President/CEO
Education Management Corporation

11/06/06
Date

Consent Form to Conduct Research

Location: Hartford Job Corps Academy

I, Anita Cardella, on behalf of Hartford Job Corps Academy, approve research to be conducted at the Hartford Job Corps Academy. The research is being conducted by a PhD candidate, Tracey K. Cooley, to investigate the "Design, Development and Implementation of a Wireless Local Area Network (WLAN)".

Anita Cardella, Academy Director
Hartford Job Corps Academy

11/6/06
Date

Appendix D

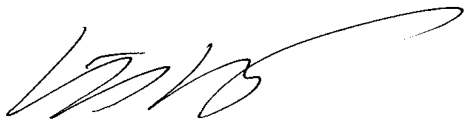
Institutional Review Board (IRB) Approval Memorandum

NOVA SOUTHEASTERN UNIVERSITY
Office of Grants and Contracts
Institutional Review Board

MEMORANDUM

To: Tracey Cooley

From: Ling Wang, Ph.D.
Institutional Review Board



Date: May 22, 2008

Re: *Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study*

IRB Approval Number: wang05220803

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms these must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE REACTIONS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and 954-262-2020 respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Protocol File
Office of Grants and Contracts (if study is funded)

Appendix E

Institutional Review Board (IRB) Participation Letter

Participation Letter
Title of Study: Design, Development and Implementation of a Wireless Local Area Network (WLAN): The Hartford Job Corps Academy (HJCA) Case Study

Funding Source: None.

IRB approval #: wang05220803

Principal investigator
Ms. Tracey Cooley
275 Hartland Ave
Pittsfield, ME 04967
(207) 212-9021

Co-investigator
Marlyn Littman, Ph.D.
3301 College Avenue
Fort Lauderdale, FL 33314
(800) 986-2247 Ext. 2078

Institutional Review Board
Nova Southeastern University
Office of Grants and Contracts
(954) 262-5369/Toll Free: 866-499-0790
IRB@nsu.nova.edu

Site Information
Nova Southeastern University
Center for Psychological Studies
3301 College Avenue
Fort Lauderdale, FL 33314

Description of Study: Tracey Cooley is a doctoral student at Nova Southeastern University engaged in research for the purpose of satisfying a requirement for a Doctor of Philosophy degree. The goal of this study is to develop a model for WLAN implementation for the Job Corps (JC) system based on the experience at HJCA.

If you agree to participate, you will be asked to complete an online questionnaire. The data from this questionnaire will be used to develop a model for WLAN implementation for the JC System. The questionnaire will take approximately thirty minutes to complete.

Risks/Benefits to the Participant: There is minimal risk involved in participating in this study. There are no direct benefits to agreeing to be in this study. Please understand that although you may not benefit directly from participation in this study, you have the opportunity to enhance knowledge necessary to develop a model for WLAN implementation. If you have any concerns about the risks/benefits of participating in this study, you can direct your questions to Ms. Cooley and/or the IRB office at the numbers listed above.

Cost and Payments to the Participant: There is no cost for participation in this study. Participation is completely voluntary and no payment will be provided.

Confidentiality: Information obtained in this study is strictly confidential unless disclosure is required by law. Your name will not be used in the reporting of information in publications or conference presentations.

Participant's Right to Withdraw from the Study: You have the right to refuse to participate in this study and the right to withdraw from the study at any time without penalty.

I have read this letter and I fully understand the contents of this document and voluntarily consent to participate. All of my questions concerning this research have been answered. If I have any questions in the future about this study they will be answered by the investigator listed above.

I understand that the completion of the online questionnaire implies my consent to participate in this study.

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