

UNIVERSIDAD TÉCNICA DEL NORTE



FACULTAD DE INGENIERÍA EN CIENCIAS APLICADAS CARRERA DE INGENIERÍA ELECTRÓNICA Y REDES DE COMUNICACIÓN

IMPLEMENTACIÓN DE LA RED LAN INALÁMBRICA QUE GARANTICE LA PERFORMANCE DE ADMINISTRACIÓN MEDIANTE EL ACCESO A LOS RECURSOS DE LA RED EN LA UNIVERSIDAD TÉCNICA DEL NORTE (UTN)

PROYECTO PREVIO A LA OBTENCIÓN DEL TÍTULO DE INGENIERÍA EN ELECTRÓNICA Y REDES DE COMUNICACIÓN

INFORME TÉCNICO

AUTOR: EDWIN VINICIO GUERRA MORALES

DIRECTOR: ING. CARLOS VÁSQUEZ

IBARRA, 2014

Contenido

1. CURRENT STATUS OF WIRELESS LAN AND RESOURCES.....	3
1.1. Background.....	3
1.2. Description Infrastructure Network UTN.....	3
1.3. Description Infrastructure Wireless LAN Network UTN	3
1.4. Issues with the current Red UTN	4
1.5. Requirements	4
2. INFRASTRUCTURE DESIGN MOBILITY WIRELESS LAN TECHNICAL COLLEGE NORTH	4
2.1. Design requirements	4
2.2. Wireless Network Technology	4
2.3. Hierarchical design model	5
2.4. Addressing the Network	5
2.6. Determining the Wireless Network Equipment.....	5
2.7. APs coverage of Wireless Network.....	6
2.8. Distribution channels	6
2.10. Security Policies	7
3. IMPLEMENTATION OF THE WIRELESS LAN TESTS AND FUNCTIONALITY IN THE TECHNICAL UNIVERSITY OF NORTH.....	8
3.1. Configuring the Wireless LAN Controller	8
3.2. Installing and Configuring the Captive Portal Wifidog.....	8
3.3. Installing and Configuring Webmin	8
3.4. Installing and Configuring Shorewall	8
3.5. Installing and Configuring the Squid Proxy	8
3.6. LDAP User Management	8
3.7. User Management by filtering MAC.....	8
4. CONCLUSIONS	8
5. RECOMENDATIONS	9
6. REFERENCES	9

IMPLEMENTATION OF THE WIRELESS LAN TO GUARANTEE THE PERFORMANCE MANAGEMENT THROUGH THE RESOURCE ACCESS NETWORK AT UNIVERSIDAD TÉCNICA DE NORTE (UTN)

E. Vinicio Guerra Morales – Author, Ing. Carlos Vásquez – Head Teacher

Abstract - The present project has as objective to implement a wireless local area network (WLAN) that allows access through authentication to network resources through a AAA server responsible of validating the entry of each user and additionally controlling the access to Internet through a Captive Portal at “Universidad Técnica del Norte” (UTN). We developed a study about the basics of wireless networks to understand some important concepts such as the IEEE 802.11 protocol, types of antennas, handoff / roaming, security in wireless networks, and others. After that we analyzed the current operating process of the wireless network that had great coverage deficiencies. Then we analyze the design requirements, the wireless network technology, design hierarchical model, network addressing, scalability analysis, equipment’s settings, coverage of Access Points (APs), channels’ distribution, management and configuration of Wireless LAN Controller (WLC), comparative analysis of captive portals, security policies, install and configure the captive portal, authentication server and Firewall - Proxy.

1. CURRENT STATUS OF WIRELESS LAN AND RESOURCES

1.1. Background

The significant increase in network applications has resulted at Universidad Técnica del Norte (UTN) many shortcomings in the performance and capacity of its services and resources. Undoubtedly acquired technological growth has improved in some way benefits the university, which has generated benefits such as digitization of information and disadvantages as traffic congestion by countless packets of information that are enrolled in the network

Students need access to a wireless LAN network within each of the faculties of the UTN, but given the circumstances has not been able to establish good policies on the use, consumption and capacity where the processes undertaken to

ensure its functionality. At strategic points around the institution were implemented in September Access Points (APs), they do not cater to cover an area of coverage and much less efficient mobility.

Any source of reliable information is a complement to query for academic education of students of the UTN; why library resources, repositories and Internet access are a methodological tool for participants in the learning and teaching; identifying the criteria and study procedures.

1.2. Description Infrastructure Network UTN

The Technical University of North has invested heavily in the process of updating all the technological infrastructure was outdated, which prevented meet the new requirements demanded by the growth of the network and data communications. Access to Internet and network resources across technological university is essential, even more so to have more than 9000 users including students, teachers, administrators and employees mansion belonging to the university, the college, the old San Vicente hospital de Paul and Yuyucocha Farms and Meadow respectively

1.3. Description Infrastructure Wireless LAN Network UTN

The Universidad Técnica del Norte currently has a Wireless LAN network short range caters not cover the entire campus and everything that involves managing academic areas such as classrooms, student associations, library, etc.

The team is responsible for managing the wireless network is a Cisco 5500 Series Wireless Controller Model 5508, by which engage the Access Points in lightweight mode with all configuration information maintained within the WLC.

1.4. Issues with the current Red UTN

One of the most popular reasons for WLANs is access without wires, but also is the biggest problem if we refer to safety where any wireless device that captures the signal from the AP, have the ability to surf for free on the Internet, using the network as a point of attack to other networks and then disconnected to avoid detection, software or steal information and introduce viruses or malware.

Radio waves generated by access points can go outside the local campus area in which anyone with a mobile computer and enter the coverage area could connect to the wireless network.

The bandwidth consumption plays an important role, because the hardware PacketShaper by outdated license does not allow sophisticated control of AB, therefore noteworthy that the growth of the institutional network has increased significantly in their applications and services.

1.5. Requirements

Based on the study of the current status of the wireless network UTN emerged some requirements that will be important for the design of it, which are listed below:

- ◆ A greater number of APs to reach areas where no current wireless network caters to cover certain areas of coverage.
- ◆ Control user access which will give greater security to the network before any type of malicious infiltrations, attacks Man-in-the-Middle, etc
- ◆ Management Services.
Roaming refers to the switchover running a user moving between two coordinators wireless network.
Control bandwidth.

2. INFRASTRUCTURE DESIGN MOBILITY WIRELESS LAN TECHNICAL COLLEGE NORTH

2.1. Design requirements

It should take into account considerations in the design of a wireless network in order to provide Internet service to a number of users that belong to the same college unfolding in different positions such as: authorities, administrative, faculty and students.

This design should meet the needs of connectivity from the university campus as educational entity required to improve learning and teaching of their professors to students.

The design must guarantee certain important parameters which are listed below:

- ◆ Availability
- ◆ Scalability
- ◆ Reliability
- ◆ Security
- ◆ Interoperability
- ◆ Number of users
- ◆ Users Authentication
- ◆ Available Bandwidth
- ◆ Centralized Management and Administration
- ◆ Mobility

2.2. Wireless Network Technology

Several technologies are used in wireless networks, the use of each depends largely on the application. A WLAN enables users terminals that are within the coverage area may be connected together.

The technology used in this design is named Wi-Fi or IEEE 802.11 supported by WECA, offering a maximum speed of 54 Mbps and able to withstand the following standards IEEE 802.11a, b, g and n.

The wireless stations and terminal equipment working in the frequency band 2.4 GHz and 5.8 GHz in our country, why use these radio spectrum have no licensing cost and have the ability to integrate easily to a wired network.

2.3. Hierarchical design model

PROPUESTA DE TOPOLOGÍA LÓGICA DE LA RED INALÁMBRICA UTN

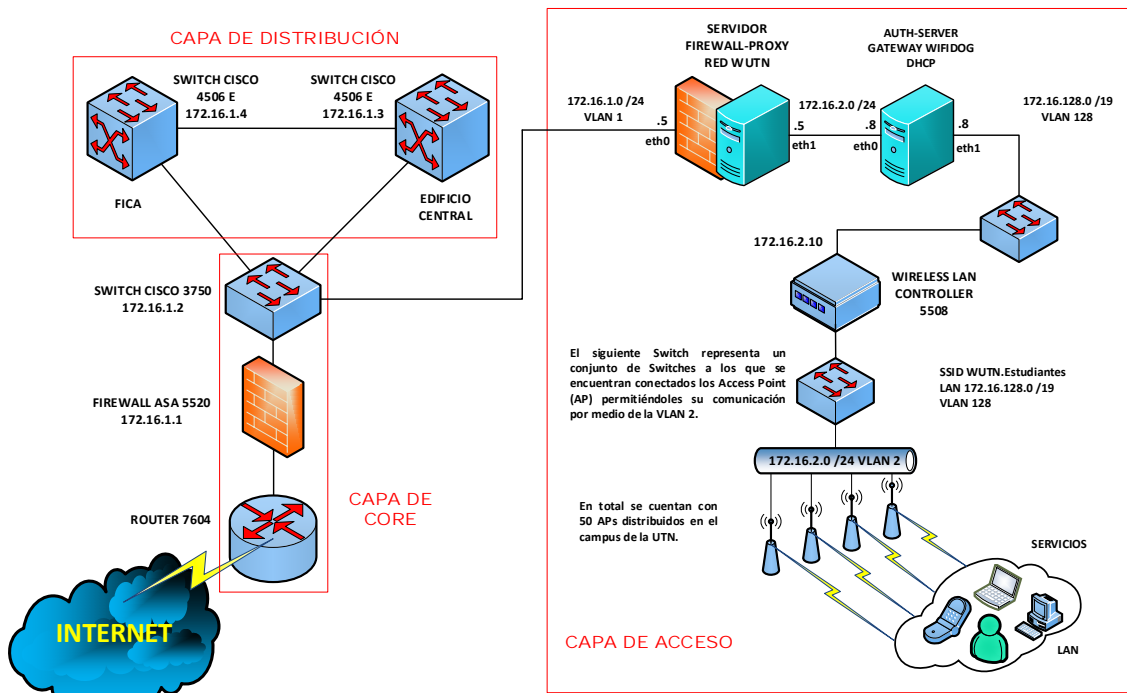


Figure 1 Design Model Hierarchical Wireless Network UTN

2.4. Addressing the Network

According to the study and design made it was decided that the addressing of the active devices on the wireless network (APs and WLC) are in the same VLAN as it had in its current operation.

2.5. Scalability Analysis Network

The network performance Technical University North are well structured because of its ability to adapt to the environment and engage new requirements regarding standards and new technologies.

One of the great benefits of wireless networks is scalability with by certain factors such as:

- ◆ Increased enough bandwidth to provide services to a number of users.
- ◆ Increased coverage area would depend on the signal power APs having installation or possibly more APs that can meet certain places where signal is lost.

One of the drawbacks to resolve remains limited radio spectrum in many situations causes loss of signal interference in the sectors that have installed APs.

According to the design proposal arises as required to increase the number of users and the coverage area of the network, it will need to increase number of APs considering license Wireless LAN Controller and maximum APs enabling us to monitor this computer.

2.6. Determining the Wireless Network Equipment

Based on the design proposed for improving describe Wireless Network equipment supporting 802.11 b / g / n, which are currently used by their compatibility and scalability with a number of wireless devices. The characteristics of this equipment will allow us to have a good layout design teams that provide wireless internet service to users.

2.7. APs coverage of Wireless Network

Calculating the Area of Coverage

Based on the technical specifications within the scope or sectoral antenna are 100 meters, an omnidirectional antenna is 50 meters, a dipole antenna is 90 meters and an internal antenna is 137 meters.

Sector Antenna

To find the area of a circular sector, actually is trying to find a fractional part of the area around the circle where the radiation lobe of the sector antenna is shown. The fraction was determined by the ratio of the central angle of the sector, the central angle around the circle, which is 360; or by the ratio of the arc length and the length of the entire circumference is viewed as in Figure 2. The area is equal to the central angle (120 °) multiplied by Pi and radius squared, the result will be divided by 360.

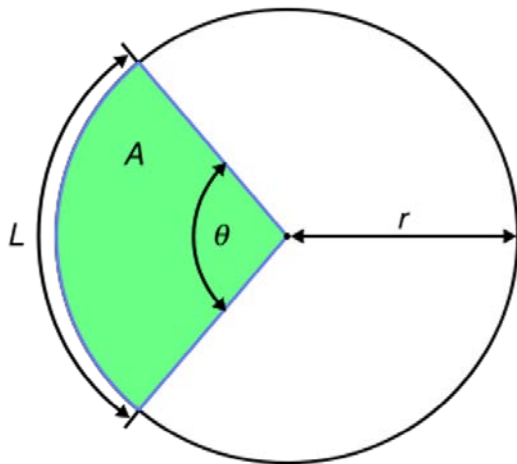


Figure 2 Coverage area of a Sectoral Antenna

A: Área

θ: Ángulo central

r: radio

$$A = \frac{\theta^\circ}{360^\circ} \pi r^2$$

$$A = \frac{120^\circ}{360^\circ} \pi (100m)^2$$

$$A = 10471.97551 m^2$$

$$A \approx 10472 m^2$$

Omnidirectional Antenna

To find the circular area, actually is trying to find the entire area of the circle where the radiation pattern of the omnidirectional antenna is represented as shown in Figure 3. The area equals pi times radius squared.

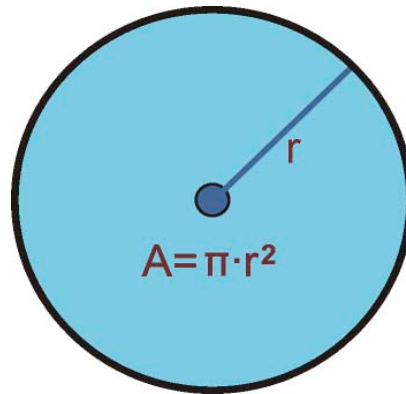


Figure 3 Area coverage of a Omnidirectional Antenna
Source: (Adeva Brito, 2014)

A: Área

r: radio

$$A = \pi r^2$$

$$A = \pi (50m)^2$$

$$A = 7853.981634 m^2$$

$$A \approx 7854 m^2$$

2.8. Distribution channels

In all implementations of wireless networks that no interference in communication through APs, it is considered configure the working channels 1, 6 and 11 based on the distribution of APs in order to solve potential problems that could cause overlapping of the signals and thus connection problems from users wanting to access resources using the Internet.

2.9. Wireless LAN Controller Management

Management functions are performed by a WLC that integrates a number of APs based on the acquired licensing support for the controller. WLC functions include managing APs, user authentication, statistics of users, security policy, channel management, output power levels, etc.

"The process of association of the LAP with the WLC occurs through a tunnel with messages relating to 802.11 and customer data. The LAP and the WLC can be located on the same subnet or VLAN but need not always be so. Enables the tunnel encapsulation between AP data within new IP packets. Tunneled data can be switched or routed through the campus network as shown in the following Figure 4 "(Ariganello & Barrientos Sevilla, 2010, p. 507).

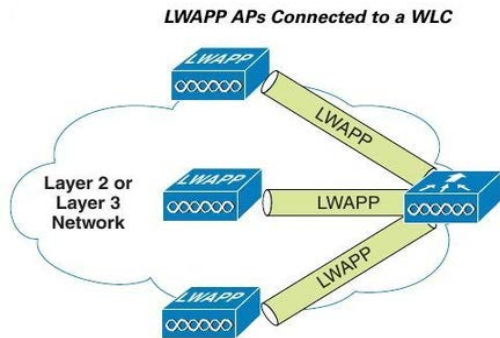


Figura 4 LWAPP Access Points
Fuente: (Fürman, 2014)

The LAP and the WLC using the LWAPP as a mechanism for tunneling divided in two different modes:

- ◆ Control LWAPP messages: messages are used to configure the LAP and manage the operation. These messages are authenticated and encrypted so that the LAP is controlled safely only by WLC.
- ◆ Data LWAPP: Packets to and from the wireless clients are associated with the LAP. Data are encapsulated within LWAPP but are not encrypted between the AP and the WLC.

2.10. Security Policies

- ◆ Maintaining the security of the wireless network of the university requires

methods to ensure that only authorized users can access it. Thus, the computer must have the physical security necessary to prevent affected the services of the wireless network.

- ◆ All access points must be registered and approved by the administrator of the network.
- ◆ Installation, administration and use of the devices on the wireless network must be in accordance with the specifications and standards of wireless networks and the policies implemented in college.
- ◆ The SSID must be configured to be identified with the university.
- ◆ No individual should connect or install any communications equipment to the network without prior authorization from the administrator.
- ◆ Wireless communications do not provide coding of the data transmitted. The protection of data is the responsibility of the user and the application you use to transmit data.
- ◆ Do not allow or encourage the use of the wireless network to use the administrative systems of the University where confidential data transmitted or received.
- ◆ The user's computer connected to the wireless network, is subject to monitoring, penetration testing and security audits.
- ◆ Any team that represents a security risk to the communications network of the university campus, may be disconnected from the network and who has registered the team will be notified.
- ◆ Anything that can not be resolved with users regarding the wireless network system will be referred to DDTI located in the central building of the UTN specifically to Area Networking and Communications to make the decisions needed.

3. IMPLEMENTATION OF THE WIRELESS LAN TESTS AND FUNCTIONALITY IN THE TECHNICAL UNIVERSITY OF NORTH

3.1. Configuring the Wireless LAN Controller

- ◆ Serial Port Properties
- ◆ Clear and Reset settings
- ◆ Basic Configuration Attributes
- ◆ Summary and WLAN interface
- ◆ Checking the version of the Software on the WLC.
- ◆ WLC Software Upgrade.
- ◆ Remove the primary or secondary WLC image.
- ◆ Interfaces
- ◆ Management Access Points
- ◆ Management WLANs
- ◆ AP Group Management
- ◆ Port Mapping the Access Points

3.2. Installing and Configuring the Captive Portal Wifidog

- ◆ Introduction
- ◆ Hardware Configuration and Installation
- ◆ Installation Process
- ◆ Equipment features (server)
- ◆ Test Equipment
- ◆ Topology description test
- ◆ Installing Wifidog

3.3. Installing and Configuring Webmin

- ◆ Installing Webmin on CentOS 6.5
- ◆ Installing using RPM
- ◆ Webmin installation using the repository for Yum
- ◆ RPM based distributions compatible
- ◆ Considerations of interest.

3.4. Installing and Configuring Shorewall

- ◆ Shorewall configuration files
- ◆ Activate and control shorewall

3.5. Installing and Configuring the Squid Proxy

- ◆ Installing Squid
- ◆ Configuring Squid

3.6. LDAP User Management

For administration and management of the database user's LDAP "phpLDAPAdmin" tool is used; which allows you to add, modify and delete OUs, groups, users and attributes quickly and efficiently.

3.7. User Management by filtering MAC

MAC filtering is a very practical to control access to wireless networks method, which greatly optimizes only registered devices can make use of the network. The MAC address is simply a unique identifier for each device but not so sure because there may be spoofing MAC addresses.

Integrating the MAC address with Squid Proxy was performed, whereby access to pages, words and formats extension download always denied and when not registered the MAC of the final device.

4. CONCLUSIONS

- ◆ Have fulfilled the objectives outlined in this paper titration: Design a Wireless LAN Network situational analysis prior to that served as the basis for future implementation.
- ◆ For the realization of a network infrastructure design should take into account considerations such as availability, scalability, reliability, security, interoperability, number of users, user authentication, bandwidth availability, management and centralized management and mobility to meet the needs of the users belonging to the university campus.
- ◆ Calculations coverage area access points help support and sustain good design Wireless Network Infrastructure.
- ◆ It is considered to manually set the working channels 1, 6, 11 based on the layout design of wireless APs

- ◆ RADIUS is a standards-based protocol, and any platform that aims to support RADIUS must be compatible with the standard.
- ◆ RADIUS is a possibility that organizations can perform with your current technology infrastructure, the same as will fit without major economic or functional impacts.
- ◆ The Linux operating system selected for the Captive Portal WiFiDog was Debian for its flexibility in the installation and configuration of each of the files, while the operating system used for Firewall - Proxy was CentOS.

5. RECOMENDATIONS

- ◆ Training should be provided to the staff of Networking and Communications Management at the Technical University Northern reporting all services generated and the implications of the misuse of it.
- ◆ It is recommended to have a backup of all configuration files Captive Portal Authentication Server and Firewall-Proxy.
- ◆ Prior to the design and implementation of a wireless network must perform field tests to determine the extent of signal coverage of the Access Points because there may be factors influencing changes on the raised design.
- ◆ APs that are running do not cater to cover some areas of campus so it is recommended to increase more APs to perform load balancing and not exceed the limit of connections per AP.
- ◆ The shortcomings of the wireless network must undoubtedly the growth of users who use without any control and with two or more concurrently connected devices per user.
- ◆ In the worst case the Wireless LAN Controller stops working for any reason should consider having a backup of another WLC.

- ◆ To avoid any anomaly teams should seriously consider a backup system of own energy for Datacenter, and thus optimize network resources required.

6. REFERENCES

Adeva Brito, D. (10 de Marzo de 2014). Las Formas Geométricas. Obtenido de Sitio Web La cata de queso:
<http://blogs.redalumnos.com/0d6316c3b982c903/FORMAS>

Aguero Calvo, R. (28 de Octubre de 2011). WLAN: Estándar IEEE 802.11. Obtenido de Grupo de Ingeniería en Telemática:
https://docs.google.com/viewer?a=v&q=cache:m4wK2ELXs38J:www.tlmat.unican.es/siteadmi n/submaterials/518.pdf+ramon+aguero+calvo+redes+inalambricas&hl=en&gl=ec&pid=bl&srcid=ADGEEsJpmnb4mZOAi8gJexd42U0cBcxb_u-FFSzUTZE5bv7E7_r2uouajsNHEPrID9poW6nIzkxbHNWFJOOLK

Anguera, J., & Pérez, A. (2011). Teoría de Antenas. Barcelona: Creative Commons Deed.

Ariganello, E., & Barrientos Sevilla, E. (2010). Redes Cisco CCNP a Fondo. Madrid: Alfaomega Ra-Ma.

Barrios Dueñas, J. (10 de Abril de 2014). Configuración básica de Shorewall. Obtenido de Sitio Web Alcance Libre:
<http://www.alcance libre.org/staticpages/index.php/configuracion-basica-shorewall>

Blank, L. T., & Tarquin, A. J. (2006). Ingeniería Económica. México: McGraw-Hill.

Boyano, J. J. (10 de Abril de 2014). Instalación de Webmin en CentOS 6.3. Obtenido de Sitio Web El Blog de Juan José Boyano:
<http://jjboyano.wordpress.com/2013/01/31/instalacion-de-webmin-en-centos-6-3/>

Carlos. (10 de Febrero de 2010). Cacharrero Puro y Duro. Obtenido de Antenas Wireless:
<http://cacharreopuroyduro.blogspot.com/2010/02/antenas-wireless.html>

Chillispot. (5 de 11 de 2013). Chillispot Captive Portal. Obtenido de Sitio Web Chillispot Captive Portal: <http://www.chillispot.org/>

Cisco. (5 de Diciembre de 2013). Cisco Aironet 1130AG IEEE 802.11 A/B/G Access Point. Obtenido de Sitio Web Cisco Aironet 1130AG:

http://www.cisco.com/c/en/us/products/collatera/wireless/aironet-1130-ag-series/product_data_sheet0900aec801b9058.pdf

Cisco. (5 de Diciembre de 2013). Cisco Aironet 1260 Series Access Point. Obtenido de Sitio Web Cisco Aironet 1260: http://www.cisco.com/c/en/us/products/collatera/wireless/aironet-1260-series/data_sheet_c78-593663.pdf

Cisco. (5 de Diciembre de 2013). Cisco Aironet 1300 Series Outdoor Access Point or Bridge. Obtenido de Sitio Web Cisco Aironet 1300: http://www.cisco.com/c/en/us/products/collatera/wireless/aironet-1300-series/product_data_sheet09186a00802252e1.pdf

Cisco. (5 de Diciembre de 2013). Cisco Aironet 1400 Series Wireless Bridge. Obtenido de Sitio Web Cisco Aironet 1400: http://www.cisco.com/c/en/us/products/collatera/wireless/aironet-1400-wireless-bridge/product_data_sheet09186a008018495c.pdf

Cisco. (5 de Marzo de 2014). Cisco 5500 Series Wireless Controller. Obtenido de Sitio Web Cisco 5500 Series Wireless Controller: http://www.cisco.com/c/en/us/products/collatera/wireless/5500-series-wireless-controllers/data_sheet_c78-521631.pdf

Cisco Networking Academy. (2008). Conmutación y Conexión Inalámbrica de LAN. San José, California: Cisco Systems, Inc.

Cobo, D. (8 de Octubre de 2012). WordPress.com. Obtenido de DANICOBOINFOR: <http://danicoboinfor.wordpress.com/2012/10/08/wlan/>

Cordoba Serna, R. (10 de Mayo de 2014). Que es el servidor Proxy. Obtenido de Sitio Web Técnico en Sistema: <http://raicordoba.blogspot.com/2013/09/que-proxy-que-es-un-servidor-proxy-como.html>

Delgado Ortiz, H. H. (2009). Redes Inalámbricas. Lima - Perú: Empresa Editora Macro E.I.R.L.

Diego. (3 de Marzo de 2014). Como calcular el área de un sector circular. Obtenido de Sitio Web Todos los Como: <http://todosloscomo.com/2012/10/22/como-calcular-el-area-de-un-sector-circular/>

Eastep, T. M. (10 de Abril de 2014). Iptables made easy Shorewall. Obtenido de Sitio Web Shorewall: <http://shorewall.net/Introduction.html>

Electric Sheep Fencing LLC. (5 de 11 de 2013). PfSense. Obtenido de Sitio Web PfSense: <http://www.pfsense.org/>

Espinoza, M. P., & Loayza, C. C. (15 de Abril de 2013). Seguridad para la Red Inalámbrica de un Campus Universitario. Obtenido de Seguridad para la Red Inalámbrica de un Campus Universitario: http://www.utpl.edu.ec/seguridad/wp-content/uploads/2008/10/seg_wifi.pdf

FACAE. (15 de Junio de 2013). Universidad Técnica del Norte. Obtenido de UniPortal Web UTN: <http://www.utn.edu.ec/facae/>

FCCSS. (15 de Junio de 2013). Universidad Técnica del Norte. Obtenido de UniPortal Web UTN: <http://www.utn.edu.ec/fccss/>

FECYT. (15 de Junio de 2013). Universidad Técnica del Norte. Obtenido de UniPortal Web UTN: <http://www.utn.edu.ec/fecyt/>

Fernández Hansen, Y., Ramos Varón, A. A., & García Moran, J. P. (2009). RADIUS / AAA / 802.1x Sistemas basados en la Autenticación en en Windows y Linux/GNU Seguridad Máxima. Madrid: Ra-Ma.

FICA. (15 de Junio de 2013). Universidad Técnica del Norte. Obtenido de UniPortal Web UTN: <http://www.utn.edu.ec/fica/>

FICAYA. (15 de Junio de 2013). Universidad Técnica del Norte. Obtenido de UniPortal Web UTN: <http://www.utn.edu.ec/ficaya/>

Fierro Fierro, M. M., & González Bonifaz, F. A. (3 de Febrero de 2012). DSpace ESPOCH. Obtenido de Tesis de Estudio Comparativo de Aplicaciones para la Implementación de Portales Cautivos Empleando Interconectividad entre los Locales de Bonny Restaurant.: <http://dspace.esPOCH.edu.ec/bitstream/123456789/1492/1/18T00454.pdf>

Fürman, J. (15 de Mayo de 2014). Overlapping eduroam Networks Operated by Different Organizations. Obtenido de Sitio Web CESNET: <http://archiv.cesnet.cz/doc/techzpravy/2009/eduroam-overlap/>

- Grupo de Redes de Computadores. (30 de Mayo de 2013). GRC. Obtenido de Universidad Politécnica de Valencia:
<http://www.grc.upv.es/docencia/tra/PDF/Radius.pdf>
- Herrera Ramírez, E., Días Ramírez, A., & Calafate, C. T. (2008). Desarrollando el estándar IEEE 802.11n, un paso adelante en WLAN. México: CiComp'07.
- Hiertz et al. (Enero de 2010). The IEEE 802.11 Universe. IEEE Communications, 48(1), 62-70.
- Holt, A., & Huang, C.-Y. (2010). 802.11 Wireless Networks Security and Analysis. London: Springer.
- IEEE Std 802.11™-2012: Revision of IEEE Std 802.11-2007. (2012). Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications. New York, USA: IEEE Standards Association.
- Île Sans Fil. (5 de 11 de 2013). Wifidog a Captive Portal Suite. Obtenido de Sitio Web Wifidog a Captive Portal Suite:
<http://dev.wifidog.org/>
- Kasper, M. (5 de 11 de 2013). m0n0wall. Obtenido de Sitio Web m0n0wall:
<http://m0n0.ch/wall/>
- Kassar, M., Kervella, B., & Pujolle, G. (Junio de 2008). An overview of vertical handover decision strategies in heterogeneous wireless networks. Comput. Commun. 31, 31. Recuperado el 26 de Agosto de 2013
- Kioskea ES. (5 de Septiembre de 2013). Propagación de las ondas de radio (802.11). Obtenido de kioskea.net:
<http://es.kioskea.net/contents/819-propagacion-de-las-ondas-de-radio-802-11>
- Linux-OS. (5 de 11 de 2013). GNU/Linux, Software Libre, Tecnologías y algo mas.... Obtenido de WiFIDOG - Captive Portal Suite:
<http://www.linux-os.com.ar/linuxos/wifidog-captive-portal-suite>
- Magaña, M. (25 de Abril de 2013). Obtenido de IEEE 802.11: <http://tic-calidad-ieee.blogspot.com/>
- Magnetox24. (16 de Diciembre de 2012). Zonas de Fresnel en Redes Inalámbricas. Obtenido de Un Blog de Tecnología, Software Libre, Redes y Telecomunicaciones:
<http://magnetox24.wordpress.com/2012/12/16/zonas-de-fresnel-en-redes-inalambricas/>
- Monsalve, J. (24 de Junio de 2011). Antenas una explicación de su funcionamiento (II). Obtenido de diarioelectronicohoy.com:
<http://www.diarioelectronicohoy.com/antenas-una-explicacion-de-su-funcionamiento-ii/>
- Ramírez Pérez, C. (2011). Handoff vertical basado en procesos analíticos jerárquicos. Universidad Autónoma Metropolitana Iztapalapa. México: Casa abierta al tiempo. Recuperado el 25 de Agosto de 2013
- Ricciardi, F. (5 de 11 de 2013). Zeroshell Net Services. Obtenido de Sitio Web Zeroshell Net Services: <http://www.zeroshell.org/>
- Solano Jiménez, J. M., & Oña Garcés, M. B. (24 de Marzo de 2010). DSpace ESPOCH. Obtenido de Tesis de Estudio de Portales Cautivos de gestión de acceso Inalámbrico a Internet de la ESPOCH:
<http://dspace.esepoch.edu.ec/bitstream/123456789/103/1/18T00381.pdf>
- Soyinka, W. (2010). Wireless Network Administration a Beginners Guide. USA: McGraw-Hill.
- Stallings, W. (2005). Wireless Communication and Networks Second Edition. New Jersey: Pearson Prentice Hall.
- Vincent, S., & Vançon, T. (5 de 11 de 2013). PepperSpot. Obtenido de Sitio Web PepperSpot:
<http://pepperspot.sourceforge.net/>
- Wikipedia. (16 de Octubre de 2012). Wikipedia The Free Encyclopedia. Obtenido de Wikimedia Foundation, Inc:
http://en.wikipedia.org/wiki/IEEE_802.11
- wndw.net. (Septiembre de 2008). wndw.net. Recuperado el 2 de Agosto de 2013, de Redes Inalámbricas en los Países en Desarrollo:
<http://wndw.net/pdf/wndw3-es/wndw3-es-print.pdf>



Author – Edwin Vinicio Guerra Morales born on August 11, 1988 in the city of Ibarra. Primary education was made in the Special Education Unit Attached "La Victoria". He attended Fisco - Misional "San Francisco de Asís" high school obtaining a bachelor's degree in Physics and Mathematics in 2006. Higher education was made at Universidad Tecnica del Norte studying Engineering in Electronics and Communication Networks. Currently holds the position of Manager of Networking and Communications at Universidad Tecnica del Norte (UTN).