GRENOBLE 1
UNIVERSITE
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Academic Project Report

Open source

Subject : Establishment of a secured network

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Summary

Presentation and organisation

Project definition

The main goal of this project is the design and realise a complete and secured enterprise Network. It will organized in four main parts:

- Part 1 : Design of the network, research, feasibility
- Part 2 : Implementation, Configuration, Testing
- Part 3 : Audit by an other team (Architecture, security…)
- Part 4 : Final defence

This report is about the first part, you can find there the objectives of the project, the organization, the planning and the design of our network with the justification of the choice we have made.

Objectives and constraints

The complete design and architecture has to be made by the team, but we have some global requirements to ensure. First of all, the main concept is to use only open source software and operating system.

What does open source mean? It's a free software which has its entire source code available for everybody and anybody can redistribute it.

Of course this kind of applications has the main advantage of being free and you don't have to pay a licence. But, the configuration is usually not so simple and when a problem occur you have to count on the community, no official support is available.

Also, we will only use open source operating system, mainly GNU/Linux but FreeBSD, it means that it require some knowledge un UNIX system. Some of us has started to learn that this year, it can be a constraint. We didn't define the same system for everybody, so that each one can choose the one that he thinks is the simplest for him.

One of the main difficulty will be to work together, because we are nine and we have to separate properly the work. The communication between each pairs is a key point. The complete planning can be find at the end of the document.

Concerning the objectives we want to achieve, here is the list of the technologies we want to install :

Architecture :

- NAT
- VLans
- Firewall
- 802.1x

Wifi :

- WLan Controller
- Radius Authentication

Services :

- Web server
- Mail, Groupware

User management :

- LDAP
- SAMBA

Administration, Security :

- Proxies
- DNS
- DHCP
- Monitoring and logging tools

VoIP Architecture

Team Organization

For this project, we are seven students involved in. In a way to separate the work, this team is divided in 4 pairs plus including one student alone.

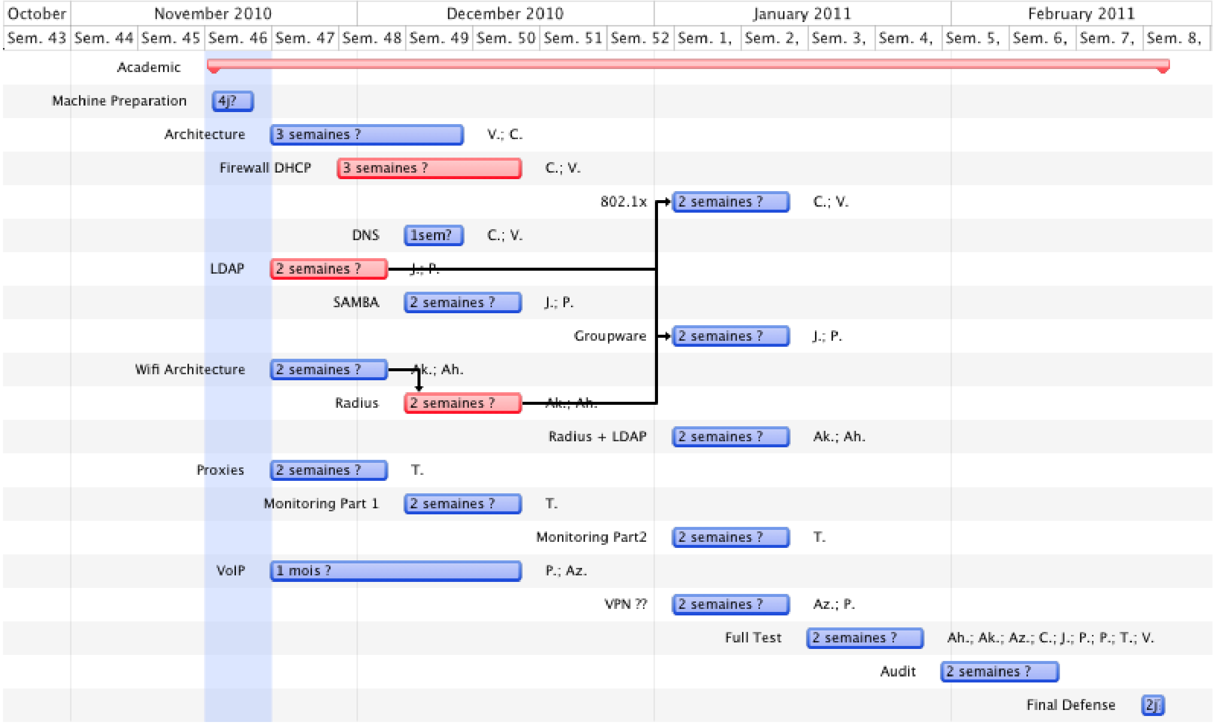
Here is below the repartition of all tasks:

VoIP	-	Pawel Podhajski
Wifi architecture	- -	Nikolaos – Stylianos Aiginitis Ahmed Altaher
LDAP/Groupware	- -	Pedro Fernandez Julien Broi
Architecture, Firewall	-	Charles Vauvarin
Monitoring, logging	-	Vinicius Tinti

Each pairs has to communicate with the other to provide all the information they need. A meeting point is organized once a week to see the progress of everyone.
In order to coordinate the team and to ensure the coherence of the project, Charles has been designated as the manager.

Global Planning

Here is followed the planning of the whole project, all tasks are not described here:



In red are the ''hot'' tasks, it means that they are critical for everybody. Thanks to the Arrow, you can see the dependencies, for example the Wifi needs at the end the LDAP server.

In order to be sure that each part will be on time and it's fully functional at the end, we have organized some validation meeting.

Validation meeting

Parts	Date
Proxies	3/12/ 2010
LDAP	10/12/2010
Groupware	17/12/2010
Radius	17/12/2010
Samba	17/12/2010
Wifi	15/12/2010

Some point cannot be validate until the end of the project, for example the architecture. We will be sure only of the good working with all the parts gathered together

Architecture (Charles)

The architecture that is implemented now is the one below. Since the beginning of the project, several modifications have been done. Some major like the modification of the whole addressing map to simplify it and the suppression of the DMZ for technical reason on the firewall.

Topology

The needed was to build an enterprise network, we decided to implement a simple architecture with one firewall, different vlan and a DMZ to store services (Mail, Web server and etc).

During the project, the global architecture are been changed two times, the first we planned to do was the one below. The idea was to have a separate vlan per server in order to increase the security and to separate as much as possible broadcast domains. The addressing map was completely optimized. After started to work, we saw that these kinds of topology provide some problems such as:

- Difficulty to add a new server (necessity to a new vlan for example)
- Configuration of the firewall difficult to maintain

We decided so to simplify this map and to redesign the complete addressing and the vlan repartition with something much simpler. Due to technical problem with a driver for a network interface card on the firewall and some other issue we will see after, the DMZ was removed also.

The new topology can be found below and the vlan's descriptions are in the next part.

Vlans and Zones

Virtual Local Area Network are use to separate different network on a same switch. There are logical network. In order to separate different types of users and also to separate users from the servers, five vlans has been defined. The routing between each Vlans is done thanks to the trunk link between the firewall and the switch.
Here is the list of the Vlans :

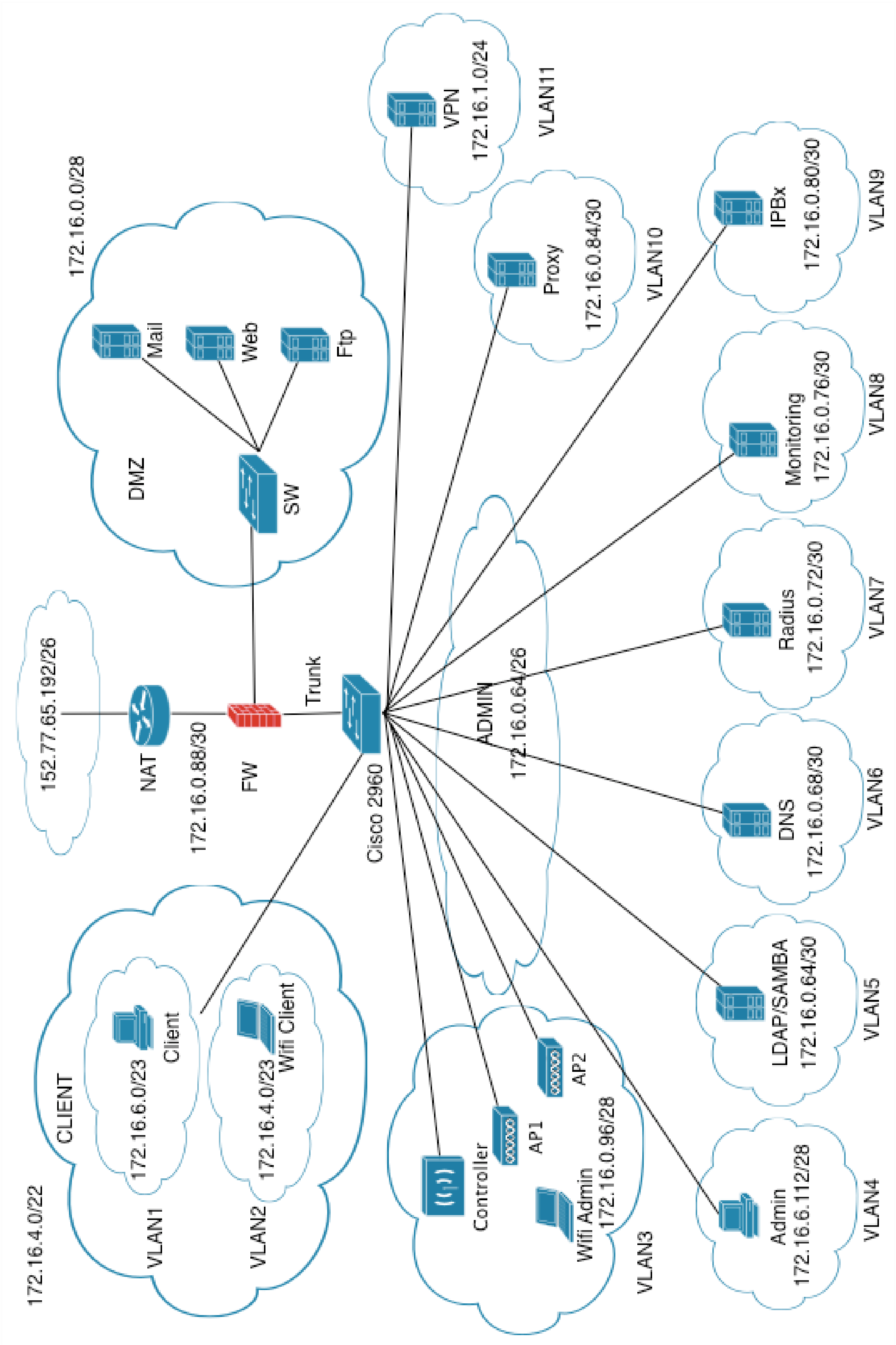
- VLAN1 : Zone for desktop Client
- VLAN 2 : Zone for Wifi Client
- VLAN 3 : Zone the administration of the Wifi (Controller and access point)
- VLAN 4 : Administration zone with all the servers
- VLAN 5 : Zone for VoIP services (IPBX and phones) and also VPN

Rules between each vlans are defined after in the firewall part.

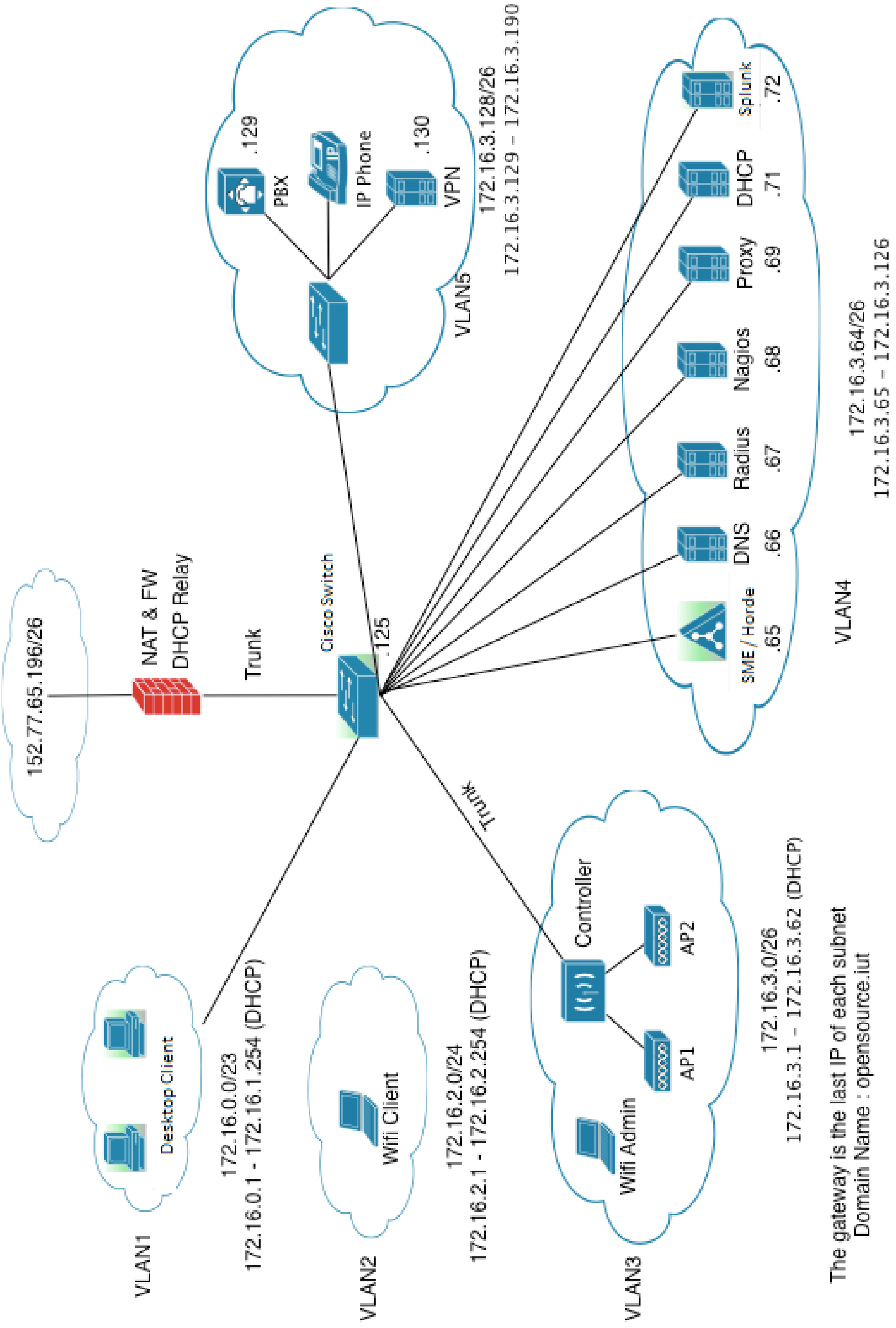
Policies

In order to define the security on our network, we had to define some basic policies for the users and to be apply on the firewall.

- To reach the internet, each machine of the network has to pass through the Local proxy server and the local DNS.
- Each client (Desktop) has to authenticate on a Domain Controller.
- Each wifi client has to authenticate on the Radius server.



Topology at the beginning



Topology after review

Firewall

Definition

This equipment is the network's heart, most of the security rely on it. The firewall will define the filtering rules for input, output connection and also between each local network. It acts on the layer three (network) and four (transport) of the OSI model. There are several types of devices, you can install this software on a basic machine (UNIX/Windows), as an example we can list: pfsense, netfilter, monowall. Such choice must be applied only in personal environment or very small organization. Otherwise, there are built-in and appliance solutions with specific hardware and software. Here, as we work only with open source product, I have chosen to use pfsense.

As I said, the main goal here is to control and rule connectivity between what we called trust zone (the internal network) or un-trust zone (internet). To control this, the firewall allows us to apply some security policies on the data flow (filtering rules).

Pfsense

Pfsense is an open source firewall distribution based on FreeBSD which is well known for its stability and the security it can provide. This project is a customized distribution of FreeBSD and offer lots of functionality, the two main ones are, of course, firewalling and routing. The install is very light and very fast. One interesting advantage is that the configuration can be made through a web interface.

Here are the functionalities we used for our configuration:

- Firewalling
- Routing between vlans
- NAT / PAT
- DHCP Relay

Some others are very interesting such as internal proxy or a VPN server. Our choice was to separate theses two services.

How does it work?

The first rule is that "Everything that is not clearly defined is forbidden". These filtering rules are based on many criteria, usually source and destination address and port and are applied in a certain order, mainly from the top to the bottom. Example: if a packet arrive we will test the compliance with the first rule, if it doesn't match we will test with the second and so one.

Stateful Firewall

There are two different types of firewall, Stateful or Stateless, the one we use there is stateful. It means that it analyses and keeps tracks of connection (TCP or UDP) initiated towards. For example, if a packet goes outside, you don't need to add rules for the replied packets. It can check for instance if a TCP packet is really the result of the previous packet and the response to a package in the other direction.

Network Rules

I have described after all the network policies that are applied inside the network. The main goal is to authorized only what is needed, nothing more. In most of the zones, the principal interest was to access the internet so some rules are redundant:

- Access to the proxy (172.16.3.69) on the port 3128
- Access to the DNS (172.16.3.66) on the port 53

Zone Wan

The Wan interface is the one on the internet with the public IP, the first rules blocked every public address to pass. The last two wan are for accessing two services we have in the internal network which are the VPN server and the IPBX. Everything else is denied.

Action	Proto	Source	Port	Destination	Port	Gateway
Block	RFC 1819	*	*	*	*	*
Block						
Pass	TCP/UDP	*	*	172.16.3.129	5060	*
Pass	UDP	*	*	172.16.3.130	1194	*

Zone Admin

This zone is especially dedicated to servers, the DNS is can access the DNS of the University, the Proxy is allowed to access the three proxies of the University too. The ping is allowed for everybody. Admin Net means all the address in the network.

Action	Proto	Source	Port	Destination	Port	Gateway
Pass	ICMP	Admin Net	*	*	*	*
Pass	UDP	172.16.3.66	*	193.54.238.51	53	*
Pass	TCP	172.16.3.69	*	152.77.24.38	3128	*
Pass	TCP	172.16.3.69	*	152.77.24.34	3128	*
Pass	TCP	172.16.3.69	*	193.54.238.42	3128	*

Zone WifiAdmin

Administration zone for the Wifi only, from here there is Internet access and the Wifi controller is able to reach the Radius in the Admin zone. The ping is allowed for everybody.

Action	Proto	Source	Port	Destination	Port	Gateway
Pass	UDP	WifiAd Net	*	172.16.3.66	53	*
Pass	TCP	WifiAd Net	*	172.16.3.69	3128	*
Pass	UDP	172.16.3.1	*	172.16.3.67	1812	*
Pass	UDP	172.16.3.1	*	172.16.3.67	1811	*
Pass	ICMP	*	*	*	*	*

Zone Wifi Client

Accessible through the SSID “OSCLIENT” only, from here you can only access the Internet. The ping is forbidden for everybody. WifiCli Net means all the address in the network.

Action	Proto	Source	Port	Destination	Port	Gateway
Pass	UDP	WifiCli Net	*	172.16.3.66	53	*
Block	TCP	WifiCli Net	*	172.16.3.69	3128	*

Zone VoIP

Dedicated zone for IP telephony and for technical reason, the VPN server is also there. Internet access is allowed and also the ping. The IPBX can reach a public one (SIP trunk) to communicate outside. VoIP Net means all the address in the network.

Action	Proto	Source	Port	Destination	Port	Gateway
Pass	ICMP	VoIP Net	*	*	*	*
Pass	UDP	VoIP Net	*	172.16.3.66	53	*
Pass	TCP	VoIP Net	*	172.16.3.69	3128	*
Pass	TCP/UDP	172.16.3.129	*	*	5060	*
Pass	UDP	172.16.3.129	*	*	10000-20000	*

Zone client

Only desktop clients are in this zone, the goal is to access the internet and some internal services (Web server, Groupware). The ping is not allowed.

Action	Proto	Source	Port	Destination	Port	Gateway
Pass	UDP	Client Net	*	172.16.3.66	53	*
Pass	TCP	Client Net	*	172.16.3.69	3128	*

NAT and Routing

The router is the equipment directly connected to the internet and is so exposed to all external malicious behavior. It is the gate of the internal network, for this reason it has to be well chosen and configured. There are two way to implement a router when we have this kind of architecture:

- The router is configured for routing and behind him is the DMZ with some public address for the servers inside. The firewall use after address translation
- The router is configured with address translation and acts as a firewall with some ACL or can be a firewall. The DMZ is so with private address

The first option means that some servers are directly exposed to the internet and should be monitored with a great carefulness. The second option is the one we choose here, it is good for medium company. The router is our firewall and will route everything between each Vlans of the network and through the Internet using NAT.

Network address translation (NAT) gives us many advantages. It has been designed at the beginning to fight against the lack of IpV4 addresses. Here only one public address is required so that from an external point of view, the company is seen as one unique IP. Every client who wants to reach the internet will have his private address translated into this one. We can have thousands of machines inside, everything is completely hidden. Concerning the input connection, by default everything is closed so that nobody can "enter".

If we have some services that have to be reachable from outside (VPN and SIP server here from example), we use a complementary protocol which is the Port Address Translation.

When a connection is initiated on the public address on a defined port, all the packets will be transmitted to a machine in the DMZ.

Configuration

- ***Outbound***

This is the configuration in order for all the machines inside the network to reach the Internet. I have decided to not filter at this level but to filter as we saw before at the firewall level. I mean NAT everything by default and after apply firewall rules.

For example, the first line means that all the address in the range 172.16.0.0/24, if they want to reach the Internet, will be translated into the public IP (152.77.65.196) on any port. The same rule is applied for each zone.

Interface	Source	Port	Destination	Port	NAT Address	Nat Port
WAN	172.16.0.0/23	*	*	*	*	*
WAN	172.16.2.0/24	*	*	*	*	*
WAN	172.16.3.0/26	*	*	*	*	*
WAN	172.16.3.64/26	*	*	*	*	*
WAN	172.16.3.128/26	*	*	*	*	*
WAN	172.16.3.192/26	*	*	*	*	*

- ***Port Forward***

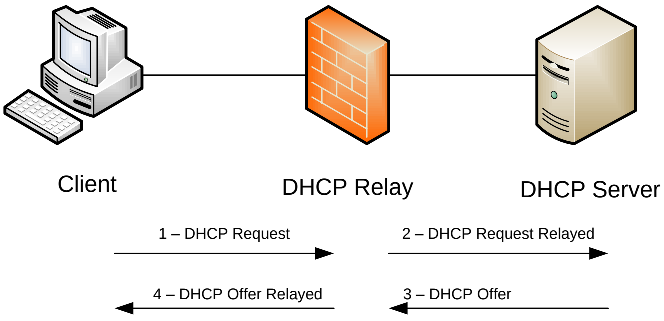
This is the PAT function I spoke before and allow only the access to two servers inside. For example, if a machine wants to access the public IP on the port 5060 (SIP), it will be forward to the IPBX (172.16.3.129) on the same port. The same rule is applied for VPN.

Interface	Protocol	Ext Port Range	NAT IP	Int Port Range
WAN	TCP/UDP	5060	172.16.3.129	5060
WAN	UDP	1194	172.16.3.130	1194

DHCP Relay

We have decided that some zones will be with static address and some other with dynamic. Only Wifi Client and Desktop Client will use a DHCP services. One problem appear here, frames send by client to ask for an IP are broadcast frames and are not route by the firewall. To solve this problem, there are two choices. The first one is to install one server per zone and to distribute addresses like this. That solution costs a lot of resources and is very difficult to manage. The second one is the use of what we called a DHCP Relay, this host is configured to forward all DHCP frames to a single server and to transmit all the replies back.

Here, the firewall is used as a DHCP Relay:



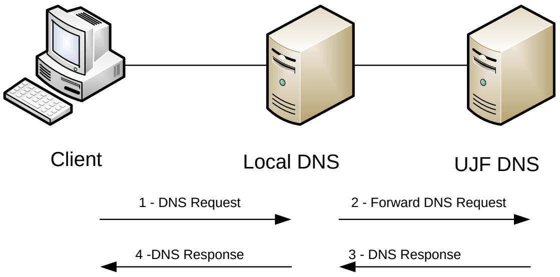
First of all, the client send some broadcast frame on the network, the firewall is listening on the port 68 and transfer this request to the Server in a unicast frame. Then the server reply and the firewall transmit the answer back to the client.

DNS

A Domain Name Service is installed on the network. This DNS server is used to resolve local names aliases like the groupware name or the mail server. Every client who wants to connect to the internet has to use this server which will forward all requests to the main one of the University. The Domain name we choose is “opensource.iut”. The main open source and used software in the world for such application is Bind actually in its version 9. This is the one we installed here.

Some interesting name on the network:

- Mail server : mail.opensource.iut , 172.16.3.65
- Web mail client : mail.opensource.iut/mail
- DNS : dns.opensource.iut, 172.16.3.66
- Proxy ; proxy.opensource.iut, 172.16.3.69



Basic schema of the forwarding system

Project Management

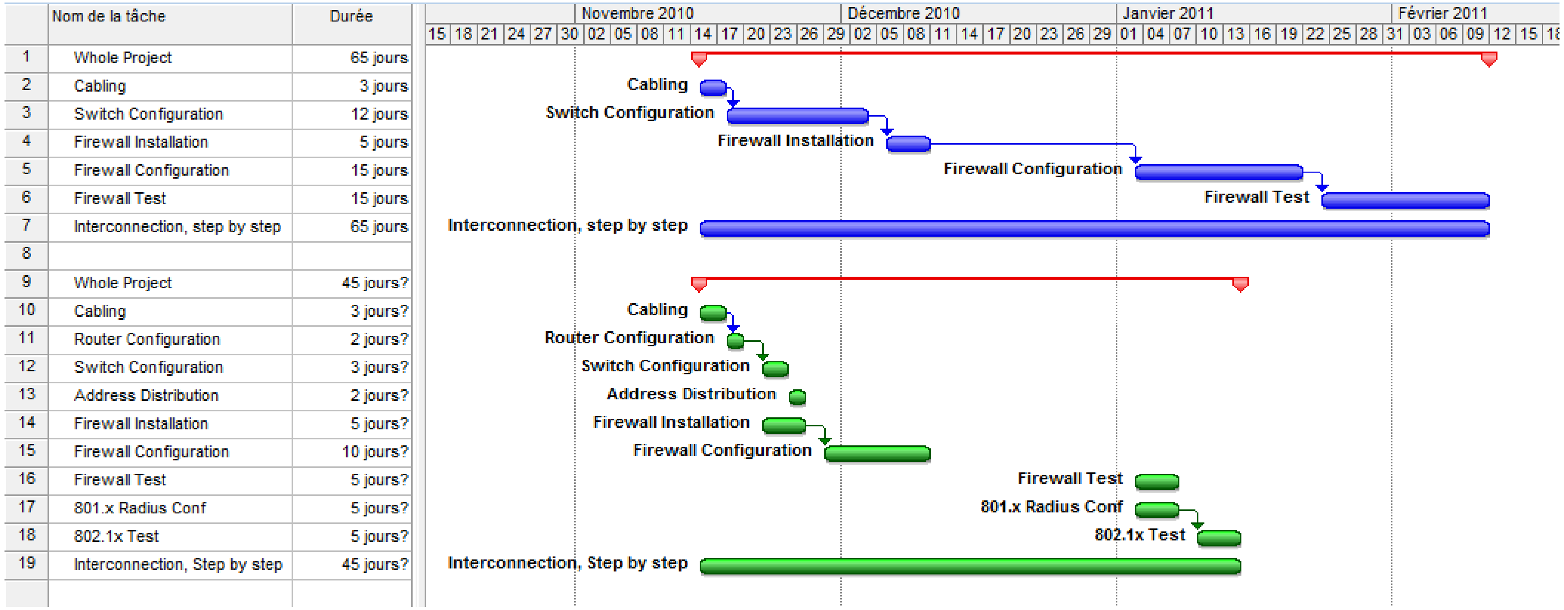
Risk analysis

This part was made during the previous study before starting the project. For my part, the main risk was to use a free product which is not always really friendly to use and sometimes there is not enough documentation. Hopefully for this part, pfsense is really good with a huge and precise documentation. The other risk was to interconnect everything together because we have to test part by part each configuration.

Schedule and delays

You can find on the next page, the first schedule (in green) that I made before starting the project and the final one (in blue). It has change for several reasons, the first one is due to the difficulty to find a good firewall system. Most of the open source products are not really made for production environment but more for little office use or personal use. The second one is that instead of working by pair, I worked alone. Therefore every parallel work that I planned to do could not be done. Also due to this, I did not have time to implement the 802.1x technology.

Another difficulty that I encounter is the fact that I had to interconnect everybody and to solve each problem that appends in this case. I have decided to be responsible of the architecture because I was also team leader. It was so easier for the organization of the group to do like this.



	Nom de la tâche	Durée
1	Whole Project	65 jours
2	Cabling	3 jours
3	Switch Configuration	12 jours
4	Firewall Installation	5 jours
5	Firewall Configuration	15 jours
6	Firewall Test	15 jours
7	Interconnection, step by step	65 jours
8		
9	Whole Project	45 jours?
10	Cabling	3 jours?
11	Router Configuration	2 jours?
12	Switch Configuration	3 jours?
13	Address Distribution	2 jours?
14	Firewall Installation	5 jours?
15	Firewall Configuration	10 jours?
16	Firewall Test	5 jours?
17	801.x Radius Conf	5 jours?
18	802.1x Test	5 jours?
19	Interconnection, Step by step	45 jours?

LDAP, Samba, GroupWare (Pedro and Julien)

Presentation of the technologies

LDAP

Lightweight Directory Access Protocol is a protocol that permits to interrogate and modify some directories databases.

In our network, we use this technology for centralizing all the users' information (passwords, email and etc). It provides thus users and passwords for the Samba server, mail addresses for the GroupWare server.

Samba

Samba is an open source server that permits to emulate an active directory server.

In our network, we use this technology in the way that a user can connect on his account and retrieve his personal files from every machine of the network.

GroupWare

Groupware or collaborative software refers to a set of software that integrates all the work in only one project with a lot of users connected through the network. There are different types of groupware like collaboration/communication tools, conferencing tools and collaborative management tools.

In our network we use the collaboration/communication tool which includes the mail services, web and other services like calendar.

Software chosen

- For LDAP technology, we choose to use OpenLDAP because it is the most documented one;
- For Samba, it is a software in himself so there is no other choice;
- For GroupWare we choose to use Zimbra because it offers many features and is user friendly. The main objective of groupware is to use the mail services integrated in this software.

We wanted to install LDAP and SAMBA on a FreeBSD distribution (both on the same machine) and Zimbra on a Debian distribution.

Finally, we decided to do not take a risk and install everything on a Debian distribution because there were not so much documents about LDAP and Samba on FreeBSD.

Software finally used

We found a distribution in which all our needs were included. Its name is SME.

Project management

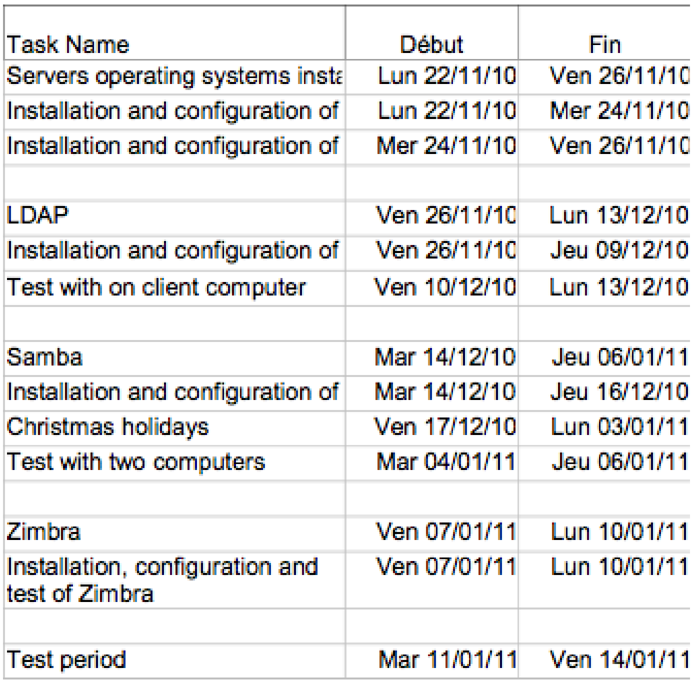
Risk analysis

Here is the first risk analysis we made:

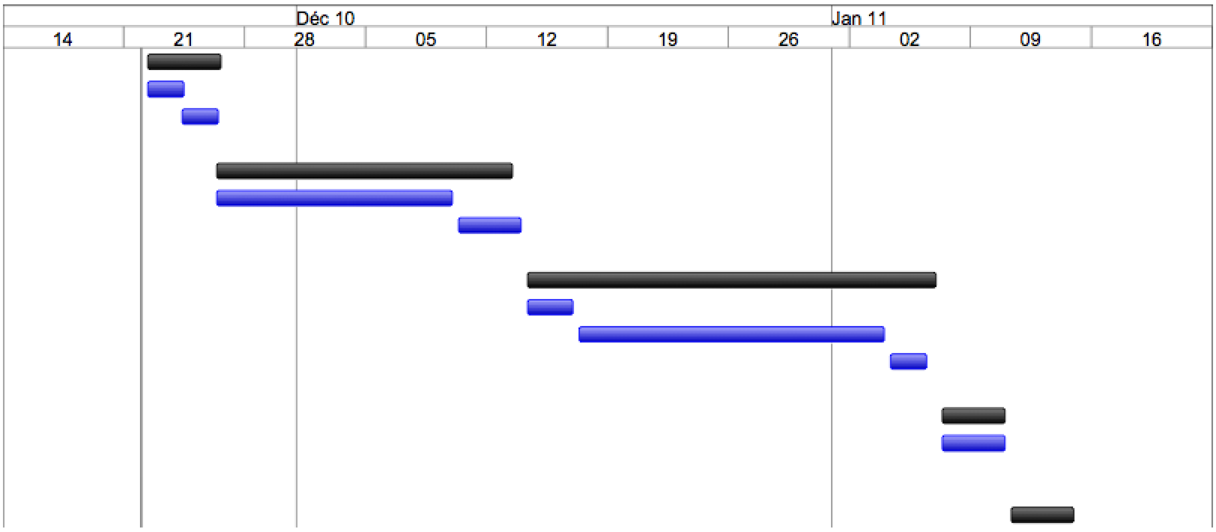
Phases (in order of complexity)	Risks	Gravity (1-4)	Probability (1-4)	Solution	Priority (1-3)
LDAP	Not configuring or installing it well	4	4	The members of the team have knowledge in this technologies thus they can help us	1
	The software doesn't exist for the current OS	3	2	Choose a OS on which the software exists	2
SAMBA	Not configuring or installing it well	4	3	The Install another OS. of the team have knowledge in this technologies thus they can help us	1
	The software doesn't exist for the current OS	3	2	Choose a OS on which the software exists	2
Debian	Not configuring or installing it well	4	2	None	2
	Hardware incompatibility	4	1	Check if the hardware is compatible, change for another bsd or linux distribution.	2
GroupWare	Not configuring or installing it well	4	1	The members of the team have knowledge in this technologies thus they can help us	2
	The software doesn't exist for the current OS	3	2	Choose a OS on which the software exists	2

Scheduling

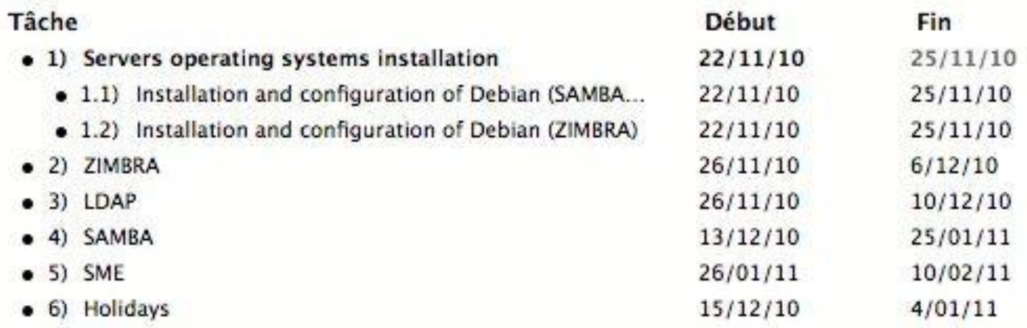
Here is the original scheduling that we previewed for the deployment of the project:



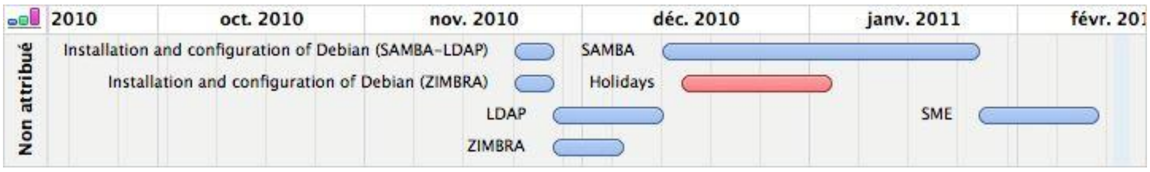
Task Name	Début	Fin
Servers operating systems insta	Lun 22/11/10	Ven 26/11/10
Installation and configuration of	Lun 22/11/10	Mer 24/11/10
Installation and configuration of	Mer 24/11/10	Ven 26/11/10
LDAP	Ven 26/11/10	Lun 13/12/10
Installation and configuration of	Ven 26/11/10	Jeu 09/12/10
Test with on client computer	Ven 10/12/10	Lun 13/12/10
Samba	Mar 14/12/10	Jeu 06/01/11
Installation and configuration of	Mar 14/12/10	Jeu 16/12/10
Christmas holidays	Ven 17/12/10	Lun 03/01/11
Test with two computers	Mar 04/01/11	Jeu 06/01/11
Zimbra	Ven 07/01/11	Lun 10/01/11
Installation, configuration and test of Zimbra	Ven 07/01/11	Lun 10/01/11
Test period	Mar 11/01/11	Ven 14/01/11



Here is the schedule that we finally followed due to the apparition of problems:



Tâche	Début	Fin
• 1) **Servers operating systems installation**	**22/11/10**	25/11/10
• 1.1) Installation and configuration of Debian (SAMBA...	22/11/10	25/11/10
• 1.2) Installation and configuration of Debian (ZIMBRA)	22/11/10	25/11/10
• 2) ZIMBRA	26/11/10	6/12/10
• 3) LDAP	26/11/10	10/12/10
• 4) SAMBA	13/12/10	25/01/11
• 5) SME	26/01/11	10/02/11
• 6) Holidays	15/12/10	4/01/11



Problems

At the beginning we succeeded in installing the operating systems in the delays. Two hands are too much to configure LDAP, that is why Julien began to install LDAP while Pedro was already installing Zimbra. LDAP and Zimbra were ready on time and we began to install Samba before the date we previewed to start.

Then a problem that we did not think about appeared. The installation of Samba was not so hard but we could not succeed in putting LDAP as a backend for Samba.

We started trying to do that in November and we were still stuck in January. Denis and the other members from the project joined us and didn't find a solution too.

So we made the decision to choose another distribution where Samba and LDAP are included into and put its LDAP database as a backend of the Zimbra server. Its name is SME.

Everything worked but another problem appeared. For technical reasons, it was impossible to put the SME LDAP as a backend of Zimbra, the only groupware that we could use was Horde which is included in SME. We thus finally installed SME with Samba, OpenLDAP and Horde included.

When we finished that installation, we tried to fix the first problem that we had firstly (put LDAP as a backend of Samba) but we could not do so we kept the SME configuration that is working well even if there is a problem with the routing part in the network: the computers that are not in the same VLAN than the server and that try to connect to the Samba server can't. So we could only connect on Samba when we were in the same VLAN than it.

Technical information about SME

Introduction

SME Server is build on CentOS using the Red Hat Entreprise Linux source. It has advantages including:

- Simple to set up and use
- Secure and stable to operate
- Cross platform and extendible to meet future needs
- Open source an Free to use

This distribution that include many services:

- File and print sharing
- NAT
- Mail server (Horde)
- FTP
- Firewall
- VPN
- Samba (multi-platform)
- LDAP
- Backup
- And much more

We decided to use a few of these: LDAP, Samba, FTP, Horde and File Sharing (E-BAYS).

Installation

The installation is really simple, you just to download the current stable version on this website: http://wiki.contribs.org/SME_Server:Download

After the installation, your system will restart and will ask you several question about the configuration you want to apply:

- The system password;
- Your system name and domain name;
- Operation mode (Your server can act as a gateway or a simple server);
- The type of ethernet adapters that will be used by your server to communicate with the internal network and the Internet. (Typically, the server software will detect this information automatically) ;
- Configuration of your local network;
- Configuration of your external network (Only if the server acts as a gateway);
- Optional information.

Our server operational mode is just a simple server. The system name is sme and domain name is opensource.iut.

Here is the local network configuration:

- IP:172.16.3.65
- MASK: 255.255.255.192

Configuration screen

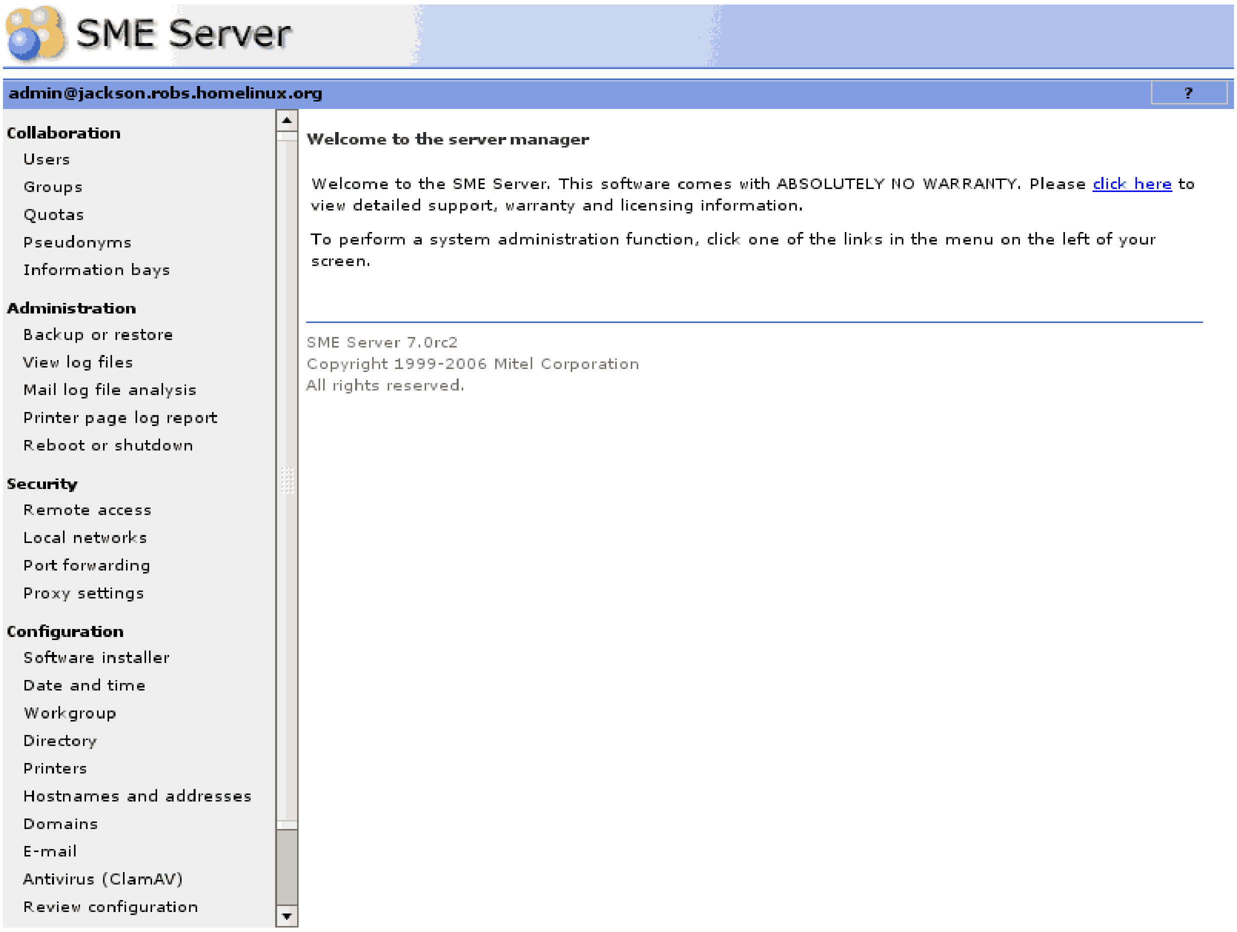
Once installed, you have to connect to the server-manager. The server manager is your control panel for administrating the SME. It can be accessed via a web browser from any client connected to the same local network using one of those URLs:

- https://www.yourdomain.xxx/server-manager
- https://ip-of-your-server/server-manager
- https://name-of-your-server/server-manager

As we used an external dns server, we had several names for accessing to our server (ldap.opensource.iut, sme.opensource.iut, mail.opensource.iut and ftp.opensource.iut).

Once connected on this web site, it will ask you to log in. The default user name for administrating the server is « admin » and the password is the one you entered during the installation.

Welcome to the server-manager console:



Welcome to the server manager

Welcome to the SME Server. This software comes with ABSOLUTELY NO WARRANTY. Please click here to view detailed support, warranty and licensing information.

To perform a system administration function, click one of the links in the menu on the left of your screen.

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In this console, you can configure your server.

Global configuration

In the configuration panel of SME, you should firstly configure the Date, time, hostnames and addresses of the server and decides of who can access to the services proposed by the server.

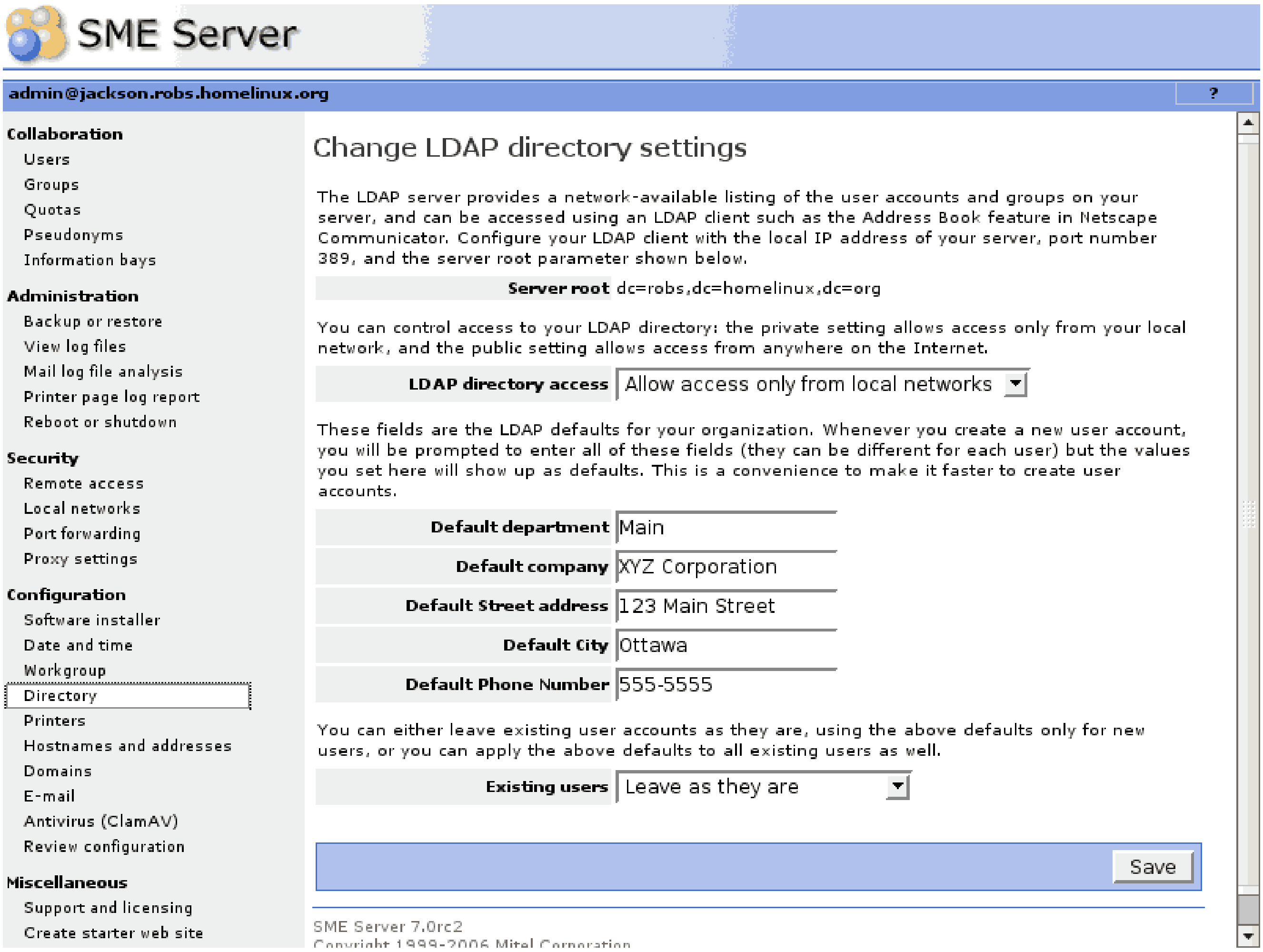
All this stuff can be configured in:

- Configuration – Date and Time;
- Configuration – Hostnames and addresses;
- Security – Local networks.

You can also configure SSH access to your server and other optional stuff in Security – Remote Access.

Configuration and population of LDAP under SME

You can't disable LDAP in sme. It's the core of the distribution so its always activated. You have several configuration settings in the section Configuration – Directory in the configuration screen.



Change LDAP directory settings

The LDAP server provides a network-available listing of the user accounts and groups on your server, and can be accessed using an LDAP client such as the Address Book feature in Netscape Communicator. Configure your LDAP client with the local IP address of your server, port number 389, and the server root parameter shown below.

Server root dc=robs,dc=homelinux,dc=org

You can control access to your LDAP directory: the private setting allows access only from your local network, and the public setting allows access from anywhere on the Internet.

LDAP directory access: Allow access only from local networks

These fields are the LDAP defaults for your organization. Whenever you create a new user account, you will be prompted to enter all of these fields (they can be different for each user) but the values you set here will show up as defaults. This is a convenience to make it faster to create user accounts.

Default department	Main
Default company	XYZ Corporation
Default Street address	123 Main Street
Default City	Ottawa
Default Phone Number	555-5555

You can either leave existing user accounts as they are, using the above defaults only for new users, or you can apply the above defaults to all existing users as well.

Existing users: Leave as they are

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To populate the LDAP, you have to go in Collaboration – Users / Groups section. In these one you can create and manage groups of users or users in the LDAP directory.

For each group created, the sme distribution automatically creates one mail address that forwards received mails to all the members of this group. The format of this mail address is “groupname”@”mycompany.xxx”.

For each account created, the SME distribution automatically creates three pseudonyms linked to this account. For example if I add an user “Julien Broi”, three pseudonym are created:

- jbroi;
- julien.broi;
- julien_broi.

The three pseudonyms are linked to the same user account so it shares the same data. Also, one mail address corresponding to each pseudo is created and they all end to the same mailbox.

Once the accounts are created, you have to set their own password for them to be activated.

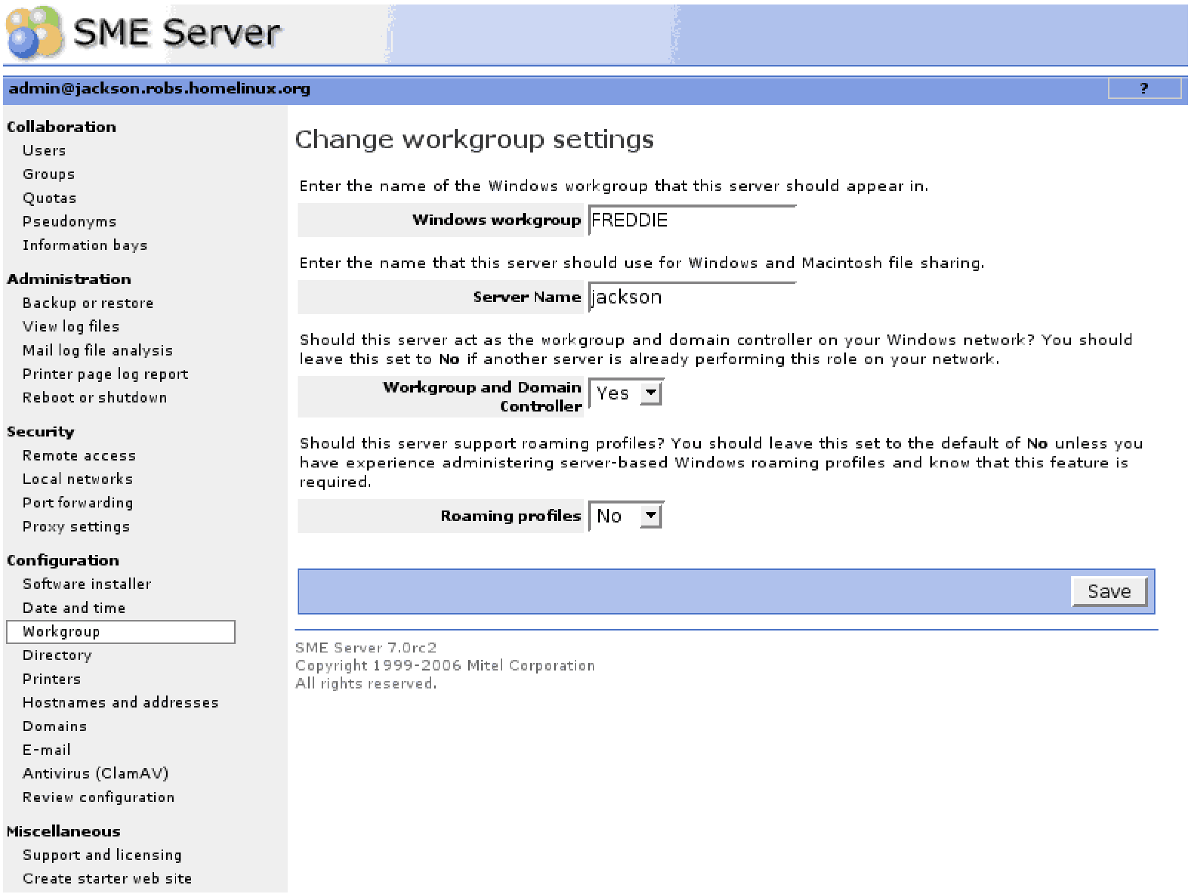
There’s a big problem with passwords storage. All the users information are stored in the LDAP while the passwords are stored in Samba. That’s why we couldn’t integrate the LDAP directory with Zimbra and other external servers where could use it.

Configuration of Samba under SME

To configure Samba, you have to go in the Configuration – Workgroup section of the configuration screen.

The configuration is really simple. You just have to define the your workgroup and activate the domain controller function. You can also activate one of the other options. We activated roaming profiles.

There is also the possibility to define quotas in Configuration – Quotas section



Change workgroup settings

Enter the name of the Windows workgroup that this server should appear in.

Windows workgroup FREDDIE

Enter the name that this server should use for Windows and Macintosh file sharing.

Server Name jackson

Should this server act as the workgroup and domain controller on your Windows network? You should leave this set to **No** if another server is already performing this role on your network.

Workgroup and Domain Controller Yes

Should this server support roaming profiles? You should leave this set to the default of **No** unless you have experience administering server-based Windows roaming profiles and know that this feature is required.

Roaming profiles No

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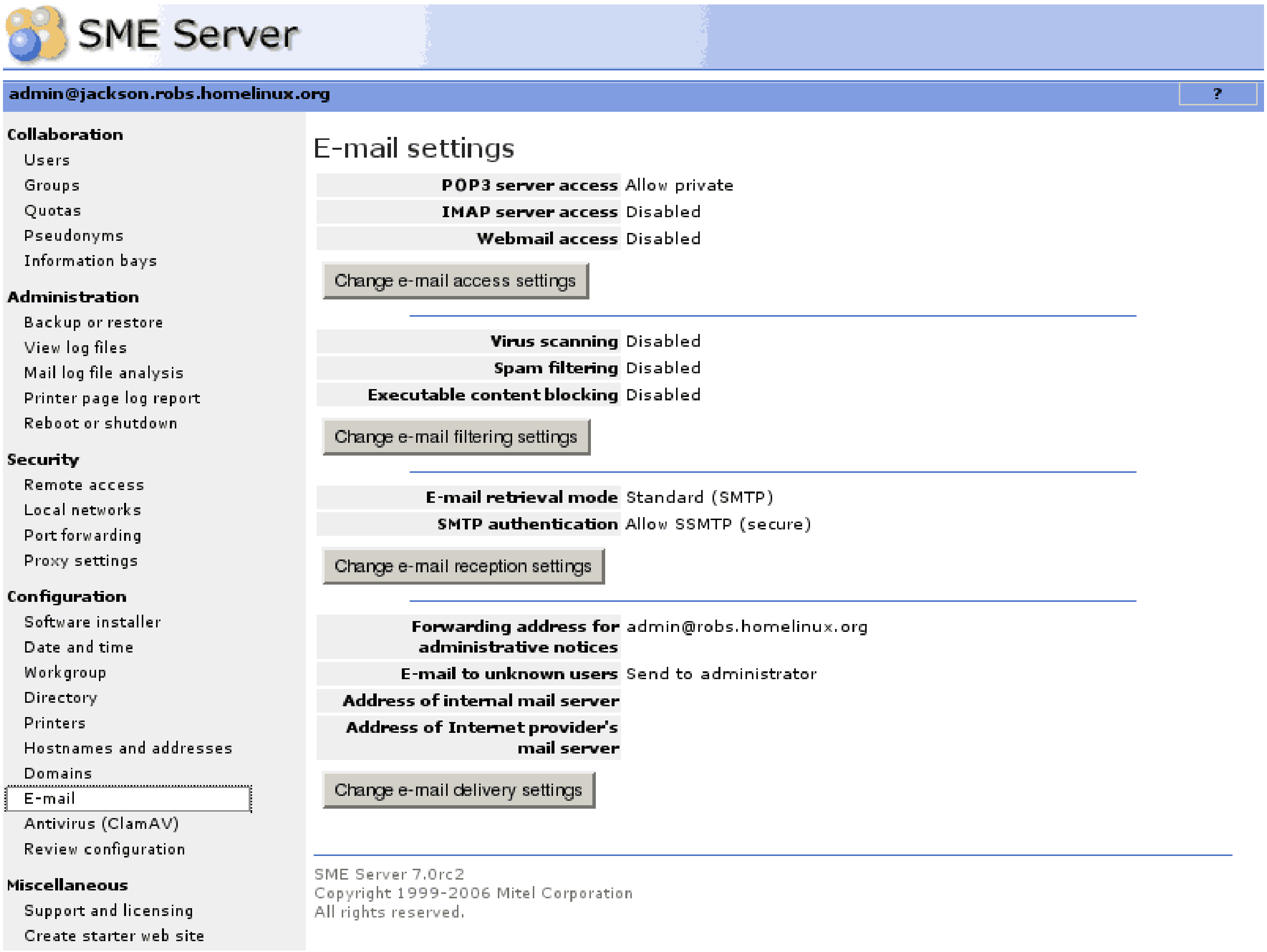
Configuration of Horde (mail) under SME

To configure the mail server you have to go in Configuration - E-mail section of the configuration screen. There are several parameters to take in account to configure your mail server.

To access to your mail, you can use or IMAP protocol or POP3. The difference between them is that POP3 download the mails on your computer. IMAP let them on the server. To send mail, you use another protocol called SMTP. Nowadays there is also another option to manage mails by a web interface in HTTP(S).

Here is the configuration screen:



E-mail settings

POP3 server access	Allow private
IMAP server access	Disabled
Webmail access	Disabled
Virus scanning	Disabled
Spam filtering	Disabled
Executable content blocking	Disabled
E-mail retrieval mode	Standard (SMTP)
SMTP authentication	Allow SSMTP (secure)
Forwarding address for administrative notices	admin@robs.homelinux.org
E-mail to unknown users	Send to administrator
Address of internal mail server	
Address of Internet provider's mail server	

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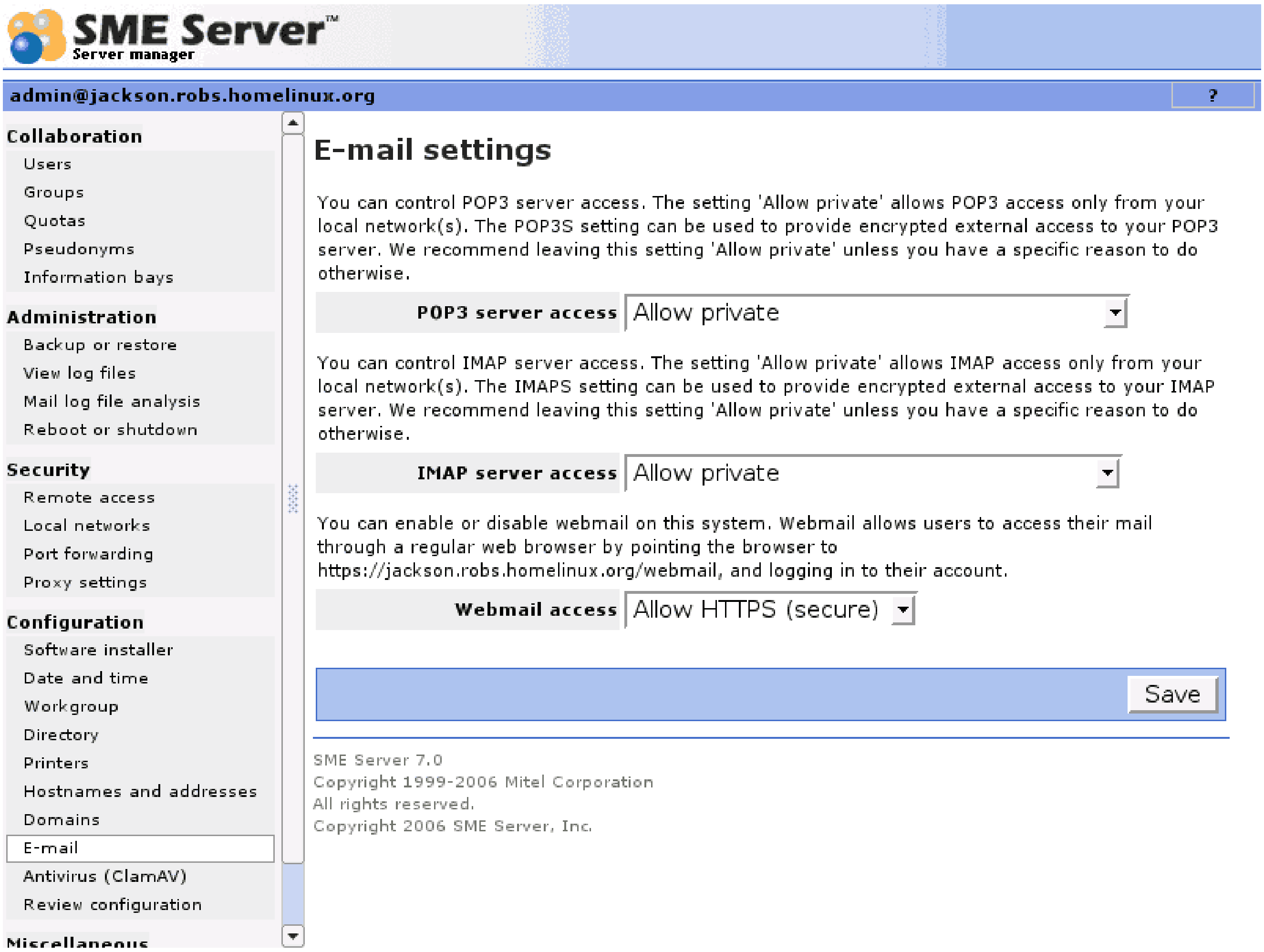
First of all you have to configure the protocols you will use for accessing the mails (POP3 and IMAP). I advice you to configure them in secure public mode thus the mails you receive will be ciphered (POP3S and IMAPS).



E-mail settings

You can control POP3 server access. The setting 'Allow private' allows POP3 access only from your local network(s). The POP3S setting can be used to provide encrypted external access to your POP3 server. We recommend leaving this setting 'Allow private' unless you have a specific reason to do otherwise.

POP3 server access Allow private

You can control IMAP server access. The setting 'Allow private' allows IMAP access only from your local network(s). The IMAPS setting can be used to provide encrypted external access to your IMAP server. We recommend leaving this setting 'Allow private' unless you have a specific reason to do otherwise.

IMAP server access Allow private

You can enable or disable webmail on this system. Webmail allows users to access their mail through a regular web browser by pointing the browser to https://jackson.robs.homelinux.org/webmail, and logging in to their account.

Webmail access Allow HTTPS (secure)

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Then you also have to configure the protocol you will use for sending them (SMTP). I advice you to disable the SMTP Authentication to avoid the risk that an external user sends mails via your server.

Once those first configurations are done, the mail server is ready to work. You can also configure a web access via HTTP(S) (Horde) or add some filtering rules for the mail and such things like that but this is optional.

Configuration of FTP under SME

In our SME server it is possible to configure some file sharing services like for example FTP server.

To activate the FTP server you have to go in security-remote access and there configure the FTP parameters.

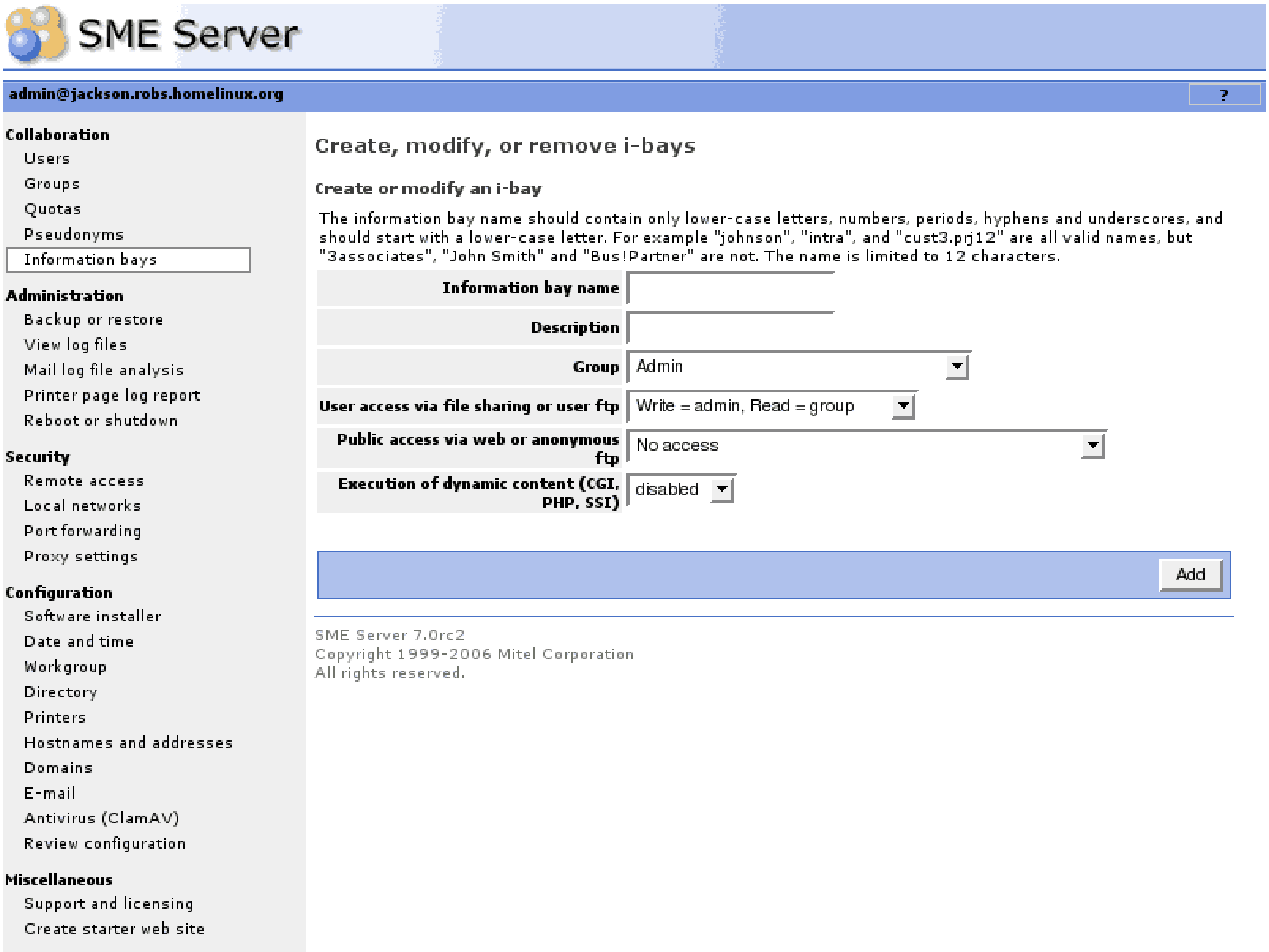
Configuration of I-bays

Information bays or also called I-bays is a powerful, easy and flexible mechanism that allow us to create information sharing sites.

It consist on folders shared on the network that can be reached with different technologies like FTP, SAMBA, etc … This is a really attracting technology that developed for SME distribution.

For these I-bays is possible to configure several characteristics like the owner, permissions to access, the rights to write and read files and can configure passwords to access to these sites.

To configure this, you have to go in Collaboration – Information bays.



Create, modify, or remove i-bays

Create or modify an i-bay

The information bay name should contain only lower-case letters, numbers, periods, hyphens and underscores, and should start with a lower-case letter. For example "johnson", "intra", and "cust3.prj12" are all valid names, but "3associates", "John Smith" and "Bus!Partner" are not. The name is limited to 12 characters.

Information bay name	
Description	
Group	Admin
User access via file sharing or user ftp	Write = admin, Read = group
Public access via web or anonymous ftp	No access
Execution of dynamic content (CGI, PHP, SSI)	disabled

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Our configuration

For concluding, here is our personal configuration of the SME.

Here are the networks that can benefits from the services offered by the server:

- 172.16..0.0/23
- 172.16.2.0/24
- 172.16.3.0/26
- 172.16.3.64/26

Here are the hostnames of our server:

- ftp.opensource.iut
- mail.opensource.iut
- sme.opensource.iut

The timeserver remained the default one.

After configuring the basis we created three groups of users in the LDAP directory(the LDAP configuration remained the default one):

- administrateurs (the administrators of the network);
- employee (the employees of the company);
- managers (the managers of the company).

Here is the table of the account we created, there user name and the group they are in:

USERNAME	GROUP
Ahmed Altaher	employee
NikolaosStylianosAiginitis	employee
Charles Vauvarin	employee
Denis Lubineau	managers
Julien Broi	administrateurs
PawelPodhajski	employee
Pedro Fernandez Gonzalez	administrateurs
ViniciusTinti	employee

As we said before for each account, three pseudo and three mail addresses that are linked to this one were created automatically by sme. Here they are:

ACCOUNT	PSEUDO1	PSEUDO2
ahmeda	ahmed.altaher	ahmed_altaher
nikolaosa	nikolaos.aiginitis	nikolaos_agnitis
charlesv	charles.vauvarin	charles_vauvarin
denisl	denis.lubineau	denis_lubineau
julienb	julien.broi	julien_broi
pawelp	pawel.podhajski	pawel_podhajski
pedrof	pedro.fernandez.gonzalez	pedro_fernandez_gonzalez
viniciust	vinicius.tinti	vinicius_tinti

The mail addresses correspond to these pseudos ("pseudo@domain.xxx").

You have to notice also that for each group, one global mail address for referring to all the users of this one was automatically created by sme. There is also default users and pseudonyms like "admin",..

We created several I-bays with different owners and rules for each one:

NAME	GROUP OWNER	AUTHENTICATED FTP ACCESS	ANONYMOUS FTP ACCESS
managing	Managers	Write: OWNER Read: OWNER	No access
Projects	Managers	Write: OWNER Read: ALL	Local network (password needed)
Publicdir	Managers	Write: OWNER Read: ALL	Everyone (no password needed)
sharepoint	Everyone	Write: OWNER Read: OWNER	Local network (password needed)
Utilities	administrateurs	Write: OWNER Read: ALL	Local network (password needed)

For samba, our workgroup name is OPENSOURCE and it acts like a windows domain controller. We also activated roaming profiles. When a users connects from everywhere, he is able to retrieve his own home directory and he mounts every I-BAYS that he can access to.

For Mail server we enabled POP3S, IMAPS and SMTP. We also configured a web access to the mails via HTTPS (Horde), spam and virus filtering.

For FTP in the global parameters, we allowed the access with or without password only from our LAN. The folders that are shared are the different I-bays and each I-bay has his own FTP parameters that must respect the global ones.

Conclusion

Finally all the services that we wanted are not organized or setup as we planned but they are present in our network and most of them are working perfectly.

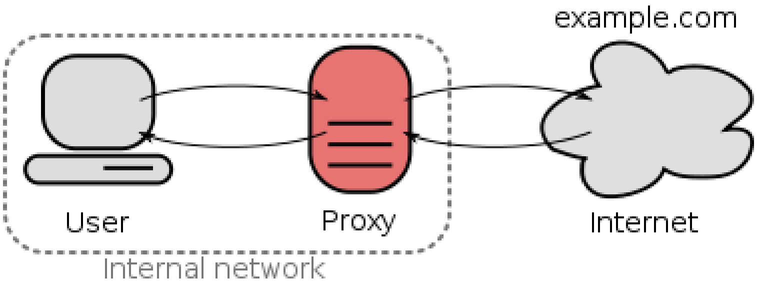
As conclusion we can say that in future projects we have to include in our risk analysis some solution for any eventual problem of collaboration between the technologies. We just thought separately about each technology but we forgot to think about their integration and the possible problems due to this.

Proxy and Monitoring (Vinicius)

Proxy

Introduction

A proxy server an application server that intermediates services requests. A well known example is a web proxy. Instead of each client go direct to the web page we delegate this task for the proxy. The proxy will perform the http request and deliver the proper result to the requester. At the security point of view, this is interesting because this hides the final client (or some dangerous information) from the outside network. If the whole network uses the proxy, from the external point of view we just have one machine doing requests. Also, we have more control over all users. By using monitoring tools we have the ability to manage what the users are doing and further more. We can block or deny any unwanted connection and add credential level in some protocols. Finally, in some cases this proxy can perform cache operations saving transferred data. Another strange (but useful) way to use is to create a reversed proxy which will forward outside requests to the proper internal server.



Internet proxy diagram from Wikipedia

Technology and requirements

Our technology used was Squid version 3. Squid is proxy server and a cache management system. It is mainly used for HTTP but can work in many protocols such as TSL, HTTPS and FTP. It is traditional free software under GPL license. There are some others less famous free proxies in the market, but this one for sure is the best option either by the documentation and community usage. It is also very easy and simple to install and configure. For these reasons we decide to use it in our project.

Our requirements are that the proxy could perform HTTP/HTTPS/FTP requests. It should integrate with an authentication service (especially with LDAP or SAMBA in our case). It should provide logging and monitoring tools. And finally it should have access list to limit and control the access.

Technical study

As guest operating system we will use Debian Lenny that provides Squid3 and Squid (version 2.6). We decided to use the new version Squid3 because both have the same requirements that we need. So the newer version may have more chance to stay supported longer. The Squid has two basic operation modes: direct and transparent. “Direct” means that each client needs to be properly configured to use Squid as proxy. “Transparent” means that the client’s requests will be captured and forwarded to the proxy. Using transparent proxy is easier because we do not need to change any configuration in the clients, however it may lead to many protocol level errors. So to avoid these errors and also increase the security and stability we prefer to use the direct mode.

By default Squid enables a proxy cache which is the reason to run Squid in a dedicated machine. In some cases it requires a lot of IO operations that may make the machine slower. In general is difficult to reach this point with Squid but is a point to be taken in consideration. The rule is: if you have services that requires IO operations avoid to put them together with Squid (if it does have the cache enable).

For the ACLs we define very simple ones. One of them is that only the internal network is accepted by the proxy. This avoids external users from using the proxy as a reflector for an attack. Another ACL that we implemented in the beginning was the login over text file and after over LDAP. Therefore, proxy users must be in the internal network and also provide their credentials to access it. There are some programs in Squid that increase the security level of Squid and also provide standard templates and blacklists like DansGuardian and SquidGuard. They are interesting to be installed. As interesting as iCAP a content filtering protocol that is supported by Squid3.

```
acl allowed_networks src 172.16.0.0/16
acl to_internal_network dst 172.16.0.0/16
# Allow only internal network to use the proxy
http_access allow allowed_networks
http_access deny all
# External proxy configuration
# Hide information about the client
forwarded_for off
# Configure external proxy for the proxy
cache_peer www-cache.ujf-grenoble.fr 3128 0 no-query default
# Force to use the university proxy (except for the internal network)
never_direct allow !to_internal_network
```

For monitoring Squid can provide verbose logs. But they are a hard to understand and my take time to infer something from it. A well know front end to these logs is Sarg. Sarg is basically a logger organizer for Squid. We want also to install it.

Configuration and explanation

The Squid configurations files are provided in the directory /etc/squid3. The main file is squid.conf the others are backup files or standard files that you do not need to change. To start and stop Squid you need to use one of the following commands /etc/init.d/squid3 start|stop|reload|restart.

Problems and delays

The installation was really easy as expected. This is interesting because it give us free time to work on the configuration. The first step was to clean and organize the configuration file that comes with huge (and useful) examples. After that we first block all access from the external network.

After, we start to use also authentication credentials over ACL. First we use a simple .htpasswd file and after we integrate it with LDAP and both worked properly. And also to increase the privacy we add an ACL that hides as information about the internal client.

Everything was good before we move to the 152.77.65.192/26 network which is behind the university proxy. For that reason we need to add ACLs to Squid to saying to never try to perform requests by it. Instead of that, it should forward the requests for the proxy server. This makes our external network works but a problem arrive after. Squid was unable to perform HTTP requests for the inside network. The problem was solved by add an exception in Squid. If the destination address is the internal network you can perform by yourself the request.

Unfortunately, we did not have time to configure more important services like DansGuardian, SquidGuard, Sarg and iCAP.

Modifications

We can say that the progress was good but still missing important parts. The only modifications that we did were to remove DansGuardian, SquidGuard, Sarg and iCAP.

Conclusions

We can say that we archived many of our primary proposes but we did not have time for the secondary ones.

Monitoring

Introduction

For providing a good quality once a service is established we need monitoring and logging tools. The main goal is to be proactive and have more knowledge about the problem. If the logging systems is working properly we can make a view from the exact moment of the problem and once detected we can start to study it. Instead of wait a problem happen again to start to debug is much better and fast to have a proper logging and monitoring system. For example with Nagios you can create monitoring tasks. From time to time Nagios will try to reach one service and perform tasks that will measure the service availability. You can cascade services and detect the impact that may arrive if this service is down. You can also be more proactive with Monit. Once the service is down Monit will try to restart it.

Technology and requirements

In our network, we want a system that could verify our server's availability and concentrate all this information. This will be useful to detect any problems inside our network and also measure the down and up time. This system need to work with as many devices as possible including: servers, desktops and network devices. Would be interesting having SNMP support. This protocol is found in many devices and it can be installed in standard machines. It is a simple way to gather and concentrate all information.

Would be interesting also if this monitoring tool could be active. As soon as a service go down it should try to turn it on again. Sometimes a service just goes down for a completely unknown reason or maybe we cannot avoid it. So if we have a proactive monitoring tool we can save time and increase the up time. Some of these monitoring tools can be very smart and even try more than one way to restart the service (always reporting their actions which will be studied after).

Finally, many services provide their own logging system. But all this logs are distributed among our devices. Would be much more interesting having a single point that concentrates all this information. This tool must connect or receive all logs information and store it. This will prevent problems with data loses and can also work as a backup log.

Technical study

For monitoring we have about three different solutions that are not exactly for the same propose. They are Nagios, Cacti and Zabbix. Choosing between them is not easy, specially because many of them are hard to install properly and configure properly. To avoid losing time on it we will use a pre-installed distribution therefore we can concentrate in the "real" work. We chose Nagios because it fulfil our requirements with the exception of the pro-activity aspect (maybe there are plugins or scripting ways to do that but we will not use it).

We could use Monit for restarting broken services but we will only do it if we have time. So we will consider that at the moment we will not provide this feature in our network.

For log concentrating we decide to use a new product called Splunk. Splunk is a log concentrator with a build in search engine. This is simply an amazing idea. All your data is concentrated in one single point (that could be multiple) and you can perform queries on that. Moreover, it does not depend on your log format since it index plain text. There is also a possibility to do masks in your log that will help Splunk to index it in more organized way. Splunk can also listen in many different ways: text file, script, tcp or udp ports. So in our opinion, this is the best option for the concentrator.

Problems and delays

We installed everything fast but we did not configure all properly. We lose to much time in Splunk. In fact the problem was the syslog and rsyslog (logging services running on Linux) that were not forwarding properly the logs for Splunk. But if we could install Splunk in all machines it would work perfectly. Although, may be not suitable for every network.

Since we lost too much time we only configured Nagios to use pings to verify the services and we do not configured hierarchical services.

Modifications

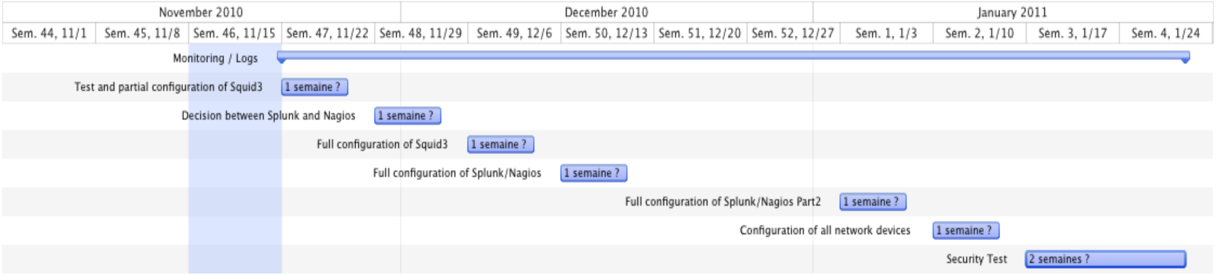
Simple configuration only. We are not using all the resources of Nagios and we should use even more. Splunk proves its values.

Conclusions

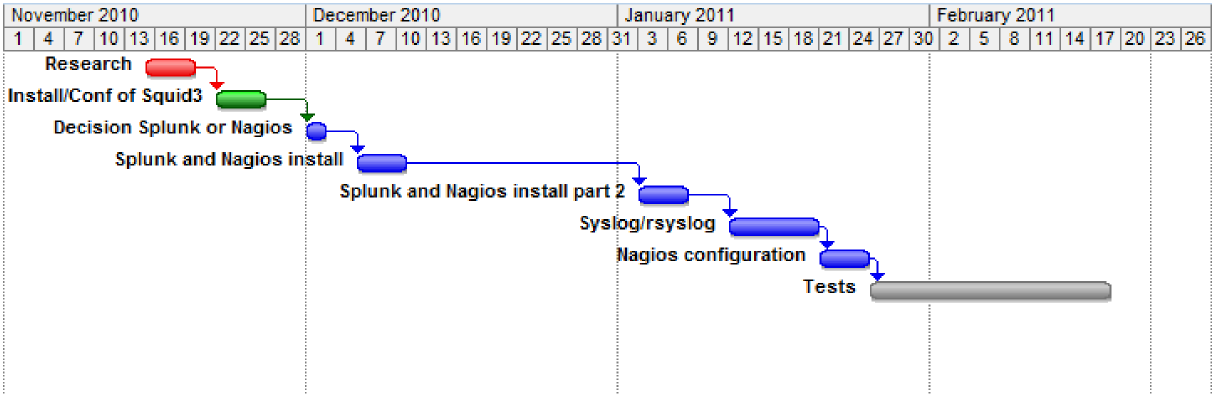
Splunk and Nagios are good tools to monitor and log our network. The combination of both is better than use only one.

General schedule

Original schedule



Final Schedule



Wifi And Radius (Ahmed and Nikolaos - Stylianos)

Introduction

Our tasks include both of WLAN and RADIUS technologies deployment and testing, hence that we use wireless fidelity (Wi-Fi 802.11) standards especially mobility options to give users free work space taking in mind security constraints and procedures .

For security reasons RADIUS authentication will be the best choice to authorize users depending on login database, rights and permissions which is AAA mechanism. Technically 1645 and 1646 UDP ports used to communicate between authenticator and authentication server in Cisco networks, so it's feasible to achieve our security task with this technique.

In this document we prepare the initiation phase regarding our subtasks that depend on other subtasks as subgroups, as a result integration will require compatibility constraints such us hardware configuration or software settings. We set our objectives towards the project requirements and specifications which are very important to reach the security target within available components.

Objectives

- Design and deploy a wireless LAN access infrastructure.
- Allow mobility of users in specified area.
- Secure WLAN by using AAA methodology.
- Using database authentication such as LDAP to increase security.

Component	Model description	Quantity
Wireless Access Point	Cisco Aironet 1242AG /1200AG	**2**
Wireless Access Controller	Cisco 2106	**1**
Switch	Cisco 2960	**1**
RADIUS Server	Computer configured to run Free RADIUS	**1**
LDAP Access	Preconfigured LDAP Server	**1**

Feasibility:

The project (subtasks) is feasible from economic and technical dimensions. In this phase we consider the availability of solutions and their costs according to our requirements and time.

Constraints:

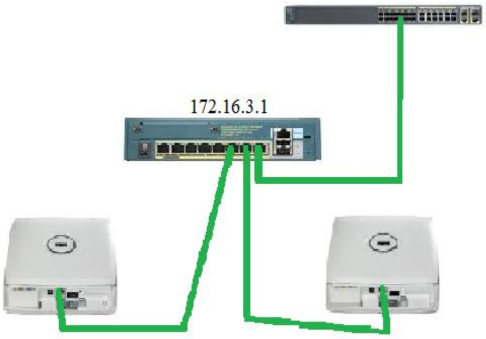
- Hardware limited options.
- Time milestones.
- Open source technologies.
- Security considerations.

Risks:

- Lake of knowledge.
- Other dependent tasks delay.
- Software compatibility problems.
- Hardware configuration problems.

Wifi Part (Ahmed)

Networking diagram



Executing the task:

The following steps explain my task to deploy the Wireless connection:

- Interconnect both of wireless access points to the wireless controller (ports 2 and 3) which connected to the switch (port 1 to port 8).
- Configuring the controller (172.16.3.1) to broadcast 2 SSIDs which are OSADMIN and OSCLIENT.
- configuring the interfaces as following

SSID	VLAN	Controller VLAN	DHCP Range	Gateway
OSADMIN	VLAN 3	Management	172.16.3.2-172.16.3.61/26	**172.16.3.62**
OSCLIENT	VLAN 2	VLAN 2	172.16.2.2-172.16.2.253/24	**172.16.2.254**

Wireless site survey:

The survey was done by Ekahau HeatMapper tool , and experimentally survey used to check the following parameters

- Wireless coverage.
- Data rates.
- Network capacity.
- Roaming capability

My experiment involved running simple tests to determine the presence of radio frequency interference and identify optimum installation locations for access points, but in my opinion was not complete because our deployment needs a real example to fix the location of the access points to determine an effective range boundary, also I did not try the walk-testing and auditing of our existing wireless network.

Radius (Nikolaos - Stylianos)

Introduction

In the following pages we will discover the world of wireless security by implementing a network with one CISCO controller, two lightweight Access Points and a RADIUS server.

Specifically we will provide all the required information in order to configure the RADIUS server in RedHat distribution. The authentication method we will use EAP-TLS with **AES** data encryption.

Basic Requirements

Hardware and Software needed:

PC with at least 256MB RAM and one NIC, we use Intel (suggested)

This PC will be used to install CentOS 5.5 and will be the PC with the RADIUS server.

Two configured CISCO Access Points (Reference WiFi part)

- PC with at least 256MB RAM and installed CentOS that will be used for our Certificate Authority. (optional)
- Windows XP Client with wireless network card.(optional)
- Linux client with wireless network card. (optional)
- MAC client with wireless network card .(optional)
- Wireshark (optional)

What is RADIUS Server ?

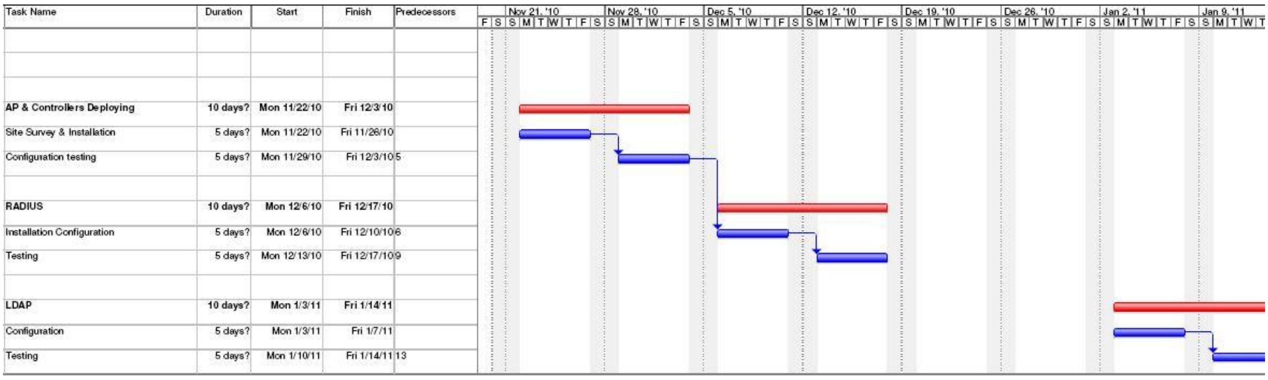
Remote Authentication Dial In User Service (RADIUS) is a networking protocol that provides centralized Authentication, Authorization, and Accounting (AAA) management for computers to connect and use a network service. The main functions of a RADIUS server is to authenticate users or devices before granting them access to a network, to authorize those users or devices for certain network services and to account for usage of those services.

Scope

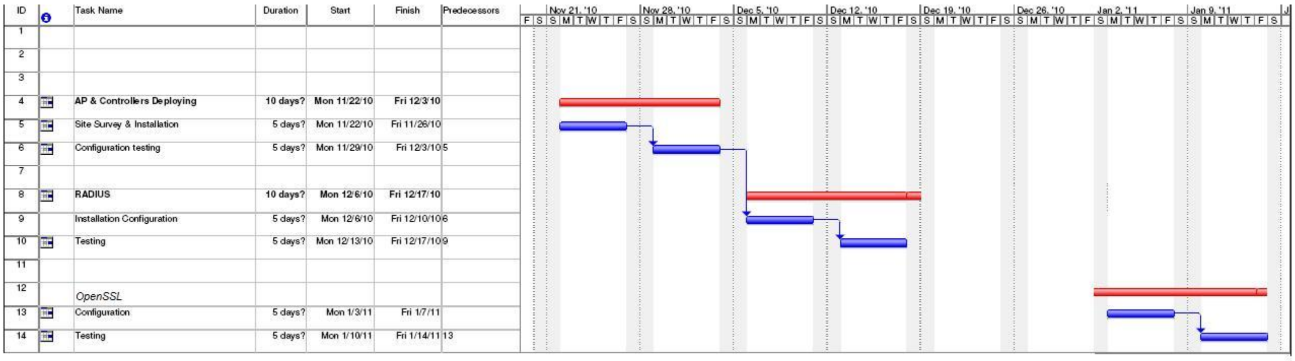
Our main goal is to implement a secure-flexible way to authenticate the users in our wireless network. In the beginning our planning was to have a database to store user names and passwords which would communicate with the RADIUS server so we could authenticate the users. This database was planned to be an LDAP database.

As its show to the first figure we would start with the configuration of the controller and the access points(Reference WiFi part).Then we would configure the FreeRadius server for two weeks (28th November until 12th December) and after the Christmas holidays we would adapt the LDAP server that our colleagues configured for one week (1st to 9th January).Finally we have the testing period for one week (10th to 17th of January).

As we studied in depth the Security authentication protocols we decided to use one of the most secure method for our network. This decision changed our project schedule. The new plan is shown in the second image.



Task Name	Duration	Start	Finish	Predecessors
AP & Controllers Deploying	**10 days?**	**Mon 11/22/10**	**Fri 12/3/10**	
Site Survey & Installation	5 days?	Mon 11/22/10	Fri 11/26/10	
Configuration testing	5 days?	Mon 11/29/10	Fri 12/3/10	5
RADIUS	**10 days?**	**Mon 12/6/10**	**Fri 12/17/10**	
Installation Configuration	5 days?	Mon 12/6/10	Fri 12/10/10	6
Testing	5 days?	Mon 12/13/10	Fri 12/17/10	9
LDAP	**10 days?**	**Mon 1/3/11**	**Fri 1/14/11**	
Configuration	5 days?	Mon 1/3/11	Fri 1/7/11	
Testing	5 days?	Mon 1/10/11	Fri 1/14/11	13



ID	ℹ	Task Name	Duration	Start	Finish	Predecessors
1						
2						
3						
4	▦	**AP & Controllers Deploying**	**10 days?**	**Mon 11/22/10**	**Fri 12/3/10**	
5	▦	Site Survey & Installation	5 days?	Mon 11/22/10	Fri 11/26/10	
6	▦	Configuration testing	5 days?	Mon 11/29/10	Fri 12/3/10	5
7						
8	▦	**RADIUS**	**10 days?**	**Mon 12/6/10**	**Fri 12/17/10**	
9		Installation Configuration	5 days?	Mon 12/6/10	Fri 12/10/10	6
10	▦	Testing	5 days?	Mon 12/13/10	Fri 12/17/10	9
11						
12		*OpenSSL*				
13	▦	Configuration	5 days?	Mon 1/3/11	Fri 1/7/11	
14	▦	Testing	5 days?	Mon 1/10/11	Fri 1/14/11	13

So now that we eliminate the LDAP variable we will use this time for testing and improving our system. Also this time can be used for the future problem that occur. These problems are caused by OpenSSL and we spent a lot of time to solve them as sawn in the above figure(2 weeks from 2nd of January to 15th of January).

Risk Analysis

The first risk that we faced was the choice of our server :

Software	Cost	Implementation	Interest	Choice
Cisco ACS	Shareware	No Experience	No	
Microsoft IAS	Shareware	No Experience	No	
Funk	Shareware	No Experience	No	
Radiator	Shareware	No Experience	No	
FreeRadius	Freeware	No Experience	Yes (BIG)	1st
OpenRadius	Freeware	No Experience	Yes	2nd
Cistron	Freeware	No Experience	Yes	3rd

Why FreeRadius ?

Before choosing FreeRadius we took in consideration reliable sources of information basically on the internet (big sites with many positive feedbacks like Wikipedia, LinuxForums etc) and we realized that FreeRadius meets all the requirements for our project.

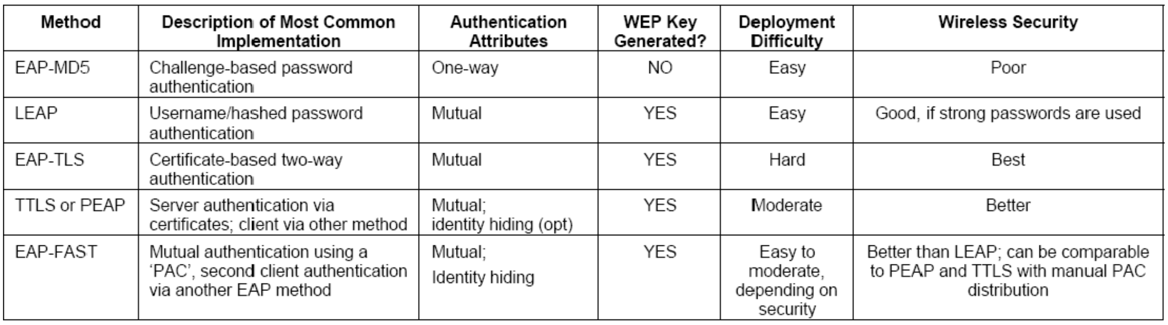
Some other big competitors in the field are :

- Cistron RADIUS: Mature, Stable, Works well, not modular, has a client (no library through).
- OpenRADIUS: offers more flexibility than Cistron in the dictionary and policies, has a language-independent FastCGI-like module interface. Has no client library either, supports large numbers of concurrent requests, redundant target servers, and on the fly PAP and CHAP password encoding.
- FreeRadius: Supports a huge number of modules, is the new standard, widely used, comes with client (no library AFAIK).Supports OpenLDAP that we could use in our project and because of the fact that is widely used we can find support on the internet for the problems what will occur during its installation. We can test the server without having a client with the radclient and the radtest commands. Specially the Radclient can send arbitrary RADIUS packets to a RADIUS server, then shows the reply. It can be used to test changes we made in the configuration of the radius server, or it can be used to monitor if a radius server is up. Remarkable the Radtest provides a simple but interesting tool for testing the FreeRADIUS server by querying it directly with requests.
  Last reason to choose this software is that we use it also in our Institute so we can have support from experienced people in this field.

The second risk was the choice of the Authentication method:

Extensible Authentication Protocol (EAP) is a universal authentication framework frequently used in wireless networks and point to point connections. The EAP protocol is most often used in wireless LAN networks but it can be used for wired LAN authentication also. The EAP have many sub-types, such as: EAP-MD5 EAP-PEAP,EAP-SIM,EAP-TLS,EAP-TTLS,EAP-AKA,EAP-IKEv2,EAP-FAST, etc. The EAP protocol that we will use in our project is EAP-TLS. It is one of the most reliable types of EAP. EAP-TLS is the original standard wireless LAN EAP authentication protocol. It is considered one of the most secure EAP standards available and is universally supported by all manufacturers of wireless LAN hardware and software including Microsoft. The requirement for a client-side certificate gives EAP-TLS its authentication strength. This client-side certificate can be in a smart card or in another physical data storage, this is very safe cause the attacker will need this certificate also and not only the username and the password of the victim. And if the attacker steal the victims smart card then he will notice it (cause its something physical) and will ask for different certificate.

Bellow we can see a table with more details of all the authentication methods compare to the implementation risk (Deployment Difficulty).



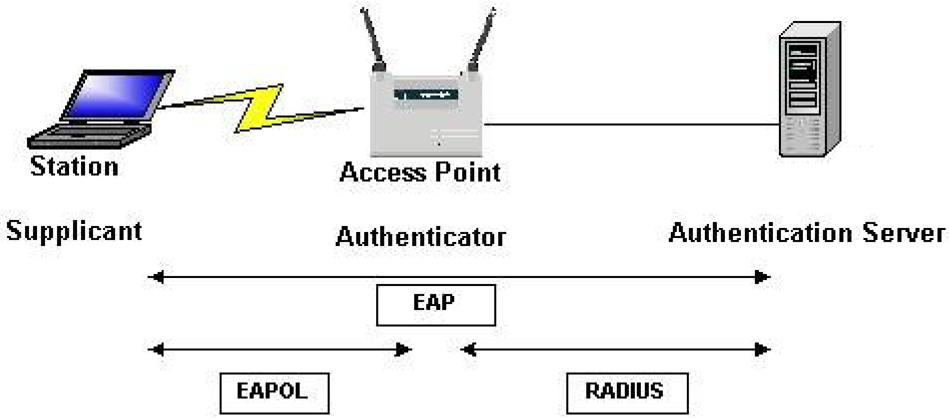
Method	Description of Most Common Implementation	Authentication Attributes	WEP Key Generated?	Deployment Difficulty	Wireless Security
EAP-MD5	Challenge-based password authentication	One-way	NO	Easy	Poor
LEAP	Username/hashed password authentication	Mutual	YES	Easy	Good, if strong passwords are used
EAP-TLS	Certificate-based two-way authentication	Mutual	YES	Hard	Best
TTLS or PEAP	Server authentication via certificates; client via other method	Mutual; identity hiding (opt)	YES	Moderate	Better
EAP-FAST	Mutual authentication using a 'PAC', second client authentication via another EAP method	Mutual; Identity hiding	YES	Easy to moderate, depending on security	Better than LEAP; can be comparable to PEAP and TTLS with manual PAC distribution

"Source: Interopnet Labs, Spectrum Security Initiative May 2005 "

Regardless the high risk, we needed to keep to our scope which is strong security to our network, so we started working on EAP-TLS method.

Technical Approach

We needed to understand the co-operation between the Controller and the radius server itself. In order to succeed this, we used first a simple Access Point to connect our users.

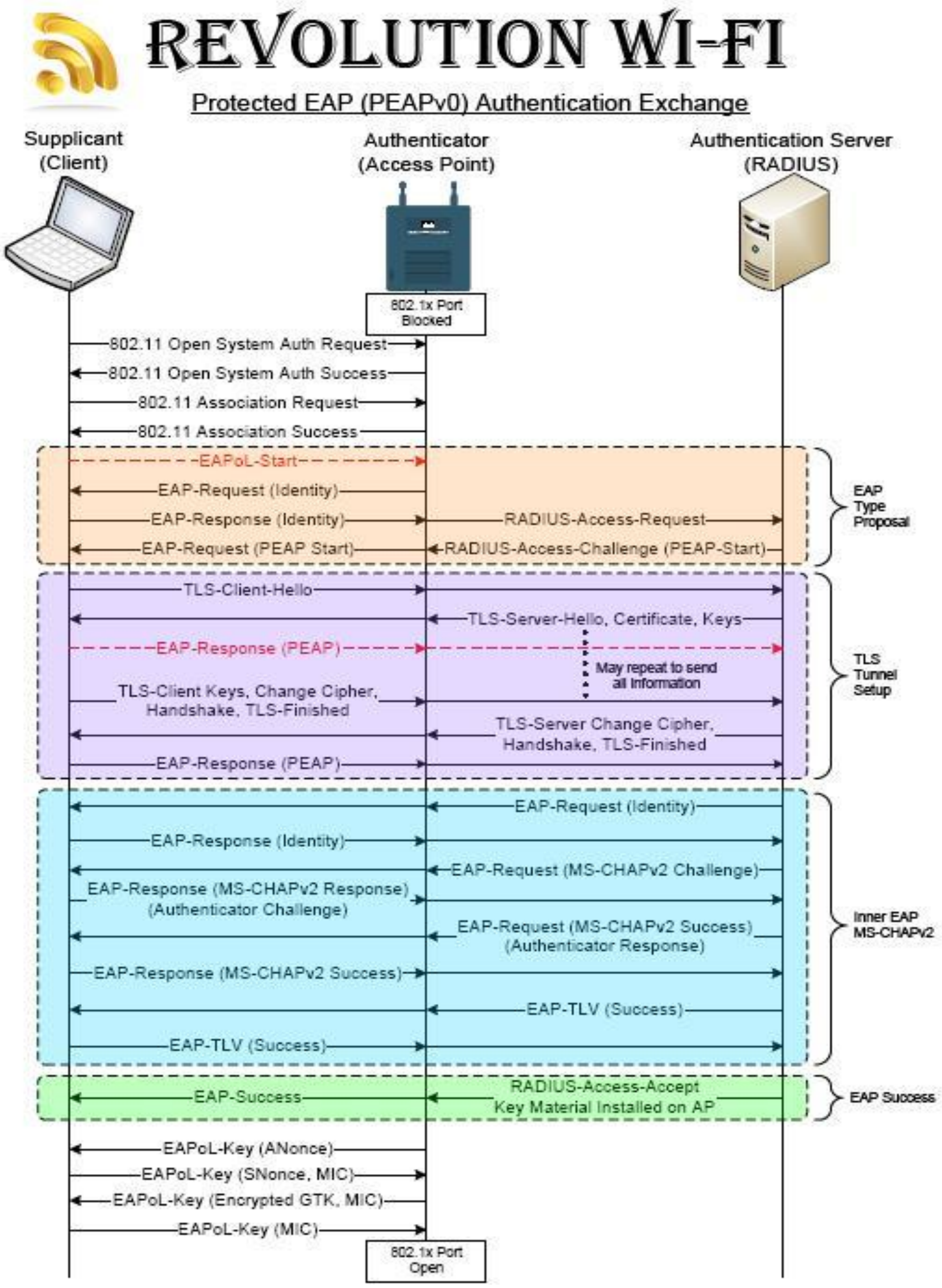


"Source: http://www.google.gr/imgres?imgurl=http://www.interlinknetworks.com"

The first authentication method we used was EAP-MD5.It is the simplest method for connecting users because it only provides authentication of the EAP peer to the EAP server but not mutual authentication. So its vulnerable to man the middle attacks.

The second step was to configure the Radius server using EAP-PEAP. In this method a user name and a password is required which is provided from a database. In our case the database is a simple text file, but as an extension can be an SQL server or an LDAP.

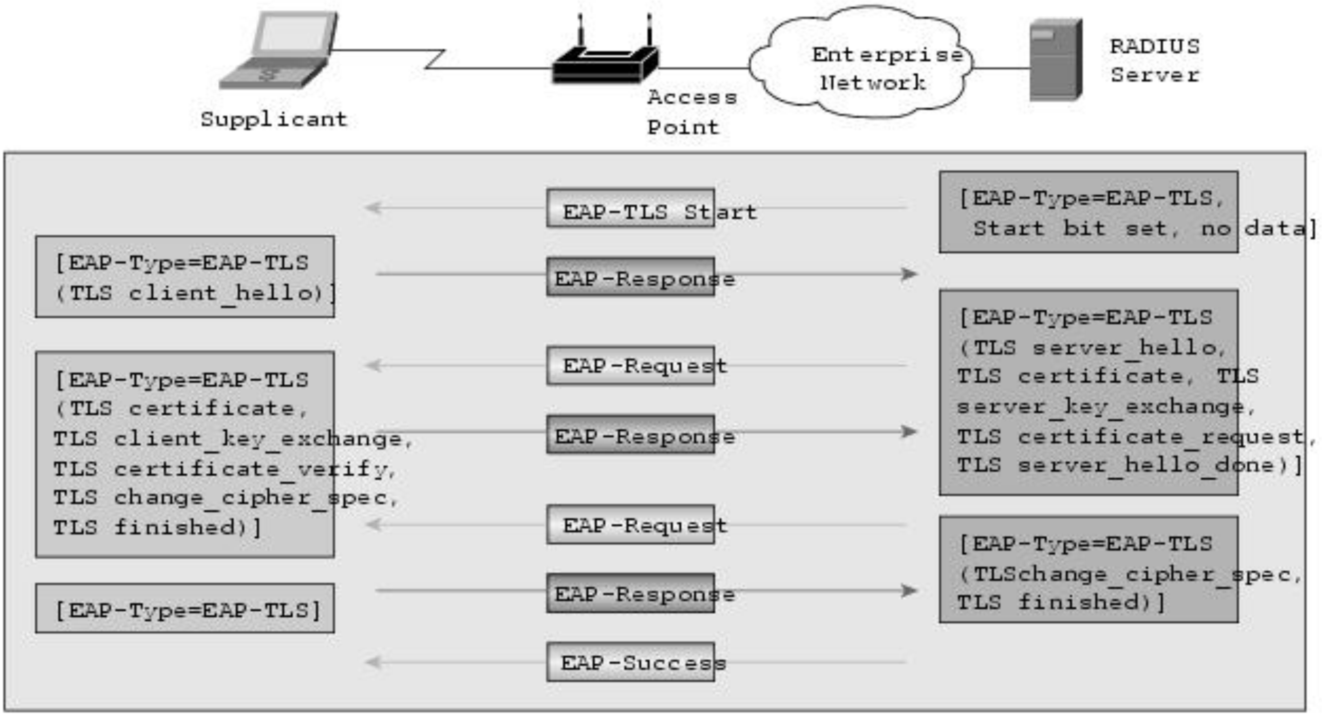
We can see below in details the negotiation between the server and the Access Point for this method


REVOLUTION WI-FI
Protected EAP (PEAPv0) Authentication Exchange
Supplicant (Client)
Authenticator (Access Point)
Authentication Server (RADIUS)
802.1x Port Blocked
802.11 Open System Auth Request
802.11 Open System Auth Success
802.11 Association Request
802.11 Association Success
EAPoL-Start
EAP-Request (Identity)
EAP-Response (Identity)
RADIUS-Access-Request
EAP-Request (PEAP Start)
RADIUS-Access-Challenge (PEAP-Start)
EAP Type Proposal
TLS-Client-Hello
TLS-Server-Hello, Certificate, Keys
EAP-Response (PEAP)
May repeat to send all information
TLS-Client Keys, Change Cipher, Handshake, TLS-Finished
TLS-Server Change Cipher, Handshake, TLS-Finished
EAP-Response (PEAP)
TLS Tunnel Setup
EAP-Request (Identity)
EAP-Response (Identity)
EAP-Request (MS-CHAPv2 Challenge)
EAP-Response (MS-CHAPv2 Response) (Authenticator Challenge)
EAP-Request (MS-CHAPv2 Success) (Authenticator Response)
EAP-Response (MS-CHAPv2 Success)
EAP-TLV (Success)
EAP-TLV (Success)
Inner EAP MS-CHAPv2
EAP-Success
RADIUS-Access-Accept Key Material Installed on AP
EAP Success
EAPoL-Key (ANonce)
EAPoL-Key (SNonce, MIC)
EAPoL-Key (Encrypted GTK, MIC)
EAPoL-Key (MIC)
802.1x Port Open

“Source: http://www.h3c.com/portal/Technical_Support___Documents/Technical_Documents”

After succeeding it we tried our main goal, which is EAP-TLS. In this method clients are authenticated only with certificates. The certificates are created and distributed by a Certificate Authority (CA).Each user has its own unique certificate. No need of database is required and this is the reason that we did not implement the LDAP server in our infrastructure. The last method was working but under certain circumstances which are explained in details at chapter, problems.

Below we can see the negotiation between the access point and the server.

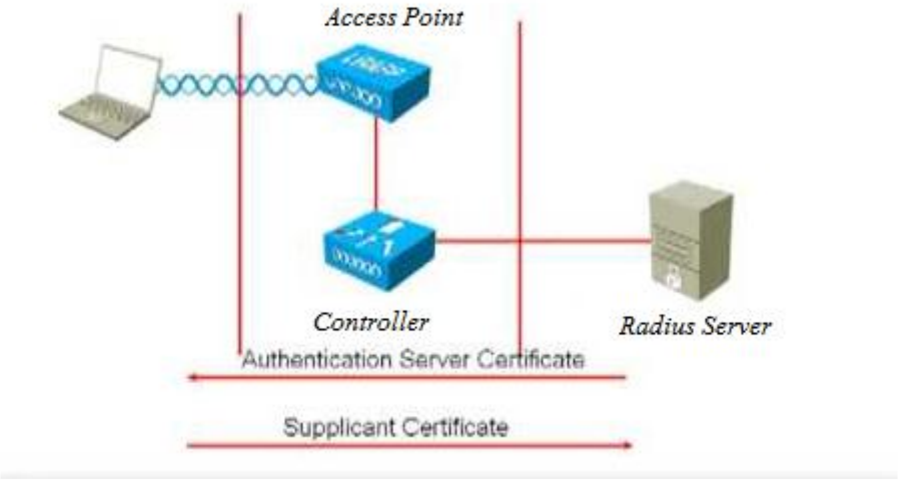

Supplicant
Access Point
Enterprise Network
RADIUS Server
EAP-TLS Start
[EAP-Type=EAP-TLS, Start bit set, no data]
[EAP-Type=EAP-TLS (TLS client_hello)]
EAP-Response
EAP-Request
[EAP-Type=EAP-TLS (TLS server_hello, TLS certificate, TLS server_key_exchange, TLS certificate_request, TLS server_hello_done)]
[EAP-Type=EAP-TLS (TLS certificate, TLS client_key_exchange, TLS certificate_verify, TLS change_cipher_spec, TLS finished)]
EAP-Response
EAP-Request
[EAP-Type=EAP-TLS (TLSchange_cipher_spec, TLS finished)]
[EAP-Type=EAP-TLS]
EAP-Response
EAP-Success

“Source : http://www.cisco.com/en/US/products/sw/secursw”

So after the preparation it was easier to combine the controller with the Radius Server because we had clear view of all the authentication methods from a simple network.

We used the CISCO controller. The controller is now the only client of the server and the users are the supplicants. So, when the users (supplicants) are trying to connect to our wireless networks the controller sends a request to the server and the server takes the decision if the user is holding the right certificate or not. If the certificate matches with the same CA of the certificate of the server and the controller then the user is authenticated and he is moved to the VLAN that he is permitted to go, if not, his requests are being rejected. Once the users are authenticated the data can be encrypted with different methods such as TKIP and AES, we have chose to use AES.

Below is our topology with one Access Point :



“Source : http://www.howtoforge.com/wifi-authentication-accounting-with-freeradius-on-centos5”

Why AES ?

The two main methods to cipher the data after the authentication of the users in a wireless network is TKIP (Temporal Key Integrity Protocol) and AES (Advanced Encryption Standard).The TKIP method is vulnerable to many similar attacks as the WEP key. As it is known a WEP key can be easily obtained with simple programs (Aircrack, AirSnot , etc) in a rather short period of time. So its not secure for our network.

On the other hand AES is a more advanced method that is nearly impossible to be hacked. The strong point of the encryption is the way that the algorithm is build. There are several mathematic functions (shift-mix rows, round key, etc) between different blocks of numbers.This makes it very hard for decrypting the messages and specially when we use 128,192 or 256 bits for each block size. Its not a coincidence that the USA army uses this algorithm for exchanging top secret data.

Why OpenSSL?

OpenSSL is an open source solution of using SSL and TLS protocols. It supports many different cryptographic algorithms DES, Blowfish, Camellia, SEED, AES and many other.

This is the reason that we use this tool to Create our Certificate authority. The type of the certificates is X.509

X.509

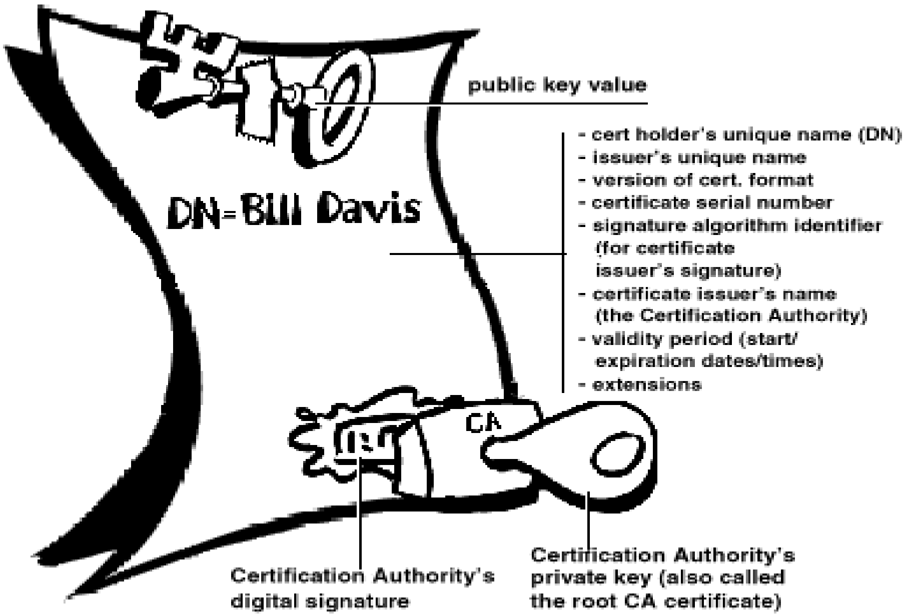
X.509 is a certificate format that the valuator is always a Certificate Authority but in PGP format anyone can be the valuator accept in some cases(hieratical structure supported certificates)

The data that these certificates contain are:

- The version of X.509
- The certificate owner public key
- The certificate owner unique identifier
- The serial number of the certificate

- The valid period of the certificate
- The name of the Certificate Authority
- The digital signature of the certificate provider (CA)
- The algorithm of the signature of CA

An example is given bellow :


public key value
- cert holder's unique name (DN)
- issuer's unique name
- version of cert. format
- certificate serial number
- signature algorithm identifier (for certificate issuer's signature)
- certificate issuer's name (the Certification Authority)
- validity period (start/ expiration dates/times)
- extensions
DN=Bill Davis
CA
Certification Authority's digital signature
Certification Authority's private key (also called the root CA certificate)

"Source : http://www.pgpi.org/doc/pgpintro/#p10"

Technical study

In the beginning we studied in deep the configuration files of the radius server radius.conf, eap.conf, users, clients.conf which are in the directory /etc/raddb/ for all the authentication methods we referred before. After that in order to implement the EAP-TLS method, as its written before we need certificates by a Certificate Authority. This certificate Authority can be in the same computer that the Radius is running or in a different machine. For security reasons we have the Certificate authority in a different machine for our project, because this CA its responsible for all the certificates in our network. In an ideal network the philosophy of Public Key infrastructure (PKI) is followed, one CA for all the network.

Step By Step Configuration

RADIUS

All the following commands should be written in the terminal window :

```
yum search freeradius  #search for the latest version of FreeRadius.

yum install freeradius x.x.x.x  #type the version to install it in your
machine.

 gedit /etc/raddb/eap.conf  &
```

Edit in the file the following lines:

```
         default_eap_type = tls

         tls {
                #
                #  These is used to simplify later configurations.

                       certdir = ${confdir}/certs
                       cadir = ${confdir}/certs

        private_key_password = ***R4D1U5P455W0rd*** #use your own
                                                    #password
                private_key_file = /etc/pki/certificates/server_key.pem

                       #  If Private key & Certificate are located in
                       #  the same file, then private_key_file &
                       #  certificate_file must contain the same file
                       #  name.
                       #
                       #  If CA_file (below) is not used, then the
                       #  certificate_file below MUST include not
                       #  only the server certificate, but ALSO all
                       #  of the CA certificates used to sign the
                       #  server certificate.
             certificate_file = /etc/pki/certificates/server_keycert.pem
                       #  Trusted Root CA list
                       #
                       #  ALL of the CA's in this list will be trusted
                       #to issue client certificates for authentication.
                       #
                       #  In general, you should use self-signed
                       #  certificates for 802.1x (EAP) authentication.
                       #  In that case, this CA file should contain
                       #  *one* CA certificate.
                       #
                       #  This parameter is used only for EAP-TLS,
                       #when you issue client certificates.  If you do
                       #not use client certificates, and you do not want
                       #  to permit EAP-TLS authentication, then delete
                       #  this configuration item.
             CA_file = /etc/pki/certificates/ server_cert.pem

                       #
                       #  For DH cipher suites to work, you have to
                       #  run OpenSSL to create the DH file first:
                       #
                       #      openssl dhparam -out certs/dh 1024 #very
                                                    #  important command
                       #
                       dh_file = ${certdir}/dh
                       random_file = ${certdir}/random
                       fragment_size = 1024 # uncomment this
                       include_length = yes   # uncomment this
                       check_crl = no
```

Now we have to edit the clients.conf so we type :

```
gedit /etc/raddb/clients.conf  &
```

```
client 172.16.3.1    {
        secret = ***J0s3PH_F0UR13R_Gr3n0BLe_1UT_R&T***  #strong password
        shortname = cisco
        nastype = other
}
```

Note that this IP (172.16.3.1) is the IP of our client, which means that is the IP of the CISCO controller. The secret that we put here must be very strong because is the shared secret !

The next step is to make the certificates by using OpenSSL :

We type:

```
yum search openssl  #search for the latest version of OpenSSL
yum install opensslx.x.x.x #type the version to install it in your machine
```

At the /etc/pki/tls/openssl.cnf We put the parameters that our Certificate Authority will have and we set them as default. With this way we only put the parameters only once, and we do not have to fill them again every time we create a new certificate.

```
# req_extensions = v3_req # The extensions to add to a certificate request
[ req_distinguished_name ]
countryName                     = Country Name (2 letter code)
countryName_default             = fr
countryName_min                 = 2
countryName_max                 = 2
stateOrProvinceName             = State or Province Name (full name)
stateOrProvinceName_default     = isere
localityName                    = Locality Name (eg, city)
localityName_default            = grenoble
0.organizationName              = Organization Name (eg, company)
0.organizationName_default      = iut
# we can do this but it is not needed normally :-)
#1.organizationName             = Second Organization Name (eg, company)
#1.organizationName_default     = World Wide Web Pty Ltd
organizationalUnitName          = Organizational Unit Name (eg, section)
organizationalUnitName_default = rt
commonName                      = radius.opensource.iut
commonName_default              = radius.opensource.iut
commonName_max                  = 64
emailAddress                    = Email Address
emailAddress_max                = 64
```

In order to use the XPextensions we have to create the following file from which we have to extract the proper information each time. These extensions are very useful for clients that using Windows operating system.

So type :

gedit   #put the below variables and save the file in /etc/pki/tls/ with name xpextensions

[xpclient_ext]
extendedKeyUsage = 1.3.6.1.5.5.7.3.2

[xpserver_ext]

extendedKeyUsage = 1.3.6.1.5.5.7.3.1

We need a new CA so we type (root certificate):

```
cd /etc/pki/tls/misc
./CA –newreq
```

We are just pressing enter because we already put the variables of our CA before in openssl.cnf

Make the directory “certificates” in the pki folder and copy the produced cacert.pem

Now we have to make a server certificate signing request :

```
$ openssl req -new -nodes -keyout server_key.pem -out server_req.pem -days
365 -config ./openssl.cnf
```

Now we can sign the server certificate request we created above, type :

```
$ openssl ca -config ./openssl.cnf \
-policy policy_anything -out server_cert.pem \
-extensions xpserver_ext -extfile ./xpextensions \
-infiles ./server_req.pem
```

Copy the signed certificate to the same directory that we configured the eap.conf to check for the certificate, which in our case is `/etc/pki/certificates/server_keycert.pem`

We need also certificates for each client, the procedure is the same also for the supplicants with only one difference.On the non Windows clients we have to edit the certificate and erase everything that is above the phrase : `--------------BEGIN CERTIFICATE--------`

And this is happening because the xpextensions are only needed when we deal with Microsoft.

Creating the client certificate (CISCO Controller) :

```
$ openssl req -new -keyout client_key.pem \
-out client_req.pem -days 365 -config ./openssl.cnf
```

We sign the certificate:

```
$ openssl ca -config ./openssl.cnf \
-policy policy_anything -out client_cert.pem \
-infiles ./client_req.pem
```

Now let’s consider one supplicant with windows XP:

```
 $ openssl req -new -keyout user1_key.pem \
-out user1_req.pem -days 365 -config ./openssl.cnf

$ openssl ca -config ./openssl.cnf \
-policy policy_anything -out user1_cert.pem \
-extensions xpclient_ext -extfile ./xpextensions \
-infiles ./user1_req.pem
```

We have to add the following command for converting the certificate to PKCS12-format file:

```
openssl pkcs12 -export -in user1_cert.pem \
-inkey user1_key.pem -out user1_cert.p12 -clcerts
```

Finally we are ready to distribute our certificates to the supplicants. The safest way to do it is with a physical method such at USB flash drives or smartcards.

Problems - Project management- Delays

The problems we encountered were many. The most important are the following :

Transforming the radius configuration files for each method separately. Specially when using the EAP-TLS method. The compatibility of the certificates for the users. The structure of the certificates changes for different operating systems. For example if we have a users that wants to connect to our network with windows (XP,Vista,7) we need to provide him different certificate than the one that uses Linux. This certificate as we saw above will include some additional information which called "XP Extensions". These extensions referred to Microsoft are in order to be sure of the identity-purpose of the certificate. So if the certificate is maiden for a server will have a sequence of numbers and if it is maiden to be client will have different number sequence in addition of course of the main structure of the certificate. The other hard thing is the configuration of the supplicants (WPA enterprise)

in order to connect to the RADIUS. The current status of the project is that we can authenticate the clients through our server but there is a unidentified problem with the DHCP relay in order for the client to get IP address. Although we can add a static IP in the client so he can connect to the internet. It is interesting to see the negotiation using Wireshark which can be found in Appendixes.

In the beginning of the project we had a general plan-diagram, which we change it at the duration of the project because our needs changed while we were gaining knowledge about the subject. We had the general structure and deadlines but we adapted it to increase our performance. Hopefully there were no delays in the project.

Modifications-Conclusion

The first planning of our project was to use an LDAP sever to for storing user names and passwords. But after studying the EAP methods we realized what we do not need to store user data so we abandon this idea. The main goal of the project achieved except the problem with the DHCP server that is mention before.

IPBX and VPN

Presentation of technologies

VoIP

Voice over Internet Protocol is a relatively new technology[1] which transports voice over Internet Protocol. It works in a different manner than Public Switched Telephone Network (PSTN). *Classical telephony* is based on a circuit switching technology, i.e. between two sides of communication there is created a path, which is whole reserved for communication and no other communication is possible over the link. VoIP is based on packet-switching technology and can be used over IP networks, for example Internet. It is an example of convergence; convergence of user's data and voice on the same physical link. VoIP is said to replace PSTN, thanks to several advantages like lower cost and less centralized infrastructure. Nevertheless it will take many years, as there are several aspects in VoIP which should be improved and standardized (Quality of service and security)

We can assume that the communication process in VoIP is carried out onto two different levels. In order to establish a connection a *signaling protocol* is used. Initially it was H.323 (with several sub-standards), still existing in many solution. Nowadays we can observe a growing popularity of SIP protocol (Session Initiation Protocol), which is said to replace H.323 in the world of VoIP. To transport voice we use RTP protocol, sent over UDP.

With VoIP technology we can build an *Internet Protocol Private Branch Exchange* (IPBX) using a hardware less expensive than classical PBX and in the same time having a lot of additional features.

VPN

Virtual Private Network is a technology used to build a "tunnel" providing access to remote users or other units to their company's or organization's network (point-to-point connections). The network is *virtual* as it is built logically over a public network (like Internet). In VPN the traffic is usually ciphered, which enhances the security. The traffic can be also compressed, which makes the technology effective also using slower internet connection. There are several types of protocols and technologies which are linked with VPN: IPsec, PPTP or SSL/TLS.

[1] We can assume that the beginning of VoIP technology was in the mid of 1990's, when the first softphone (software phone) was released by VocalTec under the name of "Internet Phone".

Software chosen

1. For VoIP infrastructure I decided to use Asterisk, as it is the leading solution in opensource and I could count on community support. After some research I decided to use Trixbox (formerly Asterisk@home) as it contains an already preinstalled Asterisk and lots of other tools, such as FreePBX, which helps managing a server with a web-based interface. Trixbox is preinstalled on a Linux CentOS distribution and it supports certainly SIP protocol.
2. For the VPN I decided to use OpenVPN solution. It uses SSL/TLS as far as encryption is concerned. For authentication we can use pre-shared key (PSK), certificates or username and login. I decided to install OpenVPN on a Debian distribution.

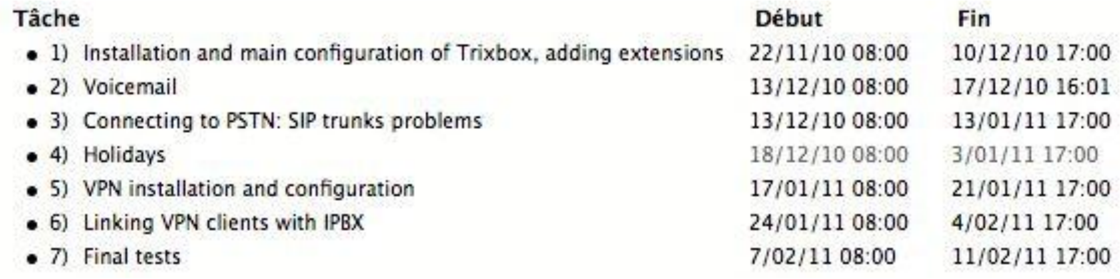
Project management

Initially I was supposed to work on the project together with Aziza. As she left our group in December I worked on the project alone.

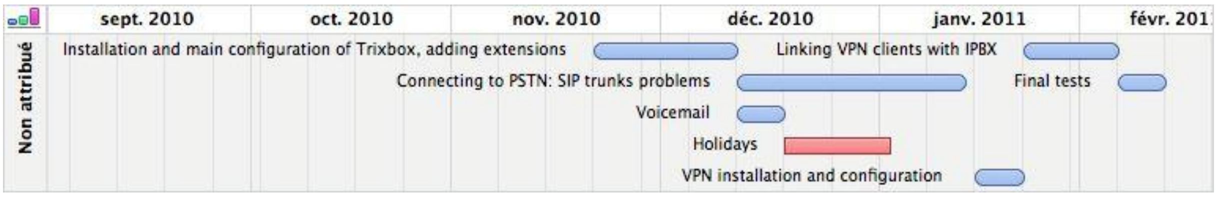
Here is the original scheduling that I previewed for the deployment of the project.

	Task	**Week**
IP PBX	Installing and main configuration of Trixbox +Extensions	47-48
IP PBX	Connecting to PTSN, Digital receptionist, Voicemail, Recording calls	49-50
VPN	Installation	1-2

During the project I met a problem when I wanted to connect IPBX with some SIP providers. Because of closed ports it was not possible to connect to PSTN through them. I decided then to link VPN clients with the VoIP infrastructure. It complicated the infrastructure but finally I managed to connect VPN users with IPBX. Here is the schedule which I followed during the project:



Tâche	Début	Fin
• 1) Installation and main configuration of Trixbox, adding extensions	22/11/10 08:00	10/12/10 17:00
• 2) Voicemail	13/12/10 08:00	17/12/10 16:01
• 3) Connecting to PSTN: SIP trunks problems	13/12/10 08:00	13/01/11 17:00
• 4) Holidays	18/12/10 08:00	3/01/11 17:00
• 5) VPN installation and configuration	17/01/11 08:00	21/01/11 17:00
• 6) Linking VPN clients with IPBX	24/01/11 08:00	4/02/11 17:00
• 7) Final tests	7/02/11 08:00	11/02/11 17:00



Project description

IPBX

IPBX installation: As far as Trixbox installation is concerned I did not encounter bigger problems. Burning a CD with an ISO image and installation itself do not need a comment. During that I specified the password and configured a network interface. The IP address for the server is 172.16.3.129/26.

Creating extensions: After installation I started to explore Asterisk CLI and FreePBX web interface, in order to create some users extensions. I created 4 extensions, 2 of them are configured on IP phones (Grandstream BudgeTone 100 and 200). In order to be able to configure them I needed to configure them properly with their keypads, then I realized that one of them was out of order, it was not possible to type IP address. After replacing it I managed to configure them with their web interfaces. I could see in FreePBX they were detected (2 IP phones online), in Asterisk CLI it was also visible, together with their IP addresses (172.16.3.150 and 172.16.3.151) and their latency. Then I could establish a fist call in our VoIP infrastructure. It worked properly, the voice was heard. I also configured an extension on my and Charles' laptops (a temporary solution).

Problems with SIP trunk: The next point was establishing a connection with a PSTN. In order to do that I decided to connect IPBX to some VoIP providers. I decided to create a first trunk to justvoip.com provider. It was successful (its IP and status were visible in Asterisk CLI – command *sip show peers*). I could establish a connection from a phone to my mobile, unfortunately I could not hear any voice. After an analyze with Wireshark I recognized it was a problem with RTP packets, which probably were blocked. Changing the value of RTP ports to be used in rtp.conf did not solve the problem. The ports are closed at the university router, which makes external communication impossible and this could not be walked around.

After this failure I connected to another VoIP operator, actio.pl as they provided a fixed phone number free of charge. I wanted to reach IPBX from outside, in spite of blocked ports. Initially I could not see the status of this connection, it was visible in Asterisk CLI as *not monitored*. I called the number, after creating an internal route, but it did not work. Having changed *qualify* variables in this extension to *YES,* I could see that connection was established (usually for incoming calls this option is turned off, so it was in configuration file on a website o action.pl). Knowing that connection status is OK I called the phone number (48625974482) but again no phone rang. Analyzing it with Wireshark I noticed that a SIP REQUEST message reached Asterisk but the connection could not be established because of a message 501: unsupported method. It found out that it meant *The SIP request method is not implemented here*. I searched actio.pl website and found that *useragent* field in sip.conf should be different than Asterisk. I did it but I did not help. Trying to find another solution I searched in polish usenet and found some post of people having the same problem, which they could not solve (action.pl specialists neither, according to their posts). Because of that I decided to quit this question, especially that I would be able only to establish connection, the voice would be blocked anyway.

Configuration of additional features: I installed voicemail services on the extensions, on one of them it is in French (it was necessary to download some packages). I decided not to work on IVR, as it would be limited only to the internal infrastructure. Instead of that I decided to allow VPN clients to access the internal infrastructure.

VPN

Installation and configuration: The configuration of VPN was not very difficult, but a will to link it with VoIP infrastructure caused several problems. I decided to grant access to users with an authorization based on certificates. Thus, I needed to create CA (which is no longer on VPN server) and I created certificates which I distributed on my and Charles' laptops. OpenVPN server was placed in a separate VLAN (DMZ), forwarding and NAT were enabled and the clients were translated from 10.0.0.0/24 to the internal network obtaining IP address of the OpenVPN server. Connection was established and there were successful pings towards IPBX VLAN and others.

Connecting VPN clients with IPBX

As mentioned before I could not connect with PSTN because of closed ports. Therefore, I decided to connect VPN clients with IPBX. As I already had VPN working I tried to register form my laptop to IPBX. Connection did not cause problems, but again there was no voice. As analyzed with Wireshark the traffic from VPN was forwarded to the university router and came back then to IPBX VLAN. It was the reason why the voice was *cut*. Certainly it was due to a rule on our firewall which forwarded all SIP and RPT packets outside, to a default route. It did not seem to be a very big problem, Charles changed the rules in order to route it to IPBX VLAN, but it did not help – the packets were still routed outside our network. Charles and Vinicius made a lot of effort to fix it, but the problem has not been solved. As the deadline was moving closer we decided to put OpenVPN server in the IPBX VLAN. Its IP address is 172.16.3.130. It made sense, as there were no other services in our DMZ. Putting it into IPBX VLAN walked around the routing problem and we could have a phone conversation through VPN.

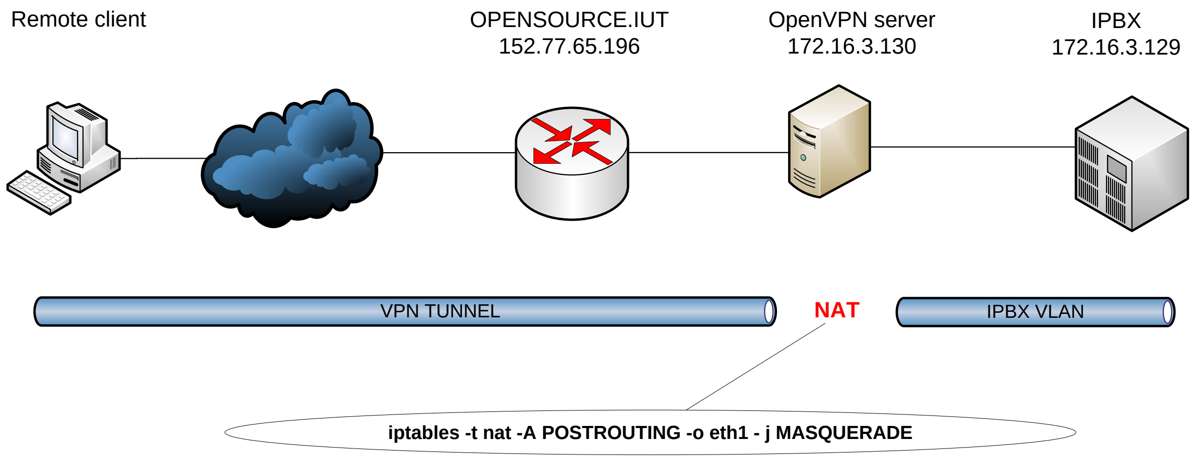
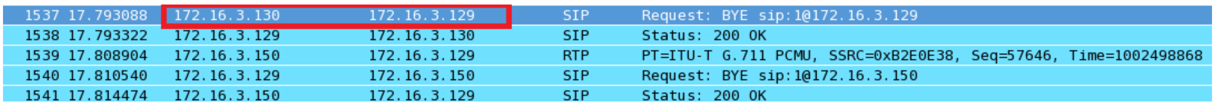


Fig 1. VPN client, server and IPBX server



```
1537 17.793088  172.16.3.130    172.16.3.129    SIP    Request: BYE sip:1@172.16.3.129
1538 17.793322  172.16.3.129    172.16.3.130    SIP    Status: 200 OK
1539 17.808904  172.16.3.150    172.16.3.129    RTP    PT=ITU-T G.711 PCMU, SSRC=0xB2E0E38, Seq=57646, Time=1002498868
1540 17.810540  172.16.3.129    172.16.3.150    SIP    Request: BYE sip:1@172.16.3.150
1541 17.814474  172.16.3.150    172.16.3.129    SIP    Status: 200 OK
```

Fig 2. Translated IP address of a remote client. Taken at IPBX server (172.16.3.129)

Summary

Eventually not everything has been achieved in the project (communication with external world), which however did not depend on me (closed RTP ports). A possible solution could be connecting IPBX directly to PSTN with a special card, however it was not planned in the beginning and later there was not enough time to work on that. Instead of this I managed to interconnect VPN clients with IPBX, which was not planned in the beginning and, in my opinion, is an interesting point in the ensuing situation.

Radius (Nikolaos - Stylianos)

Appendix

Negotiation between the RADIUS and the Controller by Wireshark.

```
No.     Time        Source          Destination       Protocol Info
      1 0.000000    172.16.3.1      172.16.3.61       RADIUS   Access-Request(1) (id=29, l=246)

Frame 1: 288 bytes on wire (2304 bits), 288 bytes captured (2304 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
    Code: Access-Request (1)
    Packet identifier: 0x1d (29)
    Length: 246
    Authenticator: 4dcddb6a5fee001bd087ec694a4727c7
    Attribute Value Pairs
        AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
        AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
        AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
        AVP: l=6  t=NAS-Port(5): 3
        AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
        AVP: l=8  t=NAS-Identifier(32): CISCO
        AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
        AVP: l=6  t=Service-Type(6): Framed(2)
        AVP: l=6  t=Framed-MTU(12): 1300
        AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
        AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
        AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
        AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
        AVP: l=51  t=EAP-Message(79) Last Segment[1]
            EAP fragment
            Extensible Authentication Protocol
                Code: Response (2)
                Id: 1
                Length: 49
                Type: Identity [RFC3748] (1)
                Identity (44 bytes): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
        AVP: l=18  t=Message-Authenticator(80): b2102f7344432b19db707d264cdfa517
            Message-Authenticator: b2102f7344432b19db707d264cdfa517

No.     Time        Source          Destination       Protocol Info
      2 0.001783    172.16.3.61     172.16.3.1        RADIUS   Access-challenge(11) (id=29, l=64)

Frame 2: 106 bytes on wire (848 bits), 106 bytes captured (848 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
    Code: Access-challenge (11)
    Packet identifier: 0x1d (29)
    Length: 64
    Authenticator: 30e7c1988c82706498b50801a04fbade
    Attribute Value Pairs
        AVP: l=8  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Request (1)
        Id: 2
        Length: 6
        Type: PEAP [Palekar] (25)
        Flags(0x20): Start
        PEAP version 0
    AVP: l=18  t=Message-Authenticator(80): eea5658ad26985c9eab97b9d4f5fc3e2
      Message-Authenticator: eea5658ad26985c9eab97b9d4f5fc3e2
    AVP: l=18  t=State(24): c3efb02fc3eda90c6f4be297f22826ce
      State: c3efb02fc3eda90c6f4be297f22826ce

No.     Time        Source                Destination           Protocol Info
      3 0.005083    172.16.3.1            172.16.3.61           RADIUS   Access-Request(1) (id=30, l=221)

Frame 3: 263 bytes on wire (2104 bits), 263 bytes captured (2104 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
  Code: Access-Request (1)
  Packet identifier: 0x1e (30)
  Length: 221
  Authenticator: 2970773e482db2eaaa218d66abb23752
  Attribute Value Pairs
    AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
    AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
    AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
    AVP: l=6  t=NAS-Port(5): 3
    AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
    AVP: l=8  t=NAS-Identifier(32): CISCO
    AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
    AVP: l=6  t=Service-Type(6): Framed(2)
    AVP: l=6  t=Framed-MTU(12): 1300
    AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
    AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
    AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
    AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
    AVP: l=8  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Response (2)
        Id: 2
        Length: 6
        Type: Legacy Nak (Response only) [RFC3748] (3)
        Desired Auth Type: EAP-TLS [RFC5216] [Aboba] (13)
    AVP: l=18  t=State(24): c3efb02fc3eda90c6f4be297f22826ce
      State: c3efb02fc3eda90c6f4be297f22826ce
    AVP: l=18  t=Message-Authenticator(80): 96e7d57373b04d79cf34c86b7eade86a
      Message-Authenticator: 96e7d57373b04d79cf34c86b7eade86a

No.     Time        Source                Destination           Protocol Info
      4 0.006015    172.16.3.61           172.16.3.1            RADIUS   Access-challenge(11) (id=30, l=64)

Frame 4: 106 bytes on wire (848 bits), 106 bytes captured (848 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
```

```
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
  Code: Access-challenge (11)
  Packet identifier: 0x1e (30)
  Length: 64
  Authenticator: d2a264cca83aa61ac0763d488a602548
  Attribute Value Pairs
    AVP: l=8  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Request (1)
        Id: 3
        Length: 6
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x20): Start
    AVP: l=18  t=Message-Authenticator(80): 90c4c370707a4a853b87ab80a3b63005
      Message-Authenticator: 90c4c370707a4a853b87ab80a3b63005
    AVP: l=18  t=State(24): c3efb02fc2ecbd0c6f4be297f22826ce
      State: c3efb02fc2ecbd0c6f4be297f22826ce

No.     Time        Source                Destination           Protocol Info
      5 0.012152    172.16.3.1            172.16.3.61           RADIUS   Access-Request(1) (id=31, l=316)

Frame 5: 358 bytes on wire (2864 bits), 358 bytes captured (2864 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
  Code: Access-Request (1)
  Packet identifier: 0x1f (31)
  Length: 316
  Authenticator: f1af9f2cc8f43a83115cf57c44635896
  Attribute Value Pairs
    AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
    AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
    AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
    AVP: l=6  t=NAS-Port(5): 3
    AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
    AVP: l=8  t=NAS-Identifier(32): CISCO
    AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
    AVP: l=6  t=Service-Type(6): Framed(2)
    AVP: l=6  t=Framed-MTU(12): 1300
    AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
    AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
    AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
    AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
    AVP: l=103  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Response (2)
        Id: 3
        Length: 101
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x0):
        Secure Socket Layer
    AVP: l=18  t=State(24): c3efb02fc2ecbd0c6f4be297f22826ce
      State: c3efb02fc2ecbd0c6f4be297f22826ce
    AVP: l=18  t=Message-Authenticator(80): 58d91359176a704939f8442e10cfb97a
```

```
        Message-Authenticator: 58d91359176a704939f8442e10cfb97a

No.     Time        Source                Destination           Protocol Info
      6 0.026830    172.16.3.61           172.16.3.1            RADIUS   Access-challenge(11) (id=31, l=1090)

Frame 6: 1132 bytes on wire (9056 bits), 1132 bytes captured (9056 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
    Code: Access-challenge (11)
    Packet identifier: 0x1f (31)
    Length: 1090
    Authenticator: 162ff64f0c2bed3ad82beaaf4c7ce893
    Attribute Value Pairs
        AVP: l=255  t=EAP-Message(79) Segment[1]
        AVP: l=255  t=EAP-Message(79) Segment[2]
        AVP: l=255  t=EAP-Message(79) Segment[3]
        AVP: l=255  t=EAP-Message(79) Segment[4]
        AVP: l=14  t=EAP-Message(79) Last Segment[5]
            EAP fragment
            Extensible Authentication Protocol
                Code: Request (1)
                Id: 4
                Length: 1024
                Type: EAP-TLS [RFC5216] [Aboba] (13)
                Flags(0xC0): Length More
                Length: 1859
                Secure Socket Layer
[Malformed Packet: SSL]

No.     Time        Source                Destination           Protocol Info
      7 0.040604    172.16.3.1            172.16.3.61           RADIUS   Access-Request(1) (id=32, l=221)

Frame 7: 263 bytes on wire (2104 bits), 263 bytes captured (2104 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
    Code: Access-Request (1)
    Packet identifier: 0x20 (32)
    Length: 221
    Authenticator: f27f080377a3576d49c4f8c3cf23e897
    Attribute Value Pairs
        AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
        AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
        AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
        AVP: l=6  t=NAS-Port(5): 3
        AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
        AVP: l=8  t=NAS-Identifier(32): CISCO
        AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
        AVP: l=6  t=Service-Type(6): Framed(2)
        AVP: l=6  t=Framed-MTU(12): 1300
        AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
        AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
        AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
        AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
        AVP: l=8  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Response (2)
        Id: 4
        Length: 6
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x0):
    AVP: l=18  t=State(24): c3efb02fc1ebbd0c6f4be297f22826ce
      State: c3efb02fc1ebbd0c6f4be297f22826ce
    AVP: l=18  t=Message-Authenticator(80): d157bec18615c0e0899cc387e7df7613
      Message-Authenticator: d157bec18615c0e0899cc387e7df7613

No.     Time        Source                Destination           Protocol Info
      8 0.042629    172.16.3.61           172.16.3.1            RADIUS   Access-challenge(11) (id=32, l=919)

Frame 8: 961 bytes on wire (7688 bits), 961 bytes captured (7688 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
  Code: Access-challenge (11)
  Packet identifier: 0x20 (32)
  Length: 919
  Authenticator: b8e4e3979a6bf75ff8f0e9c524a6ad46
  Attribute Value Pairs
    AVP: l=255  t=EAP-Message(79) Segment[1]
    AVP: l=255  t=EAP-Message(79) Segment[2]
    AVP: l=255  t=EAP-Message(79) Segment[3]
    AVP: l=98  t=EAP-Message(79) Last Segment[4]
      EAP fragment
      Extensible Authentication Protocol
        Code: Request (1)
        Id: 5
        Length: 855
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x80): Length
        Length: 1859
        Secure Socket Layer
    AVP: l=18  t=Message-Authenticator(80): 265ce092cb1a0b88e32ac14e3782b8f9
      Message-Authenticator: 265ce092cb1a0b88e32ac14e3782b8f9
    AVP: l=18  t=State(24): c3efb02fc0eabd0c6f4be297f22826ce
      State: c3efb02fc0eabd0c6f4be297f22826ce

No.     Time        Source                Destination           Protocol Info
      9 0.204104    172.16.3.1            172.16.3.61           IP       Fragmented IP protocol (proto=UDP 0x11, off=1408, ID=edad)

Frame 9: 267 bytes on wire (2136 bits), 267 bytes captured (2136 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
Data (233 bytes)

0000  9d 9e ad df a0 1b cc c6 91 05 2e 93 4e 34 e6 24   ............N4.$
0010  ff 7c 1e de 3b 1b 3e 28 b7 1b b0 65 5c b5 0a 3e   .|..;.>(...e\..>
0020  66 85 9b b8 ed ea d3 fc 82 72 00 86 50 9b 14 5b   f........r..P..[
0030  f8 69 1a d9 4f 91 1b 40 8f 24 a6 36 42 d7 62 42   .i..O..@.$.6B.bB
0040  6e c9 d0 c2 f4 42 0f fe 8a 4a 6c 1d 9b 48 ee 00   n....B...Jl..H..
0050  a9 d5 53 98 f8 16 25 1b 74 16 03 01 00 86 10 00   ..S...%.t.......
0060  00 82 00 80 0f 99 11 d4 36 93 f6 0c 86 77 ef 41   ........6....w.A
0070  11 44 09 5e d3 31 5e 43 9b 87 2e 2e d8 fc 7a 6f   .D.^.1^C......zo
0080  88 f3 de c3 e6 71 02 03 3f fc 45 78 50 27 68 41   .....q..?.ExP'hA
0090  5f c6 7a a1 4d 1e a7 d5 8c e2 b4 b1 36 d1 65 af   _.z.M.......6.e.
00a0  35 cc e3 a7 c7 11 3f ce 68 6f 56 d3 eb 82 66 11   5.....?.hoV...f.
00b0  ef 95 bf f5 32 a5 11 ce 70 08 b7 03 3a e9 2f 42   ....2...p...:./B
00c0  f0 5c 2d 86 45 18 12 c3 ef b0 2f c0 ea bd 0c 6f   .\-.E...../....o
00d0  4b e2 97 f2 28 26 ce 50 12 68 a3 ac f7 ac 02 7e   K...(&.P.h.....~
00e0  84 05 e4 29 c1 17 7d 2c e9                        ...)..},.

No.     Time        Source                Destination           Protocol Info
     10 0.205336    172.16.3.61           172.16.3.1            RADIUS   Access-challenge(11) (id=33, l=64)

Frame 10: 106 bytes on wire (848 bits), 106 bytes captured (848 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
    Code: Access-challenge (11)
    Packet identifier: 0x21 (33)
    Length: 64
    Authenticator: cffcf3a775fbf0c3058d9729a92be2b5
    Attribute Value Pairs
        AVP: l=8  t=EAP-Message(79) Last Segment[1]
            EAP fragment
            Extensible Authentication Protocol
                Code: Request (1)
                Id: 6
                Length: 6
                Type: EAP-TLS [RFC5216] [Aboba] (13)
                Flags(0x0):
        AVP: l=18  t=Message-Authenticator(80): 499528bb12f5888d07b5cbf29235e103
            Message-Authenticator: 499528bb12f5888d07b5cbf29235e103
        AVP: l=18  t=State(24): c3efb02fc7e9bd0c6f4be297f22826ce
            State: c3efb02fc7e9bd0c6f4be297f22826ce

No.     Time        Source                Destination           Protocol Info
     11 0.210490    172.16.3.1            172.16.3.61           RADIUS   Access-Request(1) (id=34, l=450)

Frame 11: 492 bytes on wire (3936 bits), 492 bytes captured (3936 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
    Code: Access-Request (1)
    Packet identifier: 0x22 (34)
    Length: 450
    Authenticator: bc12ba4e7c8af7b74d34ec158c83c224
    Attribute Value Pairs
        AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
        AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
        AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
        AVP: l=6  t=NAS-Port(5): 3
        AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
        AVP: l=8  t=NAS-Identifier(32): CISCO
        AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
        AVP: l=6  t=Service-Type(6): Framed(2)
        AVP: l=6  t=Framed-MTU(12): 1300
        AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
    AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
    AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
    AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
    AVP: l=237  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Response (2)
        Id: 6
        Length: 235
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x0):
        Secure Socket Layer
    AVP: l=18  t=State(24): c3efb02fc7e9bd0c6f4be297f22826ce
      State: c3efb02fc7e9bd0c6f4be297f22826ce
    AVP: l=18  t=Message-Authenticator(80): aac87a2f60a6613478195d52bc0cee07
      Message-Authenticator: aac87a2f60a6613478195d52bc0cee07

No.     Time        Source           Destination       Protocol Info
     12 0.222960    172.16.3.61      172.16.3.1        RADIUS   Access-challenge(11) (id=34, l=127)

Frame 12: 169 bytes on wire (1352 bits), 169 bytes captured (1352 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
  Code: Access-challenge (11)
  Packet identifier: 0x22 (34)
  Length: 127
  Authenticator: 1d1a909d78817448f71ac4f093c01b3a
  Attribute Value Pairs
    AVP: l=71  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Request (1)
        Id: 7
        Length: 69
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x80): Length
        Length: 59
        Secure Socket Layer
    AVP: l=18  t=Message-Authenticator(80): d982215a206382a91dbb8d326b9f05e7
      Message-Authenticator: d982215a206382a91dbb8d326b9f05e7
    AVP: l=18  t=State(24): c3efb02fc6e8bd0c6f4be297f22826ce
      State: c3efb02fc6e8bd0c6f4be297f22826ce

No.     Time        Source           Destination       Protocol Info
     13 0.229578    172.16.3.1       172.16.3.61       RADIUS   Access-Request(1) (id=35, l=221)

Frame 13: 263 bytes on wire (2104 bits), 263 bytes captured (2104 bits)
Ethernet II, Src: Cisco_90:4c:a0 (00:24:97:90:4c:a0), Dst: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93)
Internet Protocol, Src: 172.16.3.1 (172.16.3.1), Dst: 172.16.3.61 (172.16.3.61)
User Datagram Protocol, Src Port: filenet-tms (32768), Dst Port: radius (1812)
Radius Protocol
  Code: Access-Request (1)
  Packet identifier: 0x23 (35)
  Length: 221
  Authenticator: 4211807da63e594144c657c88f4b1601
  [The response to this request is in frame 14]
  Attribute Value Pairs
    AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
    AVP: l=19  t=Calling-Station-Id(31): 00-1A-73-96-15-41
    AVP: l=27  t=Called-Station-Id(30): 00-25-45-B1-F4-F0:OSADMIN
    AVP: l=6  t=NAS-Port(5): 3
    AVP: l=6  t=NAS-IP-Address(4): 172.16.3.1
    AVP: l=8  t=NAS-Identifier(32): CISCO
    AVP: l=12  t=Vendor-Specific(26) v=Airespace(14179)
    AVP: l=6  t=Service-Type(6): Framed(2)
    AVP: l=6  t=Framed-MTU(12): 1300
    AVP: l=6  t=NAS-Port-Type(61): Wireless-802.11(19)
    AVP: l=6  t=Tunnel-Type(64) Tag=0x00: VLAN(13)
    AVP: l=6  t=Tunnel-Medium-Type(65) Tag=0x00: IEEE-802(6)
    AVP: l=3  t=Tunnel-Private-Group-Id(81): 3
    AVP: l=8  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Response (2)
        Id: 7
        Length: 6
        Type: EAP-TLS [RFC5216] [Aboba] (13)
        Flags(0x0):
    AVP: l=18  t=State(24): c3efb02fc6e8bd0c6f4be297f22826ce
      State: c3efb02fc6e8bd0c6f4be297f22826ce
    AVP: l=18  t=Message-Authenticator(80): 17cb0e1374d33531c8cf75f77d46d188
      Message-Authenticator: 17cb0e1374d33531c8cf75f77d46d188

No.     Time        Source           Destination        Protocol Info
    14 0.232260    172.16.3.61        172.16.3.1          RADIUS   Access-Accept(2) (id=35, l=206)

Frame 14: 248 bytes on wire (1984 bits), 248 bytes captured (1984 bits)
Ethernet II, Src: AsustekC_cf:7b:93 (00:1b:fc:cf:7b:93), Dst: Cisco_90:4c:a0 (00:24:97:90:4c:a0)
Internet Protocol, Src: 172.16.3.61 (172.16.3.61), Dst: 172.16.3.1 (172.16.3.1)
User Datagram Protocol, Src Port: radius (1812), Dst Port: filenet-tms (32768)
Radius Protocol
  Code: Access-Accept (2)
  Packet identifier: 0x23 (35)
  Length: 206
  Authenticator: d5d5bdf47ed437c0acdc80289cfa4d09
  [This is a response to a request in frame 13]
  [Time from request: 0.002682000 seconds]
  Attribute Value Pairs
    AVP: l=58  t=Vendor-Specific(26) v=Microsoft(311)
    AVP: l=58  t=Vendor-Specific(26) v=Microsoft(311)
    AVP: l=6  t=EAP-Message(79) Last Segment[1]
      EAP fragment
      Extensible Authentication Protocol
        Code: Success (3)
        Id: 7
        Length: 4
    AVP: l=18  t=Message-Authenticator(80): 44f796c559dd596a4c73370454e70588
      Message-Authenticator: 44f796c559dd596a4c73370454e70588
    AVP: l=46  t=User-Name(1): /home/tinti/Downloads/fwdjhgjg/user2_key.pem
```

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