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Master thesis

Analysis and performance monitoring of a large WiFi network

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Chapter 1

Introduction

With nearly 30.000 students and 10.000 staff members (including teachers and researchers), the Catholic University of Louvain (UCL) is the largest french speaking university in Belgium. The university has several campuses based in Brussels, Tournai, Mons, Charleroi and Louvain-la-Neuve, the latter being the widest. On those campuses, a wireless internet connection is provided by the university and is available for all the students and staff members for free.

Providing this wireless access for such a large community of users and all over the campus is a real struggle for the UCL's SRI team. Indeed, in order to deliver and ensure, at any time, a quality connectivity with high performance, it is vital to develop and maintain that network to keep it reliable and efficient.

In this study we focus on analyzing and implementing a monitoring tool for the wireless network infrastructure of the Louvain-la-Neuve area that will help the SRI team identifying and responding, in real-time, to the possible problems that might occur on that network.

1.1 Towards a custom WiFi Monitoring Tool

As for other universities around the world, the Catholic Univeristy of Louvain offers a large wireless network throughout its different campus. This network provides a direct and reliable connection to all of the students, staff, teachers and researchers of the university at all time. The problem with the UCL infrastructure is that it is quite huge and it is always changing. The UCL/SRI team, which is responsible for the effective development of that infrastructure and its connection with the outside world, is always trying to improve the connectivity on the site by adding access point or upgrading the

Cisco controllers for instance.

Because of that complexity, the management and the efficiency of that network has become quite difficult and buggy. Indeed, the logfiles produced by the controllers are very verbosed which induce an arduous and tricky work of decryption when the team wants to find and trace a problem that occured before on the system. Furthermore, there are more and more users trying to get a connection on the campus (laptops, smartphones,...). This might causes some disturbance on the network that leads to connectivity problems for the direct user.

In this thesis, we discuss the implementation of a WiFi monitoring tool that will help the network administrators managing the wireless infrastructure. To achieve that, we proceed in two steps. First of all, we collect all the information that travels over the network. Those information come from heterogeneous sources (from controllers logfiles to active monitoring logs through customized routers). Second, we have to analyze and process that raw data in a way that is understandable and readable for the end users.

1.1.1 Data Gathering

To work properly, our monitoring tool needs to gather data from the UCL wireless network. These data comes from various places and are quite heterogeneous. Indeed, our system implementation gathers, and stores into our private server, the logfiles containing all the information about the RADIUS, LDAP and DHCP servers as well as the information about the different WiSMs (Wireless Services Modules). Thanks to those logfiles we have a complete overview of the network status and the components at all time.

Moreover, we have designed a custom OpenWRT router that authenticate itself on the UCL network to check if there is a problem during the authentication phase. All the information that the router gathers are also stored into our server. This gives active network status information compared to the passive one collected with the different logfiles.

1.1.2 Data Analysis

The next step is the data analysis. In that phase, our system examines all the logfiles of the server and [TODO]

Throughout this thesis we explain what are the main issues encountered today on the university wireless network and how our monitoring tool is helping the network administrators managing this system. In a first chapter, we present the working environment, and more specifically, the UCL Internet infrastructure. We also discuss the different types of logs we use in our tool. In the following chapter, we present all the network components and protocols used inside the network and where connectivity problems can occur. Finally we provide and describe an implementation of our monitoring tool and we deploy it on the network to gather results and feedback.

1.2 State of the art

Here we present the state of the art of wireless network monitoring.

Chapter 2

Working Environment Overview

2.1 UCL Internet Infrastructure

The Catholic University of Louvain (UCL) is one of the biggest universities in Belgium. It gathers almost 30.000 students and about 10.000 other members from staff to teachers and researchers.

The university also owns several student campus. The headquarters of the UCL is located in the city of Louvain-la-Neuve. The campus gathering the health sciences is located in Woluwe-Saint-Lambert and more recently the cities of Tournai and Mons as well as Charleroi were added to the list.

Faced with such a scale, it is vital for the Catholic Univeristy of Louvain to develop a reliable and efficient Internet connection and wireless network able to deliver a connectivity throughout its campus and all users at all time.

The purpose the University enrolled in is to provide an Internet access and a connectivity according to the type of user who wants to connect. To do this, there are 3 main networks at the Catholic University of Louvain, each with a different SSID.

The univeristy also participates in the projet `eduroam` (which stands for education roaming). Eduroam is the secure, world-wide roaming access service developed for the international research and education community[4].

The eduroam system is a RADIUS-based infrastructure that uses the 802.1X security technology to allow for inter-institutional roaming. It allows the users visiting another institution connected to eduroam to log on to the WLAN using the same credentials the user would use if he were at his home institution[5].
The Catholic University of Louvain thus has a fourth network available with the SSID `eduroam` allowing the foreign students to be able to get an Internet connection at any time on the university locations.
The available networks at UCL are the following:

- `student.UCLouvain`: Only for the students enrolled for the current year at UCL.
- `UCLouvain`: Only for university staff as well as for the researchers.
- `visiteurs.UCLouvain`: Accessible for guests invited by the university.
- `eduroam`: Education Roaming access.

2.2 Hardware infrastructure

Using the network monitoring software InterMapper[6] we see that the UCL network is composed of seven neighborhood routers (CtPythagore, CtHalles, CtLew, CtStevin, CtCarnoy, CtMichotte and CtSH1C). Six of them are present on the Louvain-la-Neuve campus and only CtLew is on the Wolluwé Campus. Those routers task is only routing.

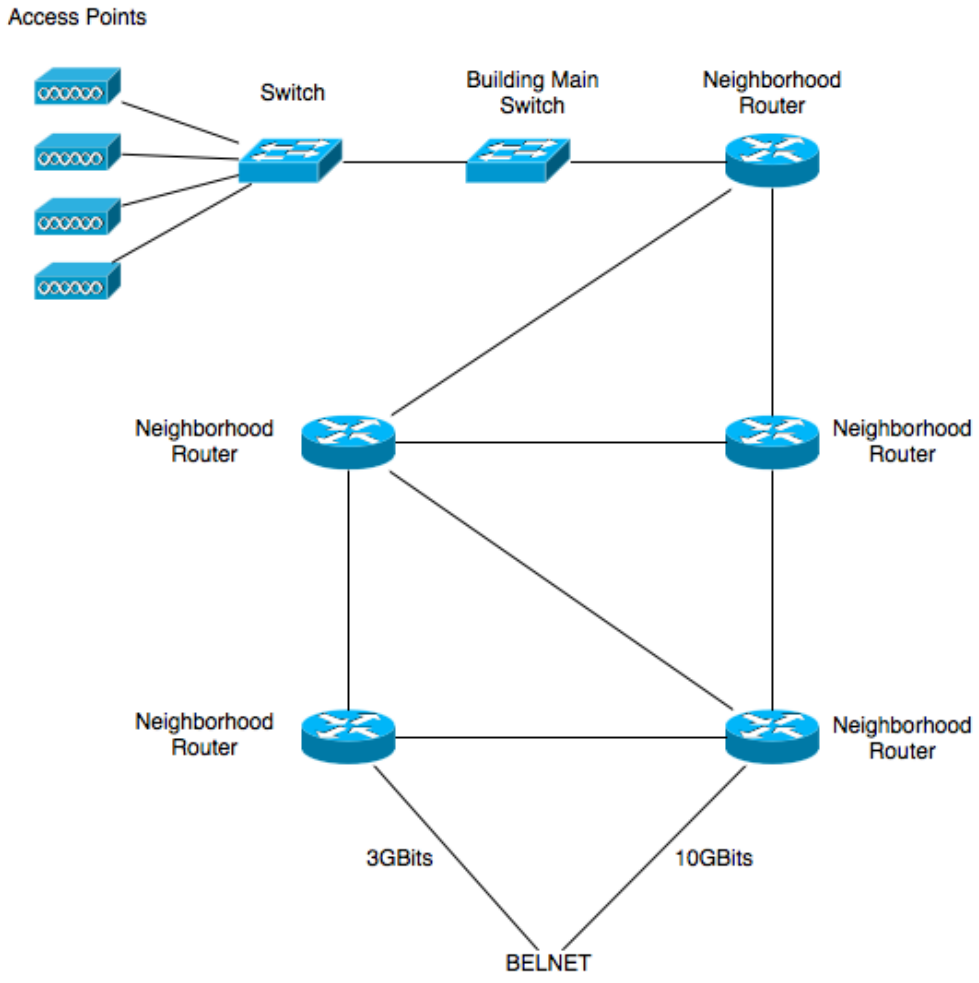
Internet access is provided by Belnet via a 10GBit ethernet link directly connected to the CtPythagore. There is also a second 3GBit ethernet link connected to the CtHalles router but this link is never used. It is only a backup link in case of failure of the main one.

The infrastrucutre also has two main servers which are CtTier2 and CtAquarium. Those main servers are datacentres that contain the RADIUS servers as well as the LDAP servers.

Then for each building there is a switch and this switch is directly connected to one of the seven routers. Each of those switches has 48 ports that are connected to the access points inside the concerned building.
Concretely, in each building we find ethernet plugs that are connected to what we call

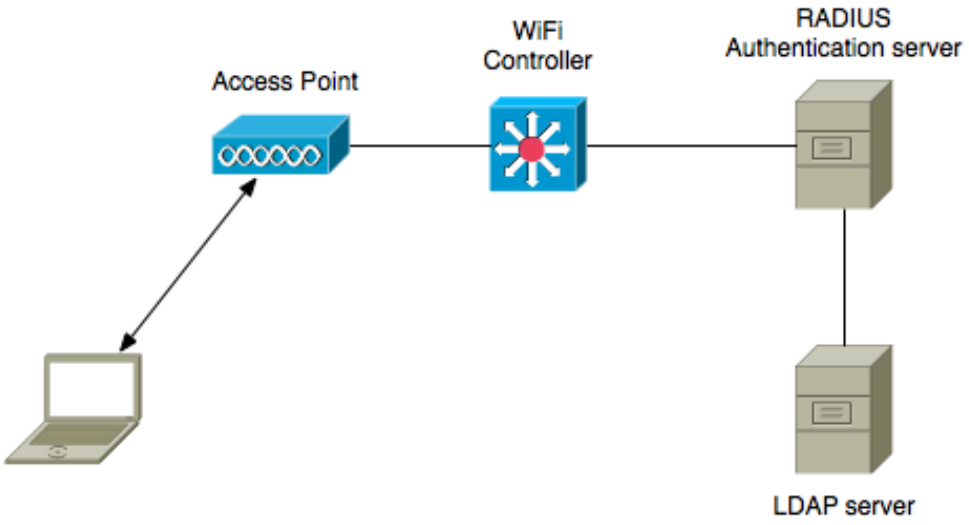
concentration points. Those points contain commutators that is connected to the building switch that is connected to one of the main routers.
An important point to mention is that the network is not a full mesh.

Here is a simplified representation of the UCL network infrastructure:



2.2.1 Network Topology

Here is the representation of the network topology:



The Catholic University of Louvain has chosen to use the IEEE 802.1X protocol for user authentication. Thus when a user wants to connect to the WiFi, the access point will realize an EAP negociation with the supplicant. It transmits this EAP information to the controller who is going to interact with the RADIUS authentication server who, in turn, is going to asks information to the LDAP server. Once the RADIUS server authenticate the requesting user, the connection is established.

2.3 Understanding the passive and active logs

Chapter 3

Network Components and Protocols

3.1 802.1X

3.2 RADIUS

3.3 WiSM

3.4 DHCP

3.5 SNMP

The Simple Network Management Protocol is an application layer protocol that facilitates the exchange of management information between network devices [7]. It is part of the TCP/IP protocol suite and it is mainly used by network administrators to get information about devices on the network and the network performances. These information help the administrators to resolve problems on the network or simply to manage it.
A SNMP network has three main components:

- `Network-management system (NMS)`: A NMS is the main component of an SNMP-managed network. It is the management entity that controls the managed devices. It uses the SNMP protocol and can interact with the managed devices to get information using special commands and messages.

- `Managed devices`: It is a network device that contains an SNMP agent. They collect and store information to make them available for the network-management systems. Those devices can be routers, servers, switches,etc. They also run the SNMP protocols to be able to respond to the requests made by the NMS.

- `Agents`: An agent is the thinking part of a managed device. It is a software module that understands the management information and translates them into a SNMP compatible form.

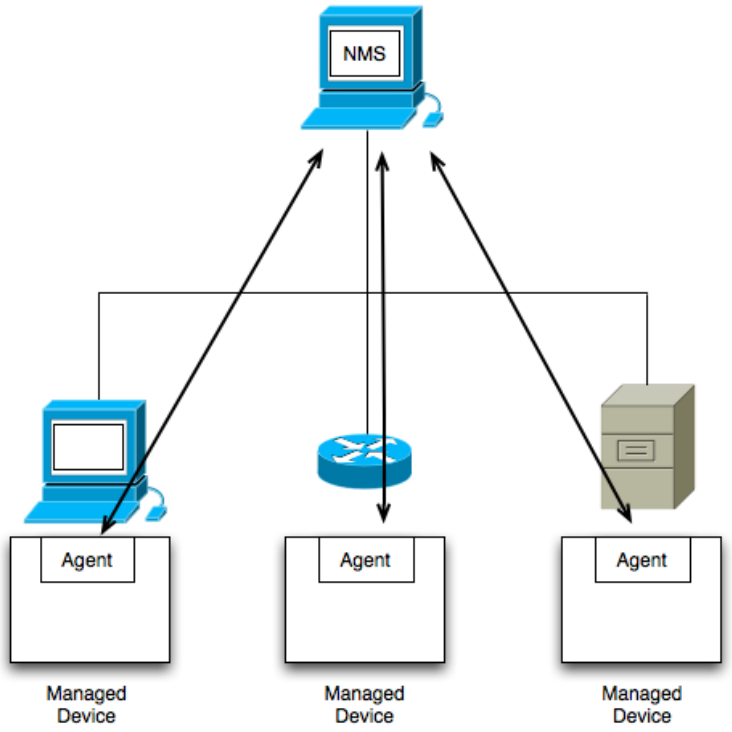


FIGURE 3.1: A typical SNMP managed network

All the network objects are described and organized hierarchically in a Management Information Base (MIB). There are MIBs for each set of related network entites that can be managed. These MIBs are accessed using a network-management protocol such as SNMP.

3.6 Problems encountered

Chapter 4

Monitoring Tool - Architecture

4.1 Architecture

The system have two very distinct entities. The first part is the one responsible for gathering information. This component handles the responsibility to keep the operational database up to date and in a consistent state. The other side of the application is the one managing the analysis made with the information gathered.

4.1.1 Gatherer

This part of the application is constituted of several modules that allow it to communicate with the various sources of information. Each module is responsible of a distinct kind of information and each of them have to transform the piece of information in a coherent entry in the database. As the information come from heterogeneous origins, each information have to be understood and transform into an entity that can be related to others. Without such transformation, the possible analysis would be really limited and not really interesting.

4.1.1.1 Logs

The first kind of information we managed to analyse was the logs files. There is one file per infrastructure component:

- Radius
- DHCP

- Wism

These elements generate several log each seconds and the first difficulty was to make a first sorting. A part of them are just informational and don't bring useful information about the state of the network. Such information will never be used during the analysis and then they don't have to be store in the database. Another part of the log are repetition of others. In fact, as each element produces its logs independently, some logs can overlap and represent the same information. Redundant information are useless and the same information don't need to be in the database twice. This can seems to be a unimportant issue but in consideration of the quantity of information proceed by the application, an overloading of the database can cause severe performance issue during the analysis phase.

4.1.1.2 SNMP

The SNMP protocol allows us to retrieve information on the controller in real-time. The module handling the SNMP request can update the information about the situation of each access point or any client. This bring a lot of interesting data regarding the users of the network but the main drawback is that the request are heavy. We can't make them at any time because it requires resources from the controller. In consequence, we have to find the right balance between keeping the database update and not overloading the controller with SNMP request. The main information extracted are the status of every access points (AP). We can see what access point are actually associated with the controller. A lot of statistics (e.g the load of the AP) are available. The same holds for the client associated to an access point. Each mobile station is indexed by the controller and statistics about it are hold.

4.1.1.3 Active Monitoring

[OpenWRT]

4.1.1.4 Database

The database have to be capable of representing each kind of information and manage the links between them. It isn't hard to create entries for a log but the difficulties appear when we make link with other entities and have to keep them in a coherent state. Several questions raised when we try to designed our database. For example, if a client is no

more associated with an access point, do we have to remove it from the database? Such questions can seem futile but have deep implication on the database.

4.1.2 Analyser

As the gatherer only put available information together, it doesn't bring anything new. In the other side, the analyse component will use the data and the links between them to extract useful information about the network. For example, the SNMP shows the people associated with an access point but only an analysis through time will allow us to detect and even forecast overload in the network. This component will manage the analyse on the database and storing the result over the time.

4.1.2.1 Utilization Statistics

4.1.2.2 Event Statistics

Chapter 5

Monitoring Tool - Implementation and Deployment

5.1 Equipment used

5.2 Testbed conditions

Chapter 6

Results and Analyzis

6.1 Results

6.2 Feedback

6.3 Modification proposed by the test users

Chapter 7

Conclusion and Future Talks

7.1 Conclusion

Appendix A

Source Code

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