DEEC
DEPARTAMENTO DE ENGENHARIA
ELECTROTÉCNICA E DE COMPUTADORES
TÉCNICO LISBOA

LAB PROJECT Nº2

IP NETWORKS AND NODE MOBILITY

1 INTRODUCTION

The Internet Protocol (IP) is the most widely used network layer protocol, constituting the basis of the Internet as well as of private networks and internal domains of telecom operator networks. Two versions of IP are relevant nowadays: IPv4 and IPv6. Recent trends towards huge numbers of networking nodes have uncovered a weakness of IPv4, which is related with its limited addressing space (32 bits). If we are to assign unique IP addresses to network devices in the future Internet (which includes the so called Internet of Things – IoT), we will need the huge address space that IPv6 can provide (128 bits). Still, to move globally from IPv4 to IPv6 is a real huge investment, which is the reason why transition is being very slow, especially since there are techniques that can help making a better use of IPv4's limited address space (e.g., private addressing and NAT). Still, the IPv6 is already overtaking IPv4 as regards the number of IP network domains.

The IP protocol, together with other protocols that complement it (e.g., IP-based routing protocols), provides something like an electronic "postal service" able to deliver a message through a sequence of routers up to its final destination. The latter being identified by an IP address, which is unique in its network domain. In order to be scalable, IP networks are organized in a hierarchic way. Parts of the network, designated subnetworks or subnets, are identified by the prefix part of the IP address. IP packet delivery is in fact done based on subnet prefixes instead of individual node prefixes in order to reduce the size of the routing tables at the routers.

IP networks are traditionally fixed. In the beginning of the Internet, user terminals were supposed to be static machines, attached to the same fixed point most of the time. Mobility was considered as moving the terminal from one point of attachment to another point of attachment. As the size and weight of the terminals was reduced and wireless technologies increased the supported data rates, the Internet went mobile. But what happens if a mobile node moves between two different subnetworks? This lab project aims to answer this question, as well as to present a solution to it.

Throughout this document, the students shall be asked to build simulation script files. Although the main guidelines for scenario construction are provided, additional procedures may be necessary, which require initiative from the students. The students shall also be asked to answer questions regarding the simulated network environment and performance results. The answers shall be included in the report, which is due in the week that immediately follows the end of the project. Together with the report, the students must deliver all the scripts and spread sheets that resulted from their work.

2 WORK DESCRIPTION

The structure of IP networks, as well as the issues raised by node mobility will be addressed in this lab assignment.

Within the OMNET++ IDE, do the following changes to the OMNET++ file tree:

- Add the example *wiredandwirelesshostswithap_lab2a* provided in the course's webpage to the folder *inet/examples/wireless/*.
- Add the example *mobileipv6_LAB2b* provided in the course's webpage to the folder *inet/examples/*.

2.1 Configuring an IPv4 Network

Q2.1: Complete the provided *wiredandwirelesshostswithap_lab2a* example in order to setup the following scenario:

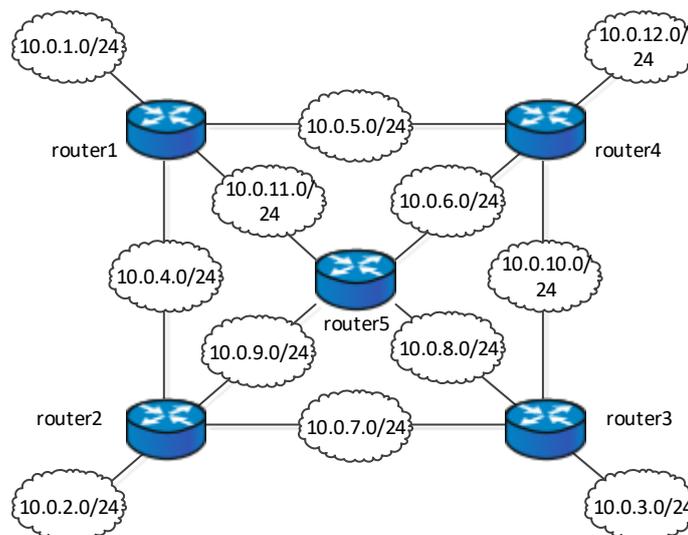- The IP network comprises a core of five routers, defining the network structure depicted in Figure 1.

Figure 1: IPv4 network structure, identifying routers and subnets.

- The route from subnet 10.0.2.0/24 to subnet 10.0.1.0/24 will be: *router2 > router5 >* router 3 > *router4 > router1*.
- The route from subnet 10.0.2.0/24 to subnet 10.0.12.0/24 will be: *router2 > router5 >* router 1 > *router4*.
-
- The route from subnet 10.0.3.0/24 to subnet 10.0.1.0/24 will be: *router3 > router4 >* *router1*.
- The route from subnet 10.0.3.0/24 to subnet 10.0.12.0/24 will be: *router3 > router4*.

- The route from subnet 10.0.1.0/24 to subnet 10.0.2.0/24 will be: *router1 > router4 > router5 > router2*.
- The route from subnet 10.0.1.0/24 to subnet 10.0.3.0/24 will be: *router1 > router5 > router3*.
- The route from subnet 10.0.12.0/24 to subnet 10.0.2.0/24 will be: *router4 > router5 > router2*.
- The route from subnet 10.0.12.0/24 to subnet 10.0.3.0/24 will be: *router4 > router5 > router3*.
- The *wirelessHost1* will move according to RectangleMobility between delimited by coordinates <50, 50, 0> and <250, 50, 0>, starting at <50, 50, 0>. The moving speed will be 1 m/s.
- The *wiredHost1* and *wiredHost2* nodes, each run one instance of the *UDPBasicApp* application. Those instances send messages to *wirelessHost1*. All messages are 100 bytes long and the interval between messages is 1 s.
- The *wirelessHost1* will run one instance of the *UDPEchoApp* application.
- The path loss exponent should be set to 2.65.

For the IP network structure, you will need to edit the *config.xml* file, which defines the existing wireless and wired interfaces, as well as the contents of the routing tables. Other parameters are configured in the *omnet.ini* file.

While filling the *config.xml* file, it is useful to check whether the file's definitions are correctly interpreted by the *IPv4NetworkConfigurator*, you can run the simulation and open the device that you wish to check. For example, Figure 2 shows the internals of *router1*. It is possible to double-click on the routing and interface table in order to check the contents. In this case, the routing and interface tables contain already 12 and 5 entries, respectively. The detailed format of the *config.xml* contents can be consulted in Section 11.9 of document */inet/doc/ inet-manual-draft.pdf*. The provided *config.xml* is incomplete but already includes examples of each type of table entry definition.
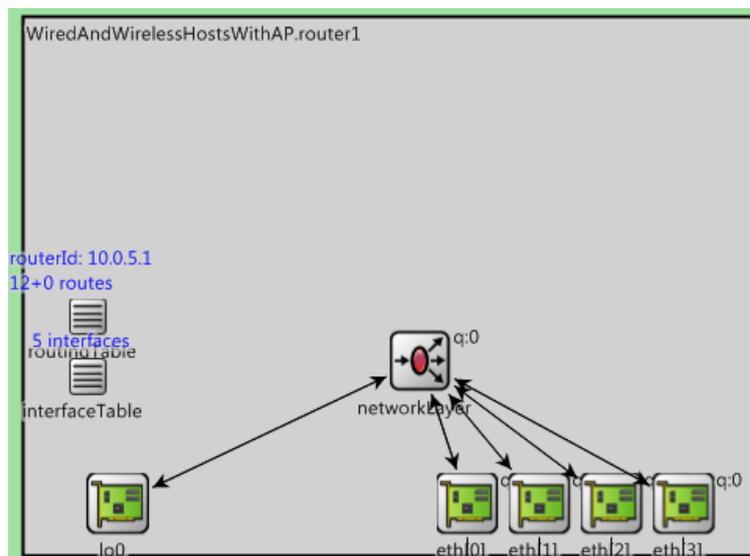
Figure 2: Inside view of *router1* during the simulation. Routing table and interface table are located on the left.

2.2   IEEE 802.11 Access Network

Based on the scenario defined in 2.1, answer the following questions:

Q2.2.1) How many BSSs and ESSs are there in this scenario?

Q2.2.2) In order to be able to communicate through the WLAN, the stations must engage in a number of management procedures: Scanning, Authentication, Association. Calculate how many data packets could be transmitted during the interval between the start of Scanning and the end of Association.

Q2.2.3) Why does the first ProbeReq get no answer from *accessPoint1*, while the second ProbeReq gets an answer? Clue: the management module of the wireless card manages the scanning procedure, so it may be useful looking at its state.

2.3   IP Networking and Mobility Issues

Based on the scenario defined in 2.1, answer the following questions.

Q2.3.1) The IEEE 802.11 data packet sent by *wirelessHost1* towards *wiredHost1* or *wiredHost2* use three address fields of the IEEE 802.11 header. One of these fields contains the MAC address of *router1*. How does *wirelessHost1* know that IEEE 802.11 frames containing IP packets sent towards *wiredHost1* or *wiredHost2* should be sent to *router1*?

Q2.3.2) Simulate the scenario during 400 s. Compare the total number of data packets sent by the applications of *wiredHost1* with the total number of packets received by the same applications. Explain the results.

Q2.3.3) How would you solve the problems identified in Q.3.2.?

2.4 Mobile IPv6

Run the *mobileipv6_LAB2b* example. You will see the scenario topology as depicted in Figure 3. IPv6 is now used instead of IPv4.
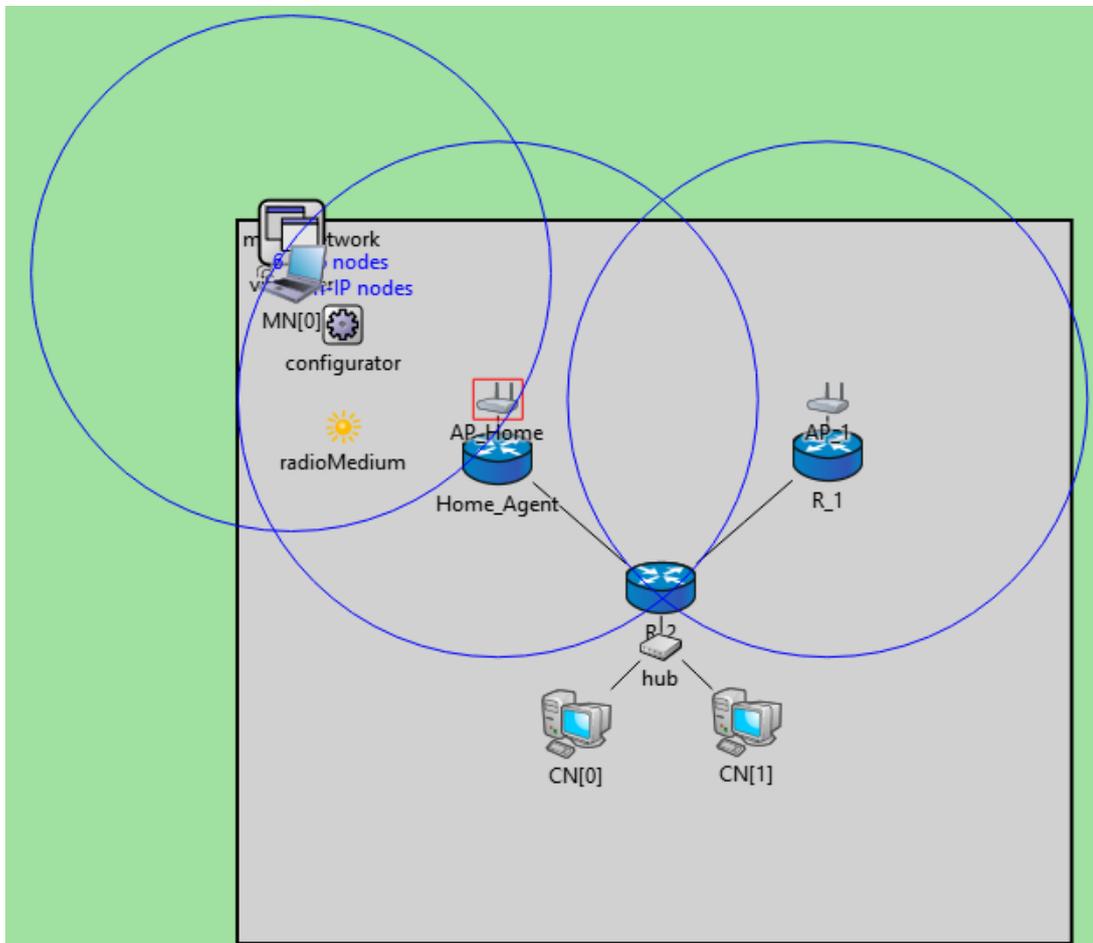

Figure 3: The xmipv6_2 example.

At this time, the interface and routing tables are automatically configured, with no need for completing the routing XML file. By clicking on a node, you have access to the list of interfaces, which includes information about assigned IP addresses. The link-local IP address of an interface is built from the interface's identifier, which in turn is built from the MAC address. A link-local address can be easily identified by its prefix FE80::. The interface and routing tables of each node can be accessed by opening the node's icon and selecting the respective module, just like in the IPv4 scenario.

Q2.4.1) Based on scenario *mobileipv6_LAB2b*, build a new scenario *wiredandwirelesshostswithap_lab2b*, with the same physical topology as the one in *wiredandwirelesshostswithap_lab2a*, but now using IPv6 with mobility support. Complete the scenario by adapting the same UDP application and traffic definitions used in 2.1 for operation over IPv6.

DEEC
DEPARTAMENTO DE ENGENHARIA
ELECTROTÉCNICA E DE COMPUTADORES
TÉCNICO LISBOA

REDES MÓVEIS E SEM FIOS
2018-2019, MEEC

Q2.4.2) In IPv6 there is no ARP procedure. Which protocol replaces ARP in IPv6? Explain succinctly how it works.

Q2.4.3) Explain why to the nodes issue NS packets from the start of the simulation.

Q2.4.4) Repeat the simulation in Q2.3.2 and compare the results. Explain the found differences and similarities.

Q2.4.5) Based on the simulation performed in Q2.4.4, check how many data packets in each flow (defined as the <source, destination, direction> tuple) are lost during each handover instance. Indicate the respective sequence number ranges.

3 GRADING

Grading of the responses shall be performed according to Table 1.

Table 1: Grading of LAB2 responses.

Question	Value
Q2.1	4.0
Q2.2.1	1.0
Q2.2.2	1.5
Q2.2.3	1.5
Q2.3.1	1.0
Q2.3.2	2.0
Q2.3.3	1.0
Q2.4.1	3.0
Q2.4.2	1.0
Q2.4.3	1.0
Q2.4.4	1.5
Q2.4.5	1.5

The organization of the delivered report and scenario files contributes with 0.0-3.0 negative points to the final mark.