Introduction to wireless networks

I.   Objectives

The objectives for this practical work are:

- Get familiar with common networking analyzer tools

- Apply those tools to well know technologies (WLAN and Celullar technologies)

- Make an initial technical characterization of WLAN and Cellular technologies

- Have a first contact with cellular communications concepts

II.   Duration

This work is expected to take 1h15.

III.   Material
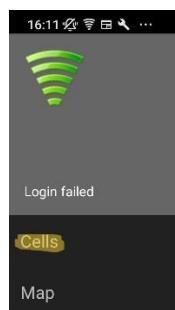
This work will use:

1. Own students Android/iOS mobile terminals (smartphones and tablets)
2. Available WLANs in the laboratory space
3. Commercial cellular networks from operators
4. Free analyzer tools, required to be previously installed at own students mobile terminals:
    1. CellMapper
    2. WiFi Monitor
   3. Speedtest

IV.   Procedures

A.   Cell Mapper
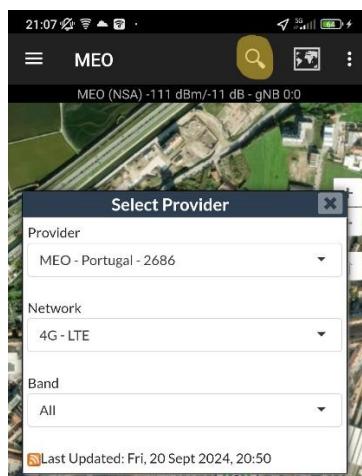
1) **Enable location** in your Android mobile terminal

2) **Start** *CellMapper* tool
3) **Check** your network operator name in the top left corner
4) **Access** the menu (top left corner) and select 'Cells'

5) In the main screen you will get a list of available cells in your vicinity, with the first being the one your terminal is connected to

6) **Note, for your case, the value highlighted in yellow in the figure ('eNB xxxx:yy', 1223:32 in the example)**

7) **Note the MCC and MNC values; compare with colleagues in different operators**

8) **Scroll** down in the main screen and check the existence of other cells being sensed by your terminal; **identify the parameter and the respective value by which they are ordered**

9) **Access** the menu (top left corner) and select 'Map'

10) **Press** the search icon in top of the screen to 'Select Provider'; in the 'Provider' field, start writing 'Portugal', until you see listed the Portuguese public operators **and select your operator; select '4G – LTE' and 'All' Bands**

11) Go to 'Map Settings' and **unselect 'Map Trails'** for better visibility in the following steps

12) Returning to the main screen, press the search icon in the bottom right corner and **select your operator ('Vodafone'/'MEO'/'NOS'/'Digi')**; after that, you will see in the screen only cell towers belonging to that operator

13) **Zoom out** to a level allowing you to see from Aveiro to Porto (*if you zoom out too much, you will get an error message regarding the number of requests to the DB*); **wait a few seconds** and see

how numbers reflecting the number of deployed cells start to appear; **are you surprised by the numbers?**
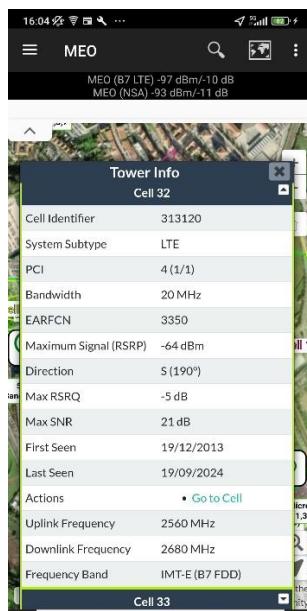
14) Change to another operator and **try an estimation on the total number of existing cell towers** in Portugal

15) **Press** the arrow icon in bottom right corner to center the map in you location

16) **Zoom/pan** until you see a blue line showing the radio connection between your terminal and the cell tower it is connected to

17) **Select** that tower (a 'Tower Info' popup window will appear) and see the provided information
   o **MCC and MNC**
   o **Bands** (see URL in references to understand this)

18) **Scroll down** until you see the cell with the number observed in step 5 (32, in this example); this is the cell in the Tower your terminal is connected to; check the following values:
   o **Bandwidth**
   o **Direction** (this is the same as azimuth)
   o **Maximum RSRP and maximum RSRQ**
   o **Up and downlink frequencies**

19) Go again to the **search icon** in top of the screen and **select '5G – NR'** as 'Network' and return to the map; you may have to select another operator (not all are shown)
20) **Select** one of the shown cell towers and **check the gNB ID**
21) **Scroll down** until you find a cell in Frequency band n78; **compare** the indicated bands, bandwidth, up and downlink frequencies with the previously obtained 4G information

B. WiFi Monitor

1) **Connect** your terminal to one of the WLAN networks available in the laboratory (e.g. 'eduroam')
2) **Start the WiFi Monitor** tool and see the first screen ("**Connection**")
3) **Annotate the indicated Channel, Frequency and RSSI**

4) Move to "**Networks**", see the list of all available WLAN networks and find yours; **which is the information used to order the networks**? Based on the used colors, see which are considered **good and ban values**

5) Among the several WLANs, **try to find a relation between the frequencies bands (2.4 vs. 5GHz) and bandwidth (20 and 80 MHz)**

6) Move to the "**Channels**" screen; **how many bands can you see? Are there channels overlapping?**
7) How do you interpret the fact that different SSIDs are shown in the same channel?

8) Move to "**Strength**"; **Which measurement is here used**? See the **temporal evolution** of that parameter; move around (you may go leave the laboratory for a moment!) and **see indicators evolution**
9) **Identify the network you are connected** to and try to find **when you are approaching or moving away** from the network center (*WLAN Access Point*)

C. Speedtest

1) Connect you terminal to one of the WLAN networks available in the laboratory (*do not use mobile data, unless you have an unlimited data plan contract!*)
2) **Start the Speedtest** tool

3) Select a **server in New Zealand** ('Change Test Server')
  - o Execute the test ('Go') and **register the delay and jitter values**
4) Now **select a server in Portugal**
  - o Execute the test ('Go') and **register the delay and jitter values**

5) **Compare the values**

V.   Links úteis

Android Apps (Google Play)

https://play.google.com/store/apps/details?id=cellmapper.net.cellmapper

https://play.google.com/store/apps/details?id=com.signalmonitoring.wifimonitoring

https://play.google.com/store/apps/details?id=org.zwanoo.android.speedtest

Cellular

https://en.wikipedia.org/wiki/LTE_frequency_bands

https://en.wikipedia.org/wiki/5G_NR_frequency_bands

Other

https://www.wilsonamplifiers.com/blog/finding-cell-tower-locations-the-complete-guide/

https://www.m2catalyst.com/apps/network-cell-info/faq