Networking Lab 7 – Performance test on WiFi

In this laboratory, we will repeat the speedtest experiments, but using a WiFi link. We need first to configure the Access Point (AP), so that each group will be using a different WiFi network, and to limit the wireless interference as much as possible.

Next, we need to configure the WiFi interface of the host to join the proper WiFi network. For this purpose, we use the `iwconfig` command which is the equivalent of the `ethtool`, but configures the wireless "link"of a WiFi interface. It is used to set the parameters of the physical layer and data link layer interface which are specific to the wireless operation (for example: the channel being used, the modulation, the physical layer speed, etc.). `iwconfig` may also be used to display those parameters, and the wireless statistics.

NOTE: not all hardware interfaces support all option. The O.S. driver may have bugs, and may not allow one to control all options.

```
iwconfig – configure a wireless network interface
```

```
Syntax: iwconfig interface [essid X] [channel C] [rate R] [enc E] [key K]
```

`essid`: Set the ESSID (or Network Name). The ESSID is used to identify the WLAN to which devices belong to.

`channel`: Set the operating channel in the device. Values are between 1 and 11 for European countries in the 2.4GHz band. See https://en.wikipedia.org/wiki/List_of_WLAN_channels for more details.

`rate/bit[rate]`: For cards supporting multiple bit rates, set the bit-rate in b/s. The bit-rate is the speed at which bits are transmitted over the medium, the user speed of the link is lower due to medium sharing and various overhead. Use `auto` to let the AP and WLAN card select automatically the best bit-rate.

`key/enc[ryption]`: Used to manipulate encryption or scrambling keys and security mode when WEP encryption is enabled. To set the current encryption key, just enter the key in hex digits as `XXXX-XXXX-XXXX-XXXX` or `XXXXXXXX`. To set a key other than the current key, prepend or append [index] to the key itself (this won't change which is the active key). You can also enter the key as an ASCII string by using the `s:` `prefix`. Passphrase is currently not supported. To change which key is the currently active key, just enter [index] (without entering any key value). `off` and `on` disable and enable encryption.

Example: configure the wlan0 interface to join the network "group-01" on channel 1 and force the speed to be 11Mb/s

```
iwconfig wlan0 essid group-01 rate 11M channel 1
```

NOTE: You may also use the `iwlist` and `iwspy` commands. Check the man pages for more info. If `WPA` is used, you need to use the `wpa-supplicant` command to configure the WiFi interface. We will not consider WPA in out tests.

1. Configuration of the host

- Disable Ubuntu Network Manager as always.
- Assign `H1, H2, H3` addresses in the subnet 192.168.0.0/24 for interfaces `ethX`. Call these addresses `E1, E2, E3` (as IP addresses associated to the Ethernet card)
- Warning: The AP is using address 192.168.0.1 – do not use it

2. Configuration of the Access Point

- Open the Firefox browser and connect to address 192.168.0.1
    - If Firefox is blocked, kill the process and restart it
        - From a shell, type **`sudo killall firefox`**
- Login using username "admin" and password "admin" [do not change the password!]
- Using the menu "Wireless" on the left, configure the WiFi network of the AP
    - Wireless Network Name: "Group-**XX**" where **XX** is the group number, e.g., 01,…, 09, 10,… note: name is case sensitive, i.e., Group-XX is different from group-XX!
    - Region: Italy
    - Mode: bg mixed [DISABLE n] – this avoids the AP using two adjacent physical channels and then reduces the interference among APs of different groups.
    - Channel: since only channels 1,6,11 are independent, we must carefully limit interference by evenly distributing groups on different channels.
      Group (1+3i): Groups 1,4,7,10,…=> channel 1
      Group (2+3i): Groups 2,5,8,11,…=> channel 6
      Group (0+3i): Groups 3,6,9,12,…=> channel 11
    - Enable wireless router radio
    - Enable SSID broadcast
    - Save settings
- Using the menu "Wireless security" on the left
    - Disable Security
    - Save settings

3. Configure the WiFi USB adapter

- Insert the USB adapter and check via `ifconfig` the name of the new wireless interface (should be `wlanX`)
- Use the `iwconfig` to assign the wifi network name to join your group wifi wlan
  `iwconfig wlanX essid Group-`**`XX`**
  Assign `wlanX` a proper IP address so that it appears as another host in the **same LAN**, e.g., W1, and W2 (where W1 and W1 are the IP addresses associated to each WiFi card) with the usual `ifconfig` command.
    - Which addresses are you going to use?
    - Can you use addresses in the 192.168.0.0/24 subnet?
    - What if you were using another subnet?

4. Check that the WiFi link and interface are up and running

The configuration of your LAN now sees 4 hosts, some of which connected to the same LAN and subnet using multiple interfaces:

- `H1` has address `E1` on Ethernet interface and address `W1` on the wireless interface.
- `H2` has address `E2` on Ethernet interface and address `W2` on the wireless interface.
- `H3` has address `E3` on Ethernet interface.
- `H4` is the switch/AP is also connected to the same subnet, with address 192.168.0.1

Check the routing tables and ARP tables. How is it possible to reach a host belonging to your subnet now?

- From `H1`, ping `H2` and check that everything works.
  - Which interface is `H1` using to reach `H2`? Which interface is `H2` using to reply to `H1`?
- From `H1`, ping `H2`, by binding ping to the WiFi interface using the `–I interface address` option. From the man page of ping: `-I interface address`: Set source address to specified interface address. Argument may be numeric IP address or name of device. What is the difference among the following commands?
  `H1: ping –I W1 E2` or `ping –I wlan0 E2`
  `H1: ping –I W1 W2` or `ping –I wlan0 W2`
  - Which addresses are contained in the ARP tables?
  - What is the MAC address seen by `H1`? By `H2`?
  - What is the RTT now? Is it stable as before, or does it varies much more? Why?
- Capture with Wireshark packets from the `wlanX` interface of `H1` and `H2` and check the trace.
  - Is there something different than pinging from the Ethernet interface?
  - Which packets are sent/received on this interface?
- Capture now enabling the "**monitor mode**" on the `wlan0` interface.
  - Double click on the `wlan0` interface name to bring the "Edit Interface Setting" window up
  - Enable "Capture packets in monitor mode"
  - Start capturing while not sending any traffic
  - How many IEEE 802.11 different frames do you recognize?
  - Can you see frames from other groups?

NOTE: there is a bug in the hardware or driver which does not allow a card to disable monitor mode and return to "managed" mode. Disconnect and reconnect the USB adapter to force a hardware reset. You need then to reconfigure your WiFi interface from scratch.

5. Performance test over WiFi

Configure the testbed so that H1 and H2 are connected via WiFi to the AP, and disconnect the cables from the Ethernet ports. Leave H3 connected using the wired Ethernet. You have now W1, W2 and E3 active IP addresses.

Consider now the following different scenarios.

A. Single flow – Ethernet to WiFi: E3 sends data to W1 [Eth => WiFi]
B. Single flow – WiFi to Ethernet: W1 sends data to E3 [WiFi => Eth]
C. Single flow – WiFi to WiFi: W1 sends data to W2 [WiFi => WiFi]
D. Bidirectional flow – Ethernet and WiFi - same hosts: E3 sends data to W1, and W1 sends data to E3 [Eth <==> WiFi]
E. Bidirectional flow – Ethernet and WiFi - different hosts: E3 sends data to W1, and W2 sends data to E3 [Eth ==> WiFi (H1), Eth <== WiFi (H2)]
F. Bidirectional flow – WiFi and WiFi: W2 sends data to W1, and W1 sends data to W2 [WiFi <==> WiFi]

For each of them:

- Predict the goodput you expect when TCP is used at the transport layer
- Predict the goodput you expect when UDP is used at the transport layer
- In scenario where TCP and UDP flow coexists, predict the goodput you expect for each flow

After having discussed the previous questions, do the actual test and check your predictions.

WARNING: given the high probability of having interference at the physical layer, **repeat the test several times!**

Do the tests confirm your assumptions?

Why you got something different from what you were expecting? Summarize the results by discussing what you would expect, and what are the differences. Try to create different scenarios, and report different experiments you did. For instance, you can test and report

- Ethernet to WiFi: What changes if H3 sends data to H1, or if H3 sends data to H2?
- WiFi to Ethernet: What changes if H1 sends data to H3, or if H2 sends data to H3?
- …
- Impact of WiFi settings (NOTE: the effectiveness of a parameter choice depends on the support of the driver and hardware WiFi interface):
    - Try forcing a given bitrate on the physical link via the `iwconfig rate` option.
    - Try changing the channel
    - Try enabling WEP encryption [`enc` param]
    - Try enabling 802.11n (if supported) [`modu` param]
    - Try changing the TX power (if supported) [`power` param]
    - Try enabling/disabling the RTS/CTS [`rts` param]
    - Try changing the number of retransmission at layer 2 [`retry` param]
    - …

As previously said, the hardware/driver of the WiFi interface may not allow you to change the parameters. Always double check that results are consistent with your predictions. Describe the experiment design, and results you obtained. If useful, use Wireshark to collect traces and produce graphs.