TEL418: Networks II Lab – Spring 2025
1st Project – Wi-Fi Doctor

Team 11
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1 Introduction

In this report we aim to present to you our designed system that simulates the functionality of a Wi-Fi doctor. While a Wi-Fi doctor should theoretically perform both diagnosis of the network and provide "treatment"(solutions) based on that diagnosis, the scope of our project stops at the diagnostic stage. Our system receives a Pcap file that has been created using a packet sniffer (Wireshark) and parses the file using our own reader library. After getting the information for each packet read we calculate the network density using a weighted average of the unique devices on each channel and their corresponding signal strengths, calculate the network throughput (*Monitor*) and determine why the network throughput is good or bad (*Analyzer*). Finally, our system provides visual representation of how the metrics checked change as we read each packet and provides a final summary of the final values at the end of the diagnosis process.

2 Design

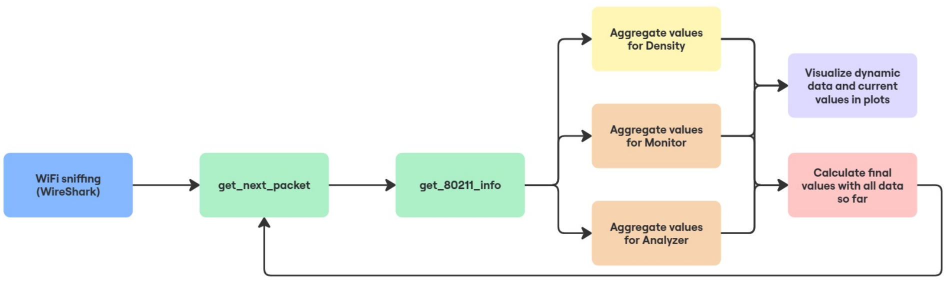


Figure 1: WiFi doctor process flowchart

2.1 Wi-Fi Sniffer

Wireshark was used to capture all pcap files and then each pcap file was parsed with our offline network monitor/analyzer (doctor.py).

2.2 Pcap Parser

Our pcap parser library is contained in the PcapReader.py file. Our main app (doctor.py) calls the PcapReader class *read_next_packet()* function to get the next packet and then use a custom function *(get_80211_info())* to retrieve all related info from the packet.

2.3 Performance Monitor

Density

For the calculation of the channel density we receive from the structure containing the packet information the BSSID, the channel, the channel frequency, the signal strength and the channel bandwidth. We group the

BSSIDs based on channel as we read the packets and keep only unique BSSIDs for each channel. We get the sum of the absolute values of the maximum signal strength detected for each unique BSSID in the channel and average the value based on the channel bandwidth. In mathematical terms the density calculation is as follows for each channel:

$$\sum_{\#unique\ \ BSSIDs} \frac{|Signal\_strength|}{Channel\_bandwidth} \tag{1}$$

Throughput

In this step the monitor uses info from packets between the 2 devices specified on program execution with options s and d. More specifically we only keep data in packets with mcs index present, as these are the only packets relevant for data rate and throughput. With each packet passed through the doctor keeps track of the aggregate sum of data rates (data_rate field in wlan radio layer), the total packets and the packets with the retry flag active(fc_retry field in wlan layer). The final calculation is made as follows:

$$Throughput = \frac{data\_rate_{sum}}{total\_packets} * (1 - loss\_rate), \qquad loss\_rate = \frac{retry\_packets}{total\_packets} \tag{2}$$

2.4 Performance Analyzer

For the performance analyzer the program has various counters ('phy', 'bandwidth', 'sgi', 'mcs', 'ssi', 'phy_gap') for each metric we are interested in. For each packet if the current packets value of a metric exceeds a threshold we increment it. For the overall performance we consider 3 categories:

- **Network configuration** *(phy, bandwidth, short GI).*
- **Channel configuration** *(mcs, signal strength).*
- **Interference** *(phy gap)*[1].

With each one taking the average value of each subsequent metrics included in it.

2.5 Visualizer

With each iteration (each packet) our WiFi doctor calculates each metric/value tracked and prints its current value in a list (right side of figure). Then for Network Performance (Question 1.2) all relevant packet fields are plotted along side the average data rate between the specified devices. Average data rate is calculated by the mean of the last 30 entries we recorded. If source and destination mac addresses are not both defined with the appropriate command line interface options when executing the program the plot shown will include only PHY and signal strength.

3 Evaluation

After successfully processing the packets from the pcap file we evaluate them based on the following scales:

3.1 Density Evaluation

Based on observation of the maximum and minimum values the performance monitor yields for channel density we define following density evaluation scale:

- If density value < 8 then we define the channel as **"Not Dense"**.
- If density value < 16 then we define the channel as **"Moderately Dense"**.
- If density value < 24 then we define the channel as **"Dense"**.
- If density value $>= 24$ then we define the channel as **"Very Dense"**.

Using the above scale we find that :

- Channel 2 (2417 MHz) for network with SSID "TUC" is classified as **"Very Dense"**.
- Channel 36 (5180 MHz) for network with SSID "TUC" is classified as **"Dense"**.
- Channel 4 (2427 MHz) for home network is classified as **"Moderately Dense"**.

- Channel 44 (5220 MHz) for home network is classified as **"Not Dense"**.

These results are to be expected as the university network has a very large amount of devices connected to its channels and as such bigger interference and a bigger network load compared to the home network.As far as the home network results go most devices seem to be connected to the 2.4 GHz band while practically none (other than our test device) are connected in the 5 GHz band.
Below are the graphs we received from the visualizer for the 4 cases we took for density metrics (university network 2.4GHz,university network 5GHz, home network 2.4GHz,home network 5GHz):

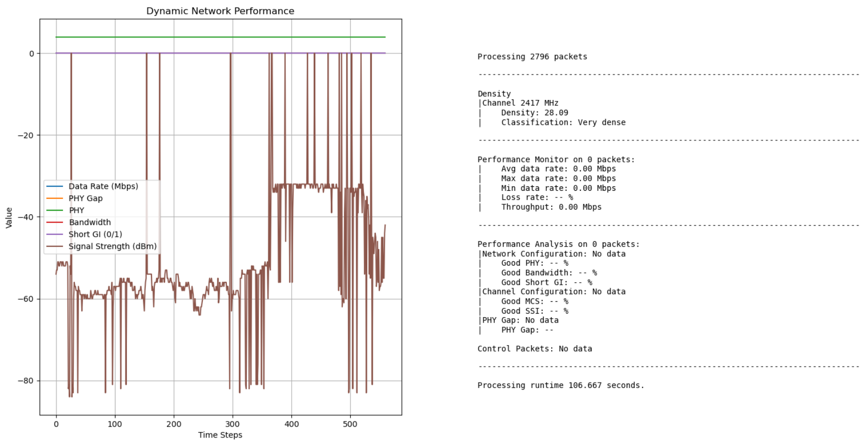


Figure 2: Channel 2 (2417 MHz) of "TUC" network

In the above graph our WiFi doctor recorded the highest signal strength of most of the examples, to add to that we checked the state of the Network with a third party app [2] and observed the most devices in this channel. Logically the metric that was recorded is **"Very dense"**.

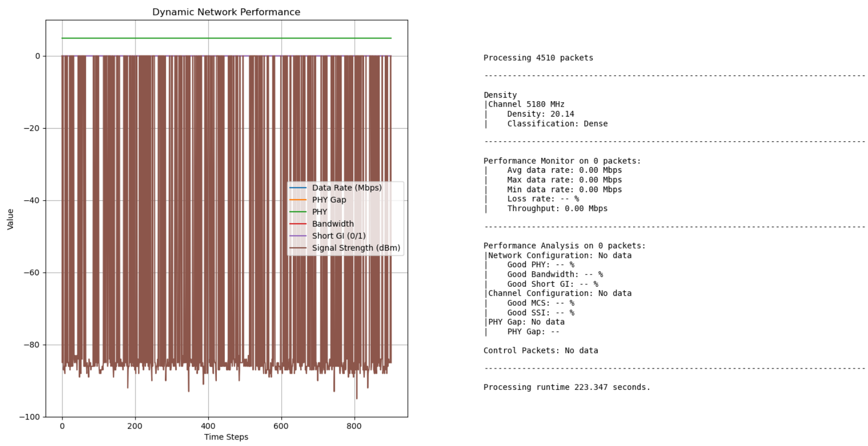
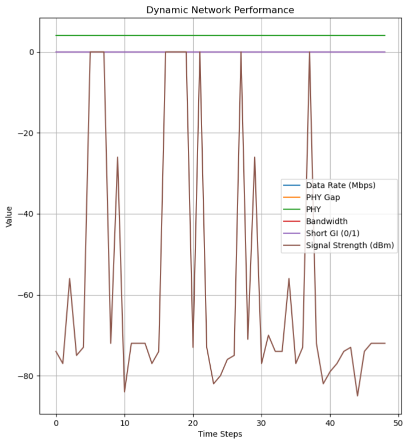


Figure 3: Channel 36 (5180 MHz) of "TUC" network

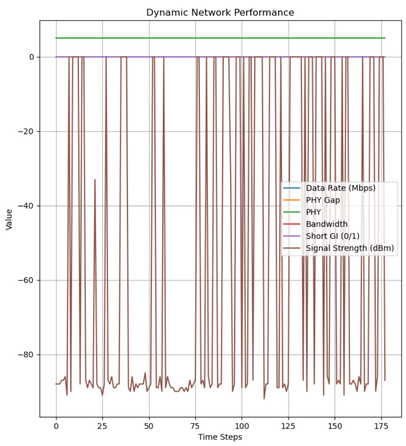
With the third party tool [2] we observe few devices on channel 36 as the 5GHz band is not as widely used as the 2.4GHz band. However, we observe great variations in the signal strengths recorded.As such, since our density metric is a weighted average of the signal strengths present, and higher signal strengths can create bigger interferences among the devices, the "Dense" classification for the channel is reasonable.




```
Processing 245 packets

------------------------------------------------------------------------------

Density
|Channel 2427 MHz
|    Density: 9.59
|    Classification: Moderately dense

------------------------------------------------------------------------------

Performance Monitor on 0 packets:
|    Avg data rate: 0.00 Mbps
|    Max data rate: 0.00 Mbps
|    Min data rate: 0.00 Mbps
|    Loss rate: -- %
|    Throughput: 0.00 Mbps

------------------------------------------------------------------------------

Performance Analysis on 0 packets:
|Network Configuration: No data
|    Good PHY: -- %
|    Good Bandwidth: -- %
|    Good Short GI: -- %
|Channel Configuration: No data
|    Good MCS: -- %
|    Good SSI: -- %
|PHY Gap: No data
|    PHY Gap: --

Control Packets: No data

------------------------------------------------------------------------------

Processing runtime 10.921 seconds.
```

Figure 4: Channel 4 (2427 MHz) of home network

In this graph we observe signal strengths between -60 and -80 dBm, with the external app [2] showing two device were present at the time of the data collection. Consequently the network was classified as Moderately Dense.




```
Processing 890 packets

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Density
|Channel 5220 MHz
|    Density: 5.73
|    Classification: Not dense channel

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Performance Monitor on 0 packets:
|    Avg data rate: 0.00 Mbps
|    Max data rate: 0.00 Mbps
|    Min data rate: 0.00 Mbps
|    Loss rate: -- %
|    Throughput: 0.00 Mbps

------------------------------------------------------------------------------

Performance Analysis on 0 packets:
|Network Configuration: No data
|    Good PHY: -- %
|    Good Bandwidth: -- %
|    Good Short GI: -- %
|Channel Configuration: No data
|    Good MCS: -- %
|    Good SSI: -- %
|PHY Gap: No data
|    PHY Gap: --

Control Packets: No data

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Processing runtime 42.716 seconds.
```

Figure 5: Channel 44 (5220 MHz) of home network

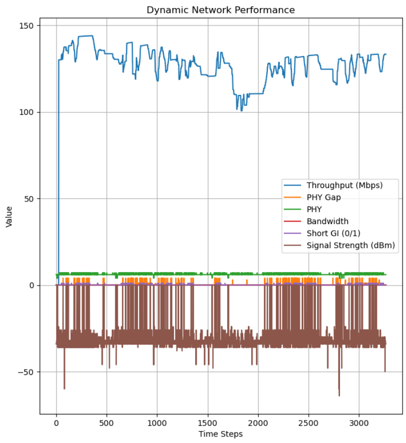
In this graph we again observe most of the signal strengths recorded to be below -80 dBm. Furthermore the external app [2] showed that only one device was present at the time. Consequently the network was classified as Not dense.

3.2 Performance Analyzer Evaluation

In order to evaluate each metric calculated by the Performance Analyzer we define a scale based on the percentage of good packets recorded in each metric:

- If value > 0.9 we classify the metric as **"Pristine"**.
- If value > 0.6 we classify the metric as **"Good"**.
- If value > 0.3 we classify the metric as **"Fair"**.
- If value <= 0.3 we classify the metric as **"Bad"**.

Below we can see the results of the Performance Analyzer for the network analysis between 2 devices:




```
Processing 16326 packets

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Density
|Channel 2412 MHz
|    Density: 3.45
|    Classification: Not dense channel

--------------------------------------------------------------------------------

Performance Monitor on 2426 packets:
|    Avg data rate: 137.89 Mbps
|    Max data rate: 144.44 Mbps
|    Min data rate: 39.00 Mbps
|    Loss rate: 7.75 %
|    Throughput: 127.20 Mbps

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Performance Analysis on 2426 packets:
|Network Configuration: Fair
|    Good PHY: 100.00 %
|    Good Bandwidth: 0.00 %
|    Good Short GI: 67.07 %
|Channel Configuration: Good
|    Good MCS: 100.00 %
|    Good SSI: 61.09 %
|PHY Gap: Good
|    PHY Gap: 1.63

3293 control packets minimally impact performance

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Processing runtime 625.204 seconds.
```

Figure 6: Pcap for Performance Monitor and Analyzer

We notice that the throughput drops when PHY drops and Short GI is 0, as can be observed around time step 1700. PHY gap doesnt't seem to affect throughput much as is is very low. Lastly we see when signal strength approaches -25 the data rate increases while when it drops closer to -50 throughput drops.

4 Related Work

The system was developed based on the knowledge acquired from the course and no papers where used. As such no related work can be mentioned.

5 References

[1] Table for MCS,SNR and RSSI https://www.watchguard.com/help/docs/help-center/en-US/Content/en-US/WG-Cloud/Devices/access_point/deployment_guide/Checklist_Charts/mcs_80211n_ac.pdf

[2] Network Analyzer https://play.google.com/store/apps/details?id=net.techet.netanalyzerlite.an