Exercise 3

Simple Measurements

• Watch the values on the main Tester screen as the Raspberry Pi boots. Describe the behavior of the Watts used.

The power slowly climbs to about 5W while booting then dipping to around 4.7W while nothing is running

• Does the Raspberry Pi power consumption reach a steady state? If not, explain why not

The Raspberry Pi reaches 4.74W spiking by + 0.3W at some points likely due to checks and different processes starting and stopping.

1.Using tcpdump, approximate the frequency of messaging on the network interface (in events/min and or events/sec, where an event is either a packet received or transmitted). Describe the technique you used to derive that value.

Using tcpdump for approximately 3 seconds gave:
484 packets captured
848 packets received by filter
273 packets dropped by kernel

this gives approximately per second:
161 packets captured
283 packets received by filter
91 packets dropped by kernel

By using tcpdump for a few seconds and excluding packets outside the time range to get an approximate value of the event/sec

2.Does the creation of user-generated network traffic impact the energy consumption of the Raspberry Pi? Observe and report the power consumption of the Raspberry Pi for each of the following scenarios:

- Ping from the Raspberry Pi to the lab machine using flooding and a large number of measurements, so that the measured power can be observed for a sufficiently long time, for example: sudo ping 192.168.10.1 -f -c 100000

  The power reached a maximum of 5.7W but on average stayed around 5.1W this is a large increase on the idle 4.7W suggesting that traffic does impact the energy consumption of the Pi

- Run the same experiments from the lab machine to the Raspberry Pi.

  The power reached a maximum of 5.3W but averaged around 5.1W similar to before. It is likely a bit less as it doesn’t have to generate the pings or check if they’re received.

- Report the results. Is it more expensive from an energy standpoint for the Raspberry Pi to send than to receive? In either case, why might that be?

  It is more energy intensive to send from the Raspberry Pi due to having to generate the signal and then send it then receive a response and measure the time. When receiving it only has to respond to the ping it has received and not do any measurements.

3. What is the maximum impact the network might have on the energy consumption of the Raspberry Pi? Observe and report the power consumption of the Raspberry Pi for each of the following scenarios:

- Use iperf in UDP mode (on both the server and the client) to measure the impact on the Raspberry Pi energy usage.
  On the server:
  iperf -s -B <server address> -u
  while on the client:
  iperf -c <server address> -i 5 -t 20 -b 1G -u
- Report the results.

  With the Raspberry Pi as the server the power averaged at 5.7W but spiked to 6.4W
  Similarly with the Raspberry Pi as the client the power stayed around 5.7W but occasionally spiked to 5.9W.

- Change that value rx-usecs to 0:
  sudo ethtool -C eth0 rx-usecs 0
- Run the iperf experiment again and report the results. Note what you expected to observe and why (and if there is any difference with what you actually observed).

  With the Raspberry Pi as the client there was it had a slightly higher average power 5.8W but there was no packets lost and the bandwidth dropped to 750 for some of the time periods.
  By reducing the value of rx-usecs to 0 it will use rx-max-frames to determine how many packets to delay before an interrupt. I expected that less of the packets would be dropped but it would be slightly slower and use more of the CPU as it would be sending more frequently.

- Return rx-usecs to its original value.
  sudo ethtool -C eth0 rx-usecs 57

CPU Activity:
A final test will stress the Raspberry Pi’s CPU. To this end, we will use the stress-ng utility.

Results:
The power consumption ranged between 6.1-6.6W. This was much higher than previous tests due likely due to the CPU being completely used and dedicated to the stress test.

Theoretical Experiments

1. As a thought experiment, select a country you would like to visit. Find its carbon intensity at electricity maps and calculate the carbon footprint of having run the Raspberry Pi throughout this exercise: CF = CI x EC where carbon footprint (CF) is in kilograms of CO_2, carbon intensity (CI) is in $kgCO_2/kWh$ (an indication how "green" is the power source), and energy consumption (EC) is in kWh.

To visit Iceland CI = 0.028$kgCO_2/kWh$ due to high geothermal use.
Total EC throughout this session = 10.70Wh = 0.0107kWh
So the CF = 0.2996g

2. What if all Things connected to the Internet were Raspberry Pi's? Estimates are that over 30B Things are connected at present, and that number will double by 2030.

a. What would be their collective carbon footprint?

   30B*0.2996g = 8.988 x 10^6 kg of CO_2

b. Is that a significant number?

   Assuming there is ~ 2 x 10^18 kg of CO_2 this is not a huge amount of carbon for the globe.

c. Is it a fair estimate of the Internet's carbon footprint? Why or why not?

   No this is not a fair estimate as Iceland has a very low carbon intensity so is not representative of the global emissions. A Raspberry Pi is a small device so to assume all devices connected to the internet are similarly small would make it an underestimate.