## LABORATORY 3: RASPBERRY PI AND 5G HAT APPLICATIONS

**Learning Outcomes**

By the end of this laboratory, student should be able to

* Dial up 5G cellular network for Raspberry Pi
* Conduct a speed test for Raspberry Pi

**Activities**

* Use Minicom in Raspberry Pi to send AT commands to RM502Q-AE module
* Conduct a speed test

# Equipment

* Window OS laptop
* Raspberry Pi 4 Model B
* Quectel RM502Q-AE 5G module
* Waveshare RM502Q-AE 5G Hat
* Ethernet cable
* SD Card containing the Raspberry Pi OS
* USB 3.0 male to male connector
* USB-C 5V Power Adapter
* Sim card

# 1. Setting up RM502Q-AE 5G Hat using Raspbian OS

**Type in the following commands in a pi terminal from a to l:**

1. Insert the SD card into the Raspberry Pi, connect monitor, keyboard and mouse to pi. Power on both monitor and pi.
2. Connect the Raspberry Pi and 5G Hat with the USB connector, attach the antennas.
3. Open a terminal and uninstall modem manager and network manager.

#### sudo apt purge modemmanager -y

#### sudo apt purge network-manager -y

1. To download Minicom, you will need to connect your Raspberry Pi to a Wi-Fi network. We are going to use “SPStudent” Wi-Fi network using your username and password. Open wpa\_supplicant file to edit Wifi configurations.

#### sudo nano /etc/wpa\_supplicant/wpa\_supplicant.conf

A screenshot of a computer

Description automatically generated

1. Open the Wificonfig text file and copy the following into the wpa\_supplicant.conf file. Replace identity with your student admission number “PXXXXXX” and password with your own. Ctrl+S to save and Ctrl+X to exit.

A computer screen shot of a black screen

Description automatically generated

1. Restart Raspberry Pi networking service and reboot the Raspberry Pi. You should be connected to the “SPStudent” Wifi already.

#### sudo systemctl restart wpa\_supplicant

#### sudo reboot

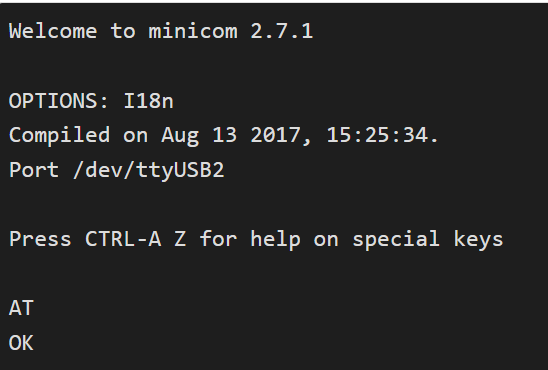
Minicom is a tool for serial debugging over Linux environment.

1. Minicom installation.

#### sudo apt-get install minicom

Activate Minicom:

#### sudo minicom -D /dev/ttyUSB2



1. After installing minicom, turn off Wifi.

**Modem Protocols for RM502Q-AE**

The RM502Q-AE 5G Hat supports three communication protocols which are MBIM, QMI and ECM. They are communication protocols used for interacting with cellular modems or mobile broadband devices. Each protocol serves a specific purpose and has its own advantages and use cases.

**MBIM (Mobile Broadband Interface Model):**

 MBIM is a modern communication protocol that provides advanced features and better performance compared to older protocols like ECM. It is widely supported in modern Windows versions and has good compatibility with Linux-based systems like OpenWRT. MBIM supports various functionalities, including data connections, network settings, signal monitoring, SMS messaging, and more. It allows for better power management and improved data throughput.

**QMI (Qualcomm MSM Interface):**

QMI is a protocol developed by Qualcomm primarily for their cellular chipsets. It is often used in devices that have Qualcomm-based modems, such as certain smartphones, routers, and embedded systems. QMI offers a comprehensive set of standardised messages for controlling and configuring the modem, including data, voice, and GPS services. It provides more advanced features and better performance compared to ECM, especially on Qualcomm-based devices.

**ECM (Ethernet Control Model):**

 ECM is an older and simpler protocol used primarily in older 3G modems. It emulates an Ethernet connection over a USB connection, making the modem appear as a network interface to the OpenWRT device. ECM is limited in functionality compared to MBIM and QMI and typically only provides basic internet connectivity without additional features like SMS or signal monitoring. While ECM may work with a wider range of modems due to its simplicity, it lacks the advanced capabilities of MBIM and QMI.

MBIM and QMI are more modern and feature-rich protocols with better performance, while ECM is a simpler protocol that may work with a broader range of modems but offers limited functionality. OpenWRT provides support for various communication modes, allowing users to select the appropriate one based on their specific modem and requirements.

1. Try to send the following AT commands commands using Minicom. We are using the ECM (Ethernet Control Model) modem protocol to dial up the 5G internet access to the Raspberry Pi.

#### AT+QNWPREFCFG= "mode\_pref", NR5G

#### AT+QENG=”servingcell”

#### AT+QCFG=”usbnet”,1 (switch to ECM mode)

#### AT+CFUN=1,1 (save and reboot)

A computer screen shot of a black screen

Description automatically generated

1. Once you got the message “Cannot open /dev/ttyUSB2”, reboot the Raspberry Pi

#### sudo reboot

1. After resetting the module, open another terminal and try with following commands.

#### ifconfig usb0

#### ping -c 10 google.com -I usb0

A screen shot of a computer

Description automatically generated

Figure 2: 10 pings

1. If you can’t ping google.com, it means the 5G hat needs more power or you can shift your 5G RPI CPE nearer to the window, switch the 5G Hat from USB to EXT PWR.
2. Connect a **second** power supply to the 5G Hat. (DO NOT UNPLUG THE POWER SUPPLY FOR RASPBERRY PI)

A close up of a circuit board

Description automatically generated

1. Ping google.com again.
2. In the Raspberry Pi desktop, hover around the up and down arrows at the top right corner. You can now see three interfaces eth0, wlan0 and usb0.

A screenshot of a computer

Description automatically generated

Figure 3: usb interface configured public IP address

Write down the IP address shown in the usb0 interface:

**Activity 1)** Dial up 5G internet access to Raspberry Pi via MBIM protocol using Minicom and answer these following questions:

* 1. Is there ausb0 interface? No. If not, what is the interface that appears once you dial up to 5G via MBIM? wwan0.
  2. Can you ping google.com or any other websites? No.
  3. Connect to “SPStudent” Wi-Fi Network and execute the following 3 commands in a pi terminal:

**sudo apt update && sudo apt upgrade**

**sudo apt install libglib2.0-dev libmbim-utils libmbim-glib-dev**

**sudo reboot**

Linux command to start MBIM network.

**sudo mbim-network /dev/cdc-wdm0 start**

* 1. Can you ping any websites now? Yes.
  2. Ping google.com with the interface wwan0.

**ping google.com -I wwan0**

A computer screen with a red and orange image

Description automatically generated

# 2. Conduct a SPEEDTEST (Optional)

\*\*DO NOT DO SPEEDTEST IF YOU DO NOT HAVE PERMISSION FROM LECTURER BECAUSE IT WILL CONSUME A LOT OF DATA

Now, if you have gotten permission to conduct speed test, do the same thing as you did in lab 1 to test the download and upload speed.

This figure below shows the 5G and 4G download speed of 5G RPI4 CPE with Cellular, LAN, WiFi connections and different modem protocols. While the 5G RPI4 CPE is using 5G Cellular network connection, QMI protocol seems to give the highest download speed, almost close to 1 Gbps. However, MBIM protocol seems to give lower network latency (11ms) as compared to QMI (15ms) which is why the MBIM protocol gives better user experience.

A table of data with text

Description automatically generated with medium confidence

Figure 4: Speedtest conducted by Qinfan (5G & AIoT intern)