Mobile APRS Station using TNC-PI and Baofeng Wide Band Transceiver

Robert Irwin KC3GIG, *robert.irwin@temple.edu*

1 Introduction

The work done in this report outlines the setup and configuration required to create a mobile Automatic Packet Reporting System (APRS) station using a Raspberry Pi, a Terminal Node Controller (TNC) and a handheld transceiver. The different paths requested by a transmitted station are examined in an effort to show how bad path choices can provide unnecessary congestion in the network.

1.1 Background

APRS is digital communications protocol used for amateur radio purposes. (Baofeng) APRS operates by receiving information on a single frequency and forwarding the data until it gets to its destination. There is information in the packet header that limits the number of times a packet can be repeated in order to limit congestion on the network caused by repeated packets. This is typically done with the WIDEn-N protocol. The WIDEn-N tells stations how many total hops, n, and how many hops remaining, N. It is very important to make informed decisions when selecting n, and N, as inappropriate choices can cause unnecessary congestion on the network.

APRS may also function as a pathway to the internet. Stations that serve this purpose are known as IGates. The station used in this report is not configured as an IGate, so all APRS functions regarding IGate traffic are ignored.

In addition to Automatic Packet Reporting System, APRS can also be known as Automatic Position Reporting System. This is because position information about each station is shared throughout the network, allowing the stations to appear on maps. The position of the station in this report is the same as K3TU, but slightly north so that the two stations would not overlap each other on the map. The station in this report, KC3GIF is a mobile station, but the GPS coordinates are hardcoded due to the lack of a GPS module for the Raspberry Pi.

1.2 Hardware

The specific hardware used in this report is a Raspberry Pi 2, a TNC-X for Raspberry Pi Rev 1.1 2/2013, a Baofeng UV-5RE transceiver, and a Raspberry Pi 7" touchscreen display. It is important to understand how the general purpose input/output (GPIO) pins on the Raspberry Pi work, and the purpose of the pins. The GPIO layout of the Raspberry Pi 2 is shown in Figure 1.1.

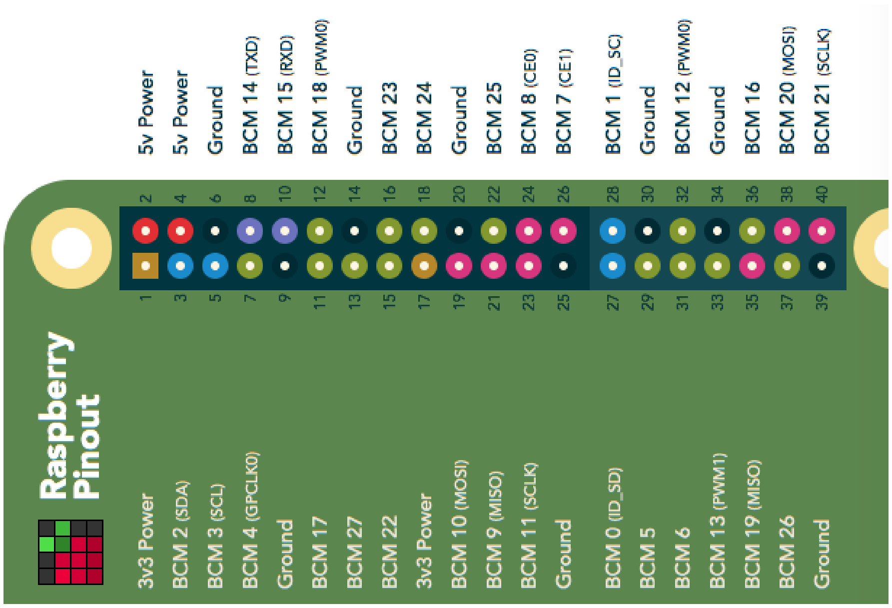

Figure 1.1: Raspberry Pi 2 Pinout[1]

The pins used in this project are 2, 6, 8, 10 which are 5V power, ground, Tx_UART, and Rx_UART. The specific use of these pins will be discussed after the rest of the hardware is presented.

The TNC-Pi is shown in Figure 1.2, followed by an actual schematic in Figure 1.3

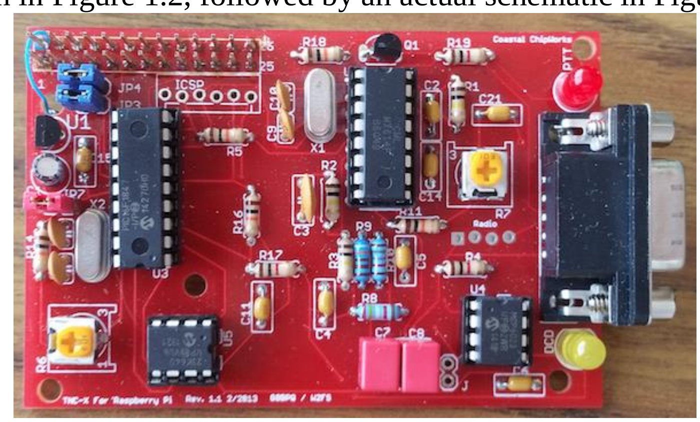
Figure 1.2: TNC-Pi

1 @Gadgetoid, @RogueHAL13, *Raspberry Pinout*

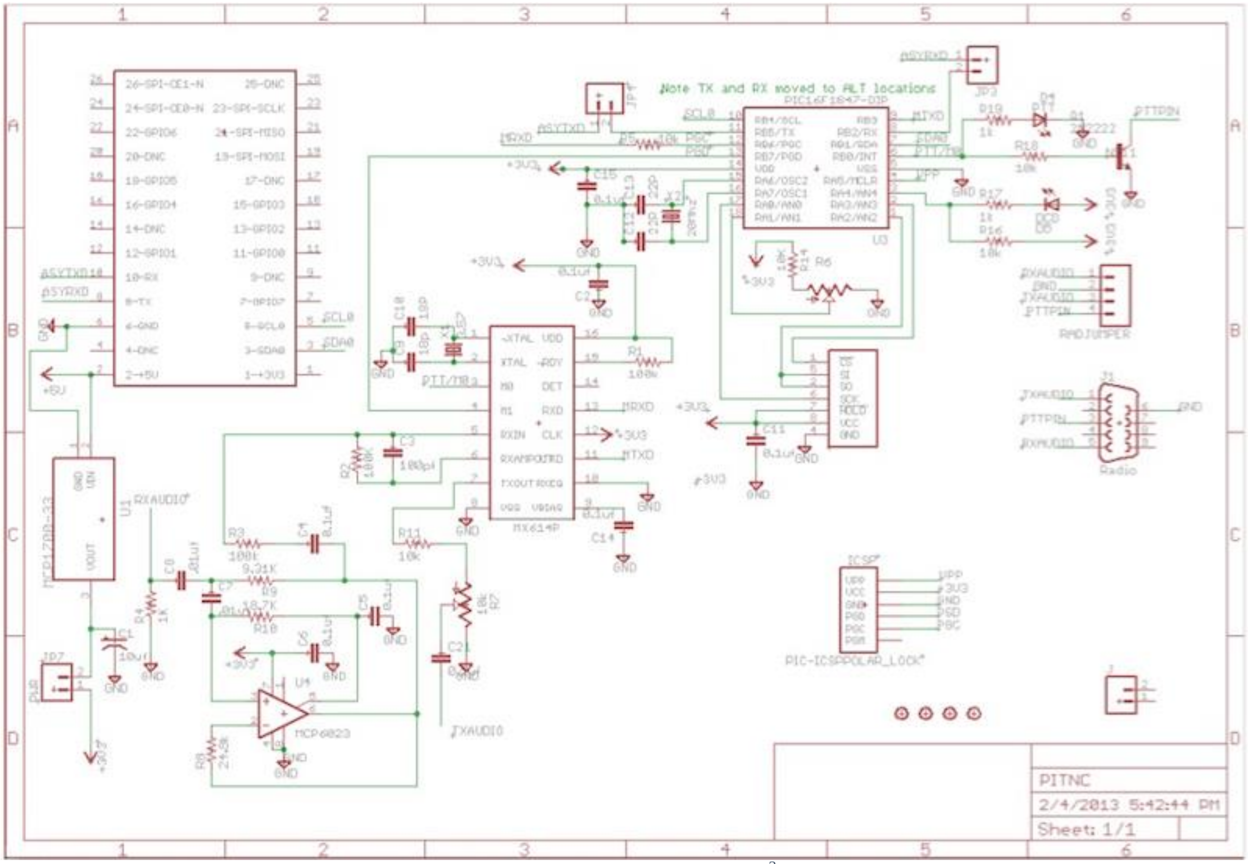

Figure 1.3: TNC-Pi Schematic[2]

The board comes unsoldered, but a helpful tutorial on the construction of the TNC-Pi can be found by following the reference in Figure 1.3.

The Raspberry Pi 2 connects to the Raspberry Pi 7" touch screen display through the Display Serial Interface (DSI) as seen in Figure 1.4

[2] John Hansen, *TNC-Pi Assembly Instructions and Operating Tips*

Figure 1.4: DSI Connection

Finally, Figure 1.5 shows how the TNC-Pi connects to the Raspberry Pi 2. Both the TNC and Raspberry Pi are powered by connected the 5V output and ground from the 7” touch screen display to pins 2 and 6 on the TNC, which is in turn connected to the Raspberry Pi. It is important to note that the TNC communicates the the Raspberry Pi through the UART (Universal Asynchronous Receiver/Transmitter on pins 8 and 10, respectively), so the Raspberry Pi operating system must be prohibited from using this peripheral. Details on the disabling of the UART will be shown in the next section.

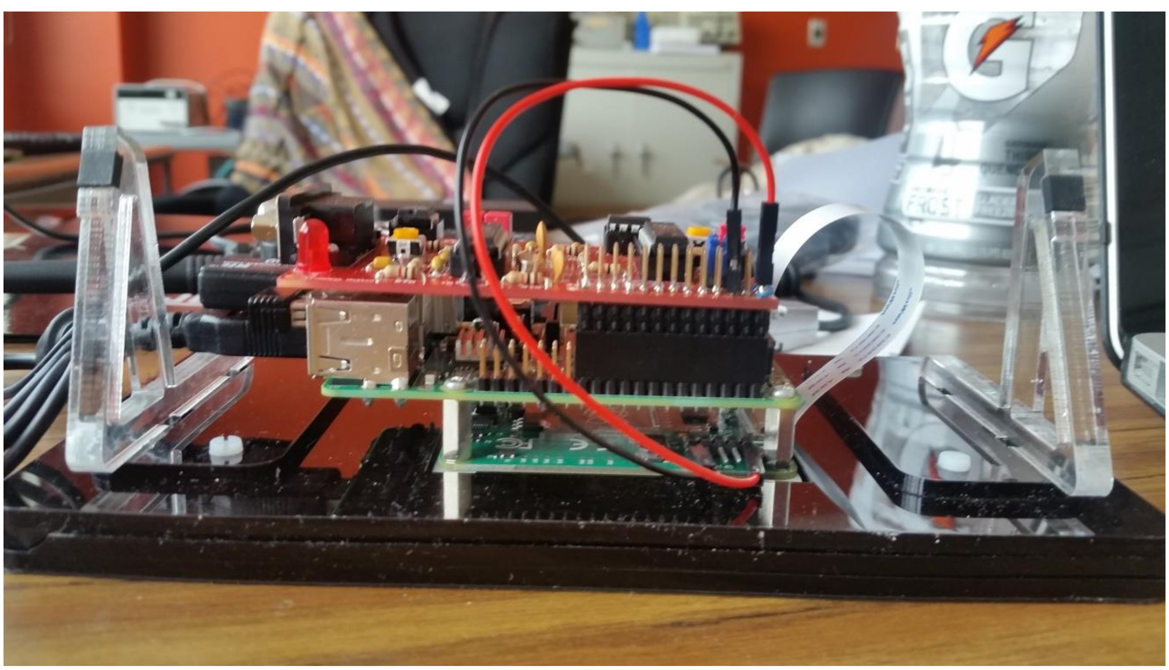

Figure 1.5: TNC-Pi Connection to Raspberry Pi

The Baofeng Wide Band Transceiver's connector is shown in Figure 1.6.

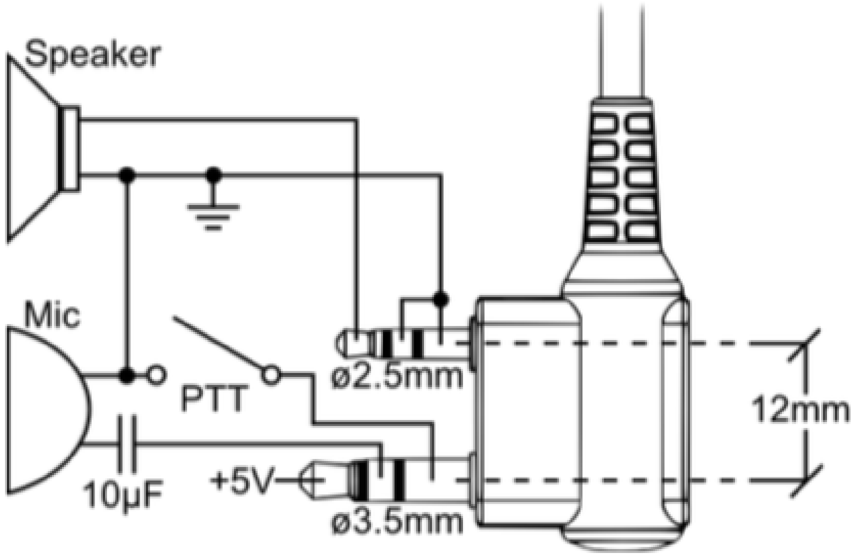

Figure 1.6: Baofeng Connector

There are two places the connector can be connected to the TNC-Pi. In this report, the transceiver is wired to the 9 pin radio connector. (See Figure 1.3) For the 9 pin radio connection, the transmit audio (3.5mm jack, middle) goes to pin 1, the push to talk (innermost on 3.5mm jack) goes to pin 3, received audio (end of 2.5mm jack) goes to pin 5, and ground goes to pin 6. For the particular headset used in this project, the white wire from the headset was received audio, the black wire was ground, the red wire was audio in, and the green wire was the push to talk signal. It is important to note that all connectors are different, and the specific pin out of the connector as well as the wiring scheme may vary. One who wishes to make their own connector should consult their specific headset, and perform continuity tests to confirm which wire carries the appropriate signals.

The connector is shown in Figure 1.7

Figure 1.7: Baofeng Transceiver and 9 Pin Connector

2 Configuration

2.1 Configuring the Raspberry Pi 2

As mentioned previously, the Raspberry Pi kernel needs to be prohibited from using the UART because the TNC-Pi will be using the UART for data transfer to and from the Raspberry Pi. This is accomplished with two steps. Before proceeding it is recommended that a backup is made containing the original contents of the file that is about to be edited. This can be done with the following command.

```
sudo cp /boot/cmdline.txt /boot/cmdline_backup.txt
```

After the file is backed up, the file is edited to remove any parameter containing ttyAMA0, which is the serial port that the TNC-Pi uses to communicate with the Raspberry Pi.

The other file that is altered is /etc/inittab. Comment out the line that contains a reference to ttyAMA0. It is important to not leave any blank lines in this file.

2.2 Installing the APRS Software

The steps done in this section require an Internet connection for the Raspberry Pi. The software used in this report is Xastir. To install the software, simply run the following command in the Linux terminal.

```
sudo apt-get install xastir
```

Once the installation is completed, the command can be run by typing "`xastir &`" without quotes into the terminal window. The ampersand makes the program run in the background so the terminal is free to do other things.

Once the program is running, click the Interface menu, and then Interface Control. Click add and then select "Serial KISS TNC" option. Ensure the TNC Port has "/dev/ttyAMA0" and the baud rate is 19200 bps. For ease of use, also click the "Activate on Startup?" box so the interface is up as soon as the program begins. The interface options are shown in Figure 2.1

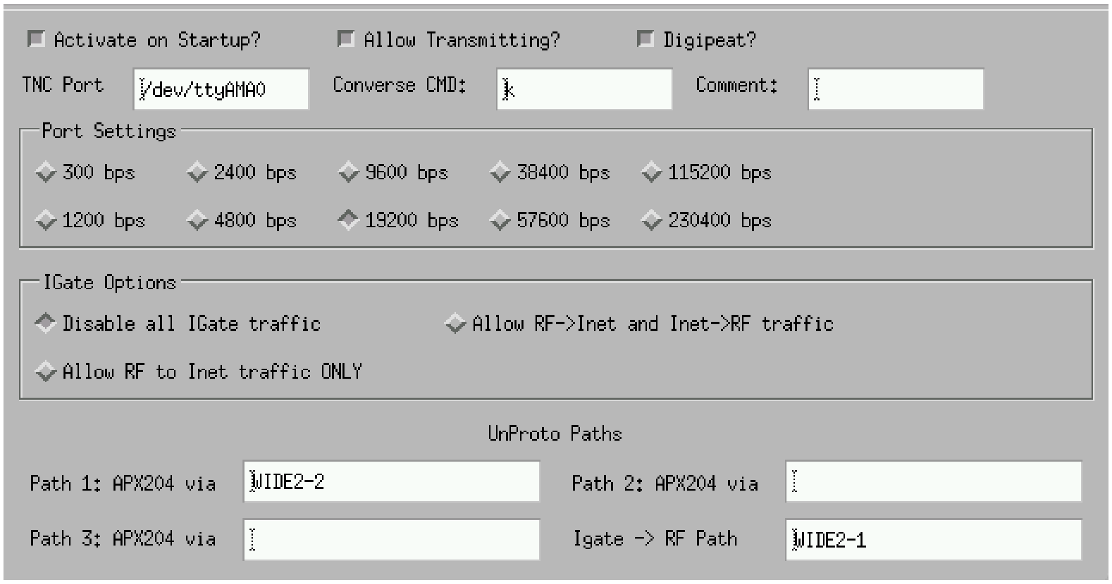

Figure 2.1: Interface Parameters

The next step is to input the station parameters. This can be done by navigating to File > Configure > Station. It is at this menu where the Callsign and GPS coordinates are entered. The station configuration parameters used in this report are shown in Figure 2.2.

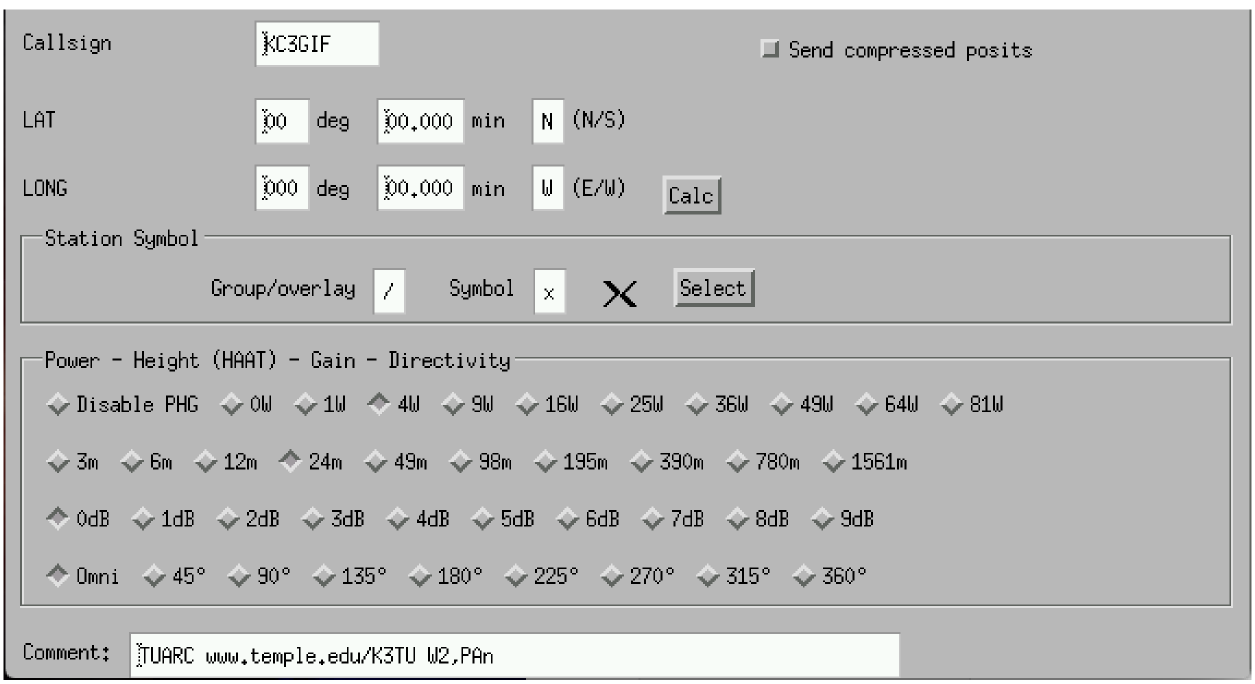

Figure 2.2: Station Configuration Parameters

2.3 Configuring the Baofeng Dual-Band Transceiver

The Baofeng transceiver can be programmed to quickly tune-in to the desired frequency, which in the case of APRS in North America is 144.39MHz. In order to program the transceiver, it must be in VFO mode. Type in the desired frequency. Then, press the MENU button. The configuration of the transceiver used in this report is shown in

TABLE 2.1: BAOFENG TRANSCEIVER CONFIGURATION

Parameter	**Value**
SQL	2
STEP	5.0k
TXP	HIGH
SAVE	OFF
VOX	OFF
WN	NARR
ABR	2
TDR	OFF
BEEP	ON
TOT	60
R-DCS	OFF
R-CTCS	OFF
T-DCS	OFF
T-CTCS	OFF
VOICE	OFF
ANI-ID	80808
DTMFST	OFF
S-CODE	1
SC-REV	TO
PTT-ID	OFF
PTT-LT	5
MDF-A	FREQ
MDF-B	FREQ
BCL	OFF
AUTOLK	OFF
SFT-D	OFF
OFFSET	00.000
WT-LED	BLUE
RX-LED	ORANGE
TX-LED	PURPLE
AL-MOD	TONE
BAND	VHF
TDR-AB	OFF
STE	ON
RP-STE	5
RPT-RL	OFF
PONMSG	FULL
ROGER	ON

A few of these parameters need further explaining, for all other parameters, please see the documentation for the Baofeng UV-5RE which can be found in the references of this report.

The SQL parameter can be set from 0-9 and is the squelch of the transceiver. This parameter determines the minimum signal power that the transceiver will pass through to the speaker, or in the case of this report, the TNC-Pi. If this parameter is set too high, it will be difficult to hear other operators' signals.

The R-DCS and T-DCS stand for reception and transmission digital coded squelch, respectively. Digital coded squelch is a system of digital code words that go along with data. The code words are sub-audible but have a wide bandwidth of about 2-300Hz. If the R-DCS is turned on to a certain system, the transceiver will only be able to decipher messages that are using the same system. In the same respect, if the T-DCS is turned on to a particular system, only people operating on the same DCS system will be able to decode the transmission.

The R-CTCS and T-CTCS (reception or transmission continuous tone coded squelch) work similarly to the R-DCS and T-DCS except continuous tones are used. The CTCS tones occupy a narrower bandwidth.

The OFFSET parameter indicates the frequency difference between received signals and transmitted signals. The SFT-D parameter indicates the direction of the frequency shift. The shift occurs for transmitted signals.

3 Results

3.1 Stations on the Map

Once all of the configuration is completed, the radio is connected to the 9 pin connector on the TNC-Pi, and the xastir software is running, stations within operational distance become visible on the map. An example of this is depicted in Figure 3.1.

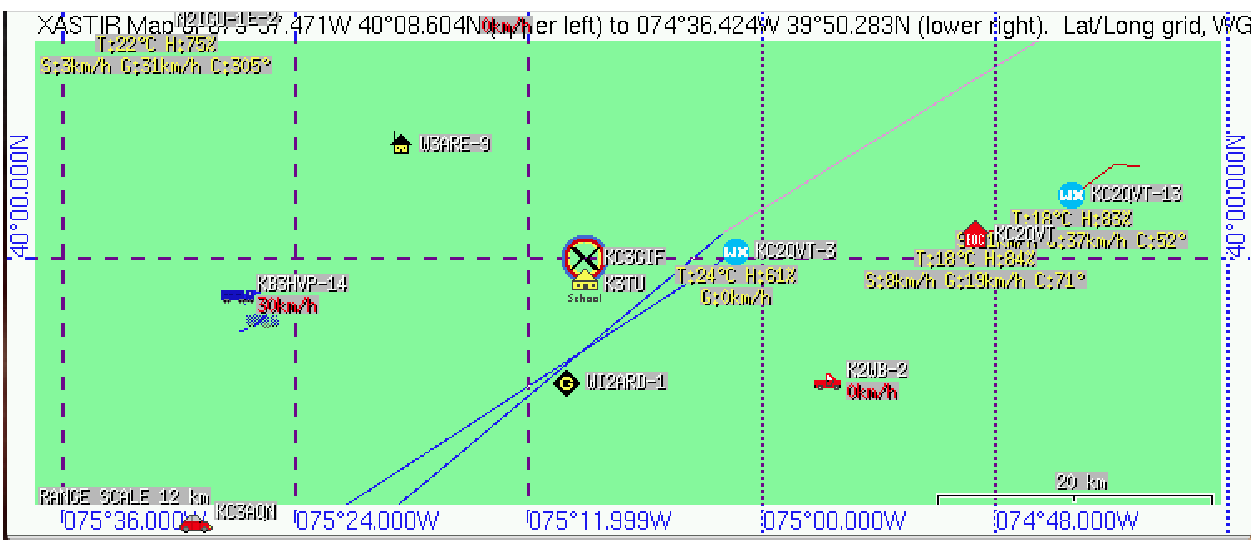

Figure 3.1: Xastir Program with Stations on Map

To begin communicating with another station right click on the station within the xastir software and click "send message to". For demonstrative purposes, a message will be sent from KC3GIF to K3TU. The message and acknowledgement, as well as other traffic picked up by the Baofeng transceiver, is shown in Figure 3.2.

```
0:TNC-> W2MER>APW261,K3TU*,WIDE2-1:>072107 Mercer County EOC
0:TNC-> W2MER>APW261,K3TU*,WI2ARD-1,WIDE2:>072107 Mercer County EOC
0:TNC-> N3FJA>APRS,W3NEP-1*,WIDE1*,WI3Z-1*,K3TU*,WIDE2*:@262215z4106.12N/07559.55W_359/008g015t061r
0:TX -> KC3GIF>APX204,WIDE2-2::K3TU     :TEST12{0G}
0:TNC-> K3TU>APU25N::KC3GIF   :ack0G}
0:TNC-> K3TU>APU25N,WIDE2-2,MAYLDG,K3TU::KC3GIF   :ack0G}
0:TNC-> KC3GIF>APX204,K3TU*,WI2ARD-1,WIDE2::K3TU     :TEST12{0G}
0:TNC-> K3TU>APU25N,WIDE2-2,WI2ARD-1,K3TU::KC3GIF   :ack0G}
0:TNC-> KC2QVT-3>APN391,K3TU*,WIDE2*:@262228z4000.20N/07501.32W_000/000g000t072r070p564P565h65b1005
0:TNC-> KJ5HY-9>SY1Y3S,N3KTX-1*,WIDE1*,N3XJT-1*,K3TU*,WIDE2*:`hA;n@Bk/]"4U}driving=
0:TNC-> WI2ARD-1>APRS,K3TU*,WIDE1*,WIDE2-2:!/:=i@;N.G& --PHG5790/G/D R-I-R H24 C30
0:TNC-> KC2QVT-13>APN391,K3TU*,WIDE2*:@262225z4002.45N/07444.08W_052/003g017t062r002p016P016h86b100
0:TNC-> KC3AQN>SYTY4S,N3IP*,WIDE1*,K3TU*,WIDE2*:`g90m"£>/`"5"}146.985MHz T156 -060_%
```

Figure 3.2: Message Traffic

The message is sent in the fourth line of Figure 3.2 and the acknowledgement is seen in the fifth line. It is important to note that the packet was sent with the alias callsign WIDE2-2. As explained in the Introduction, this means that the packet wants to take to hops, and there are two hops remaining. The path the packet actually took can be seen in line 7. Because the path from the mobile station was WIDE2-2, the packet fist went to K3TU. K3TU received the WIDE2-2, decremented to WIDE2-1, and sent then packet to the next digipeater, WI2ARD-1. WI2ARD-1 received the WIDE2-1 decremented to WIDE2-0, or WIDE2 and sent it to the destination, which was K3TU. It is evident that one must be careful when deciding how many digipeaters to use when sending a message, as it could cause congestion on the network.

4 Conclusion and Future Work

4.1 Conclusion

In this report, a mobile APRS station was set up using a handheld transceiver, a Raspberry Pi and a TNC. The configuration of all the hardware involved, and the use of digipeaters, which are crucial to mobile stations, was discussed.

As discussed in 3.1, congestion can occur if the user of an APRS station is not careful about how many digipeaters the packet requests. By adding an UNPROTO path of WIDE2-0, which means no digipeaters are requested, it is possible to view the difference in the path of the packet in comparison to Figure 3.2.

```
0:TNC-> WI2ARD-1>ID,K3TU*,WIDE1*,WIDE2-2:WI2ARD/30M1 GATE/2M1 WI2ARD-1/2M1 WIDEN-n IGATE
0:TNC-> WI2ARD-1>APRS,K3TU*,WIDE1*,WIDE2-2:>Listening on 146.52Mhz http://JeffreyFreeman.me
0:TX -> KC3GIF>APX204::K3TU     :TEST{0G}
0:TNC-> K3TU>APU25N::KC3GIF   :ack0G}
0:TNC-> KC2QVT-3>APN391,K3TU*,WIDE2*:@291652z4000.20N/07501.32W_000/000g000t052r012p117P115h59b1019
0:TNC-> N3YMW>APW261,K3ZMC-1*,WI3Z-1*,K3TU*,WIDE2*:_04291651c205s003g007t047r000p000P000h58b10156wU
0:TNC-> AA3E-2>APWW10,K3TU*,WIDE1*,WIDE2-1:@165114h4009.40N/07529.05WoAA3E-2 EOC Digi
0:TNC-> AA3E-2>APWW10,K3TU*,WIDE1,WI2ARD-1,WIDE2:@165114h4009.40N/07529.05WoAA3E-2 EOC Digi
0:TNC-> W2TIN>APS228,KC2QVT-15*,K3TU*,WIDE2*:>281320z[228]W2TIN ON THE AIR PLUMSTED, NJ
0:TX -> KC3GIF>APX204,WIDE2-0::K3TU     :TEST1{0H}
0:TX -> KC3GIF>APX204,WIDE2-0::K3TU     :TEST1{0H}
0:TX -> KC3GIF>APX204,WIDE2-0::K3TU     :TEST1{0H}
0:TNC-> K3TU>APU25N,WIDE2-2::KC3GIF   :ack0H}
0:TNC-> N2IGU-1>APZ210,WI3Z-1*,K3TU*,WIDE2*:@291653z4009.34N/07531.20W_103/000g012t052r000P001h64b1
```

Figure 4.1: Message Traffic with WIDE2-0

Seen in Figure 4.1, with the Path WIDE2-0, K3TU does not forward the message from KC3GIF, which is much more efficient in bandwidth use. This is seen in lines 12 and 13. The message in line 2 was sent with a direct path, and the acknowledgement from K3TU was sent back via the same path.

4.2 Future Work

The GPS location used in this report to show the station KC3GIF on the map in Figure 3.1 were hardcoded. GPS coordinates regarding a mobile station would always be changing, so a hardcoded position is not accurate or desirable. Future work on this project will incorporate a GPS module interfacing with either the USB interface on the Raspberry Pi, or the UART interface. If the UART interface is chosen, the TNC-Pi can be interfaced to the Raspberry Pi using the I2C protocol.

5 Bibliography

@Gadgetoid, @. (n.d.). *Raspberry Pinout*. Retrieved 4 25, 2016, from pinout.xyz: http://pinout.xyz/pinout/pin26_gpio7

Baofeng. (n.d.). *VHF/UHF FM Transceiver User's Manual*. Retrieved 04 2016, from uv3r.com: http://uv3r.com/images/UV-5R%20user%20manual.pdf

John, H. (n.d.). *TNC-Pi Assembly Instructions and Operating Tips*. Retrieved from tnc-x.com: http://www.tnc-x.com/TNCPi.pdf