**Deliverable Progress Report:**

**LONG RANGE Wi-fi and Spectrum Aggregation for Rural Broadband Applications**

**by**

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# Introduction

## 1.1 Background and purpose

There is a great need for broadband internet access in South Africa. However, conventional fiber or copper line based internet is not always an economically feasible solution in rural settings [1]. Long-range Wi-Fi networks have emerged as a low-cost solution for internet provision for both urban and rural environments in developing countries [2]. Rural broadband networks using Wi-Fi have been performed in other countries [3]-[5], and studies have been performed to characterize the viability of this technology [6], [7].

The University of Pretoria (UP) in collaboration with Dynamic Spectrum LLC (DS) and Stevens Institute of Technology (SIT) are investigating a potential solution combining long-range Wi-Fi and spectrum aggregation. DS has developed a Cognitive Wireless Network consisting of a cognitive multi-radio client and an associated secure cognitive server, together referred to as “SpiderRadio”. The client consists of commercial off-the-shelf (COTS) hardware, commodity wireless PC cards and a software stack that implements a variety of cognitive wireless protocols.

It is essential to be able to monitor and generate reports of the performance of a network in terms of various parameters, e.g. throughput, amount of data transferred, losses etc. The monitoring and reporting is vital for both testing and running phases of any network link(s). Work Space Africa, together with the University of Pretoria; have developed monitoring and reporting platforms based on open source software for network administrators managing the long-range Wi-Fi connections remotely. This monitoring software will run on the server of a point-to-point or point to multi-point network.

## 1.2 Scope of work

UP has created a long range Wi-Fi test setup consisting of a base station and a client station. The setup consists of two Wi-Fi links; one operating in the 2.4 GHz band and the other in the 5 GHz band. Performance evaluation of these links was carried out with regard to throughput, latency, spectral interference and range. UP and WSA have also developed a network monitoring solution suitable for the multi-link network. The monitoring solution aims to address the problem of segment monitoring with a grouping structure in order to support aggregation.

## Research hypothesis

The hypothesis of this research is that broadband services can be provided to rural communities in South Africa by using a combination of long range Wi-Fi and dynamic spectrum aggregation in a cost effective manner without sacrificing the quality of the service provided. A key question is how this solution compares to other proposed rural broadband technologies, such as those that rely on TVWS.

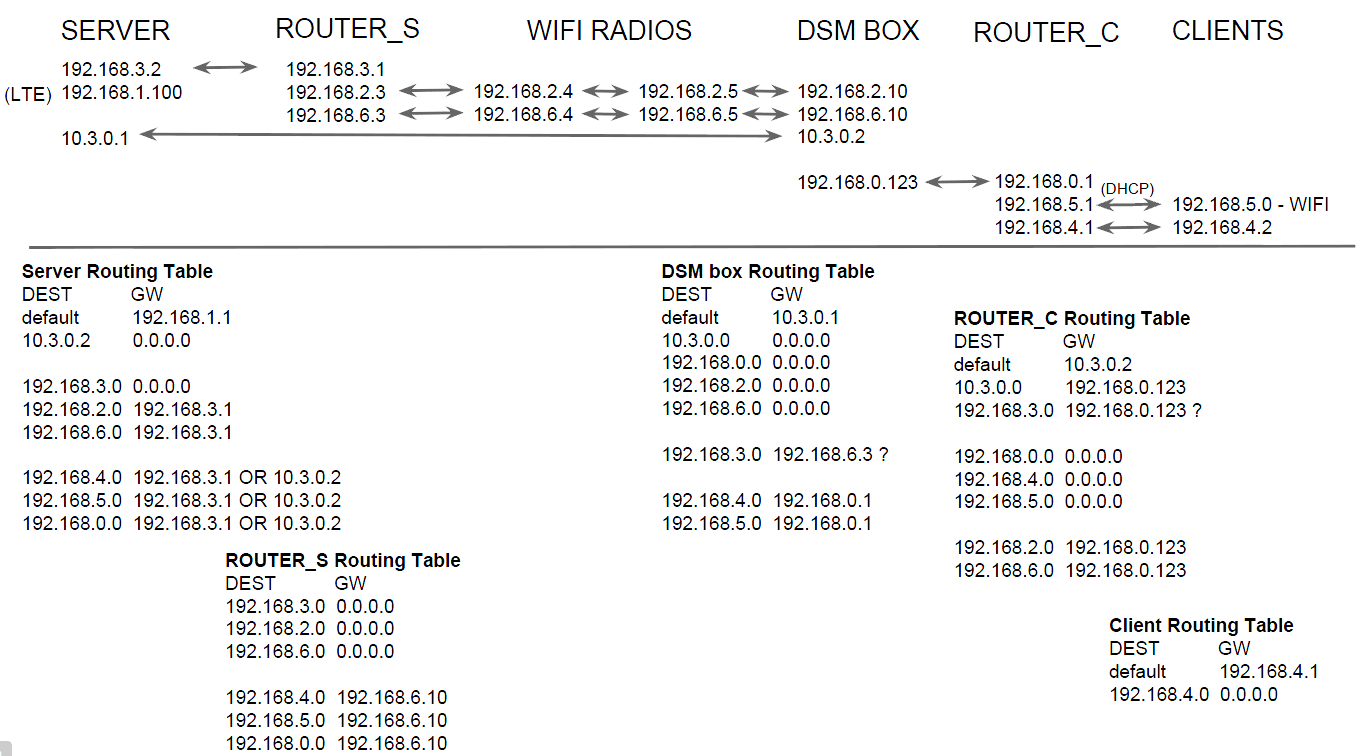
# School Setup

## 2.1 Scope of the setup

* long range Wi-Fi test setup consisting of a base station (UP server) and a client station (**Die Heuwel Primary)**
* two Wi-Fi links; one operating in the 2.4 GHz band and the other in the 5 GHz band
* There are also LTE connections at both the server and client.
* performance of the links to be evaluated in terms of throughput, latency, spectral interference and range



## 2.2 Routing configurations



## 2.3 Work done

* broken antenna replacement and configuration
* assisting Vidya to run tests on the links and aggregation
* Server setup and configuration
* Client setup and configuration
* Especially upon power outage during load shedding

# Network Management Software Development

## 3.1 Work done/knowledge gained

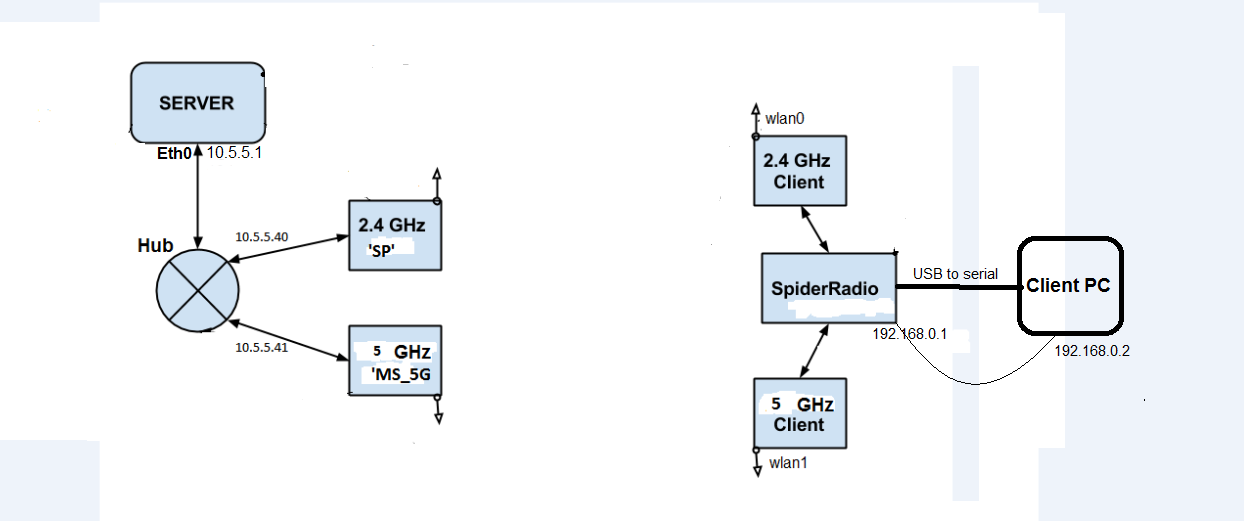
* Working with sql database (PostgresSQL)
  + Creating & deleting databases & tables
  + Assigning owners
  + Adding and deleting data in tables
  + Designing scripts to collect logged data
* Designing and generating performance test reports with JasperReports
* Deploying reports onto OpenNMS
* Working with OpenNMS
  + Adding & deleting nodes
  + Configuring data to monitor
  + Generating reports

# Wireless Lab Setup

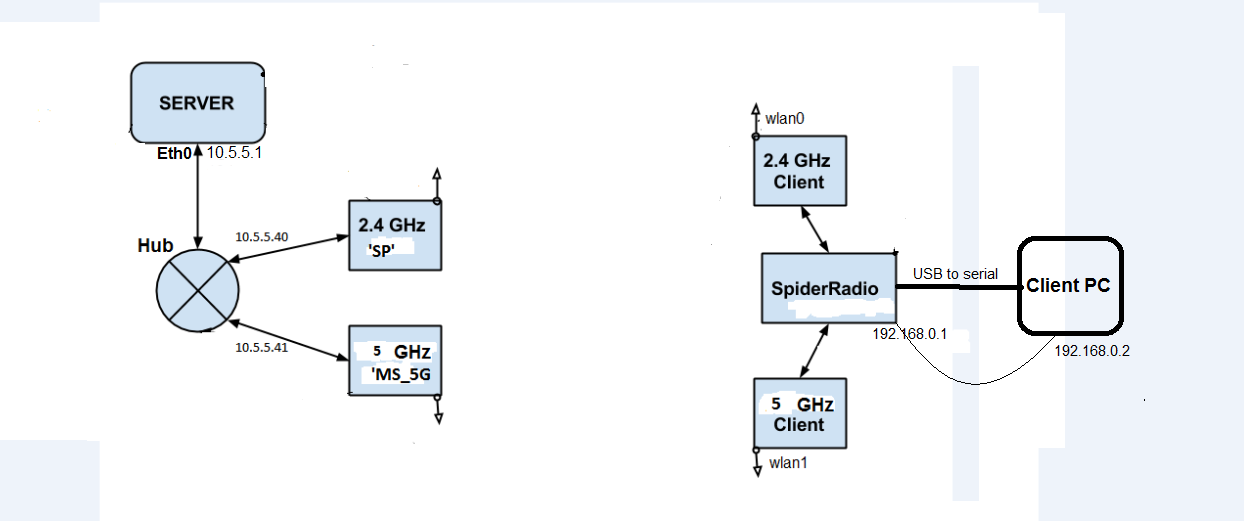
## 3.1 Work done

* Procurement of equipment (routers)
* Setting up and configuration of the setup
  + Server & client PCs
  + Spider radio
  + Wi-Fi routers
* Running separate link & aggregation iperf tests
* Video streaming
* Monitoring software deployment
* GovTech presentation preparation
  + Setting up and configuring the hardware (routers & PCs)
  + Network management software configuration
  + Performance test reports design and generation

## 3.2 Structure of the setup



## 3.3 Configuration

****

**Server Setup**

Username: malcolm

password: opennms

* cd tools
* sudo ./setup.sh

**Spider Server setup**

* cd setup
* sudo ./config.sh

**Client Setup**

Username: vsagar

password: enter123

1) Startup and connect the spider radio to the client PC via the USB to serial

* sudo kermit

- then press enter and login with above credentials

2) Connect to the wireless APs and configure routing tables

* cd bsol/ (vsagar@dsm1k3:~/bsol$)
* sudo ./setup.sh

-check that routing tables are added (rt1 & rt2)

* ip ru

-should look as follows:

*vsagar@dsm1k3:~$ ip ru*

*0: from all lookup local*

*32762: from all to 192.168.6.6 lookup rt1*

*32763: from 192.168.6.6 lookup rt1*

*32764: from all to 192.168.5.101 lookup rt2*

*32765: from 192.168.5.101 lookup rt2*

*32766: from all lookup main*

*32767: from all lookup default*

**Starting Aggregation (tunnel)**

***On Server***

* cd dsm
* ./vtund.server.sh

***On Client (spider radio in root directory:*** *vsagar@dsm1k3:~$****)***

* sudo killall -9 spidernetd
* sudo spidernetd s1 10.5.5.1 -f vtund\_client.conf

-check if tun0 comes up in ifconfig

-if not, restart the process

**Forwarding to client PC** (*make sure tun0 is up)*

***On Spider radio***

* cd bsol/
* sudo ./client\_forward.sh

***On client PC***

* sudo ifconfig eth0 192.168.0.2 up

**Video streaming**

**On server**

* cd /var/www/http
* vlc -vvv file\_name --sout '#standard{access=http,mux=ogg,dst=10.3.0.1:8080}' --loop
* ***with transcoding:*** vlc -vvv input\_stream --sout '#transcode{vcodec=mp4v,acodec=mpga,vb=800,ab=128}:standard{access=http,mux=ogg,dst=server.example.org:8080}' --loop

**On client**

* vlc http://10.3.0.1:8080

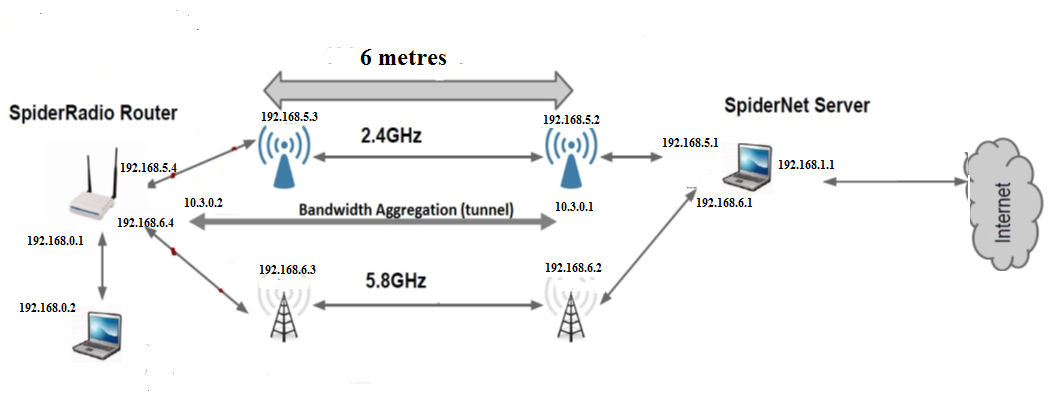
# Antenna Lab Setup

## 2.1 Work done

* Procurement of equipment (antennas & router)
* Setting up and configuration of a copy of the school setup
  + Server & client PCs
  + Arduino board (as spider radio)
  + Antennas
* Running segment & link iperf tests
  + serverPC – server radios
  + serverPC – client PC
  + server radios – client antennas
  + narrowing down the problem with the iperf tests (high losses)
* Monitoring software deployment
* SITA presentation preparation
  + Setting up and configuring the hardware (antennas & PCs)
  + Network management software configuration

## 2.2 Revised Setup

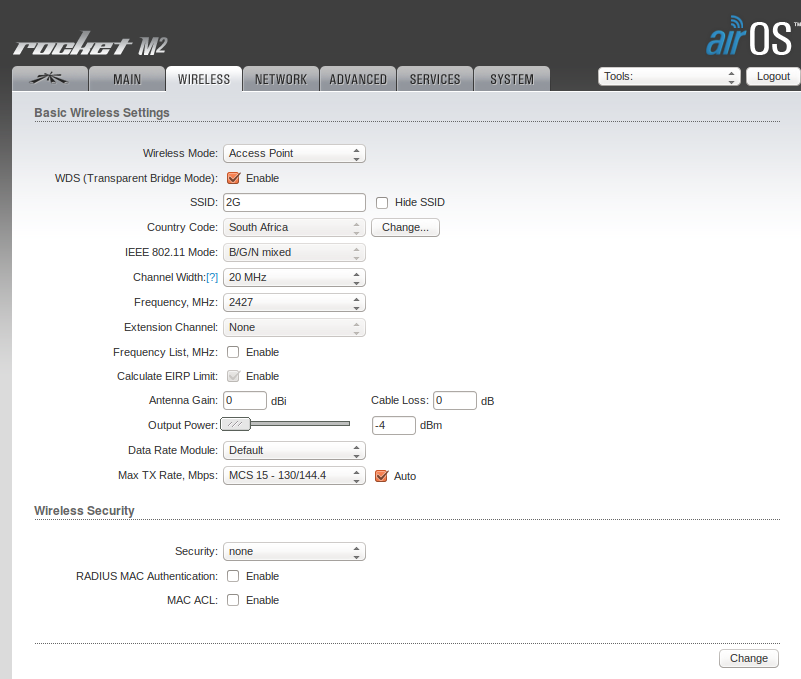
* Based on the wireless router setup

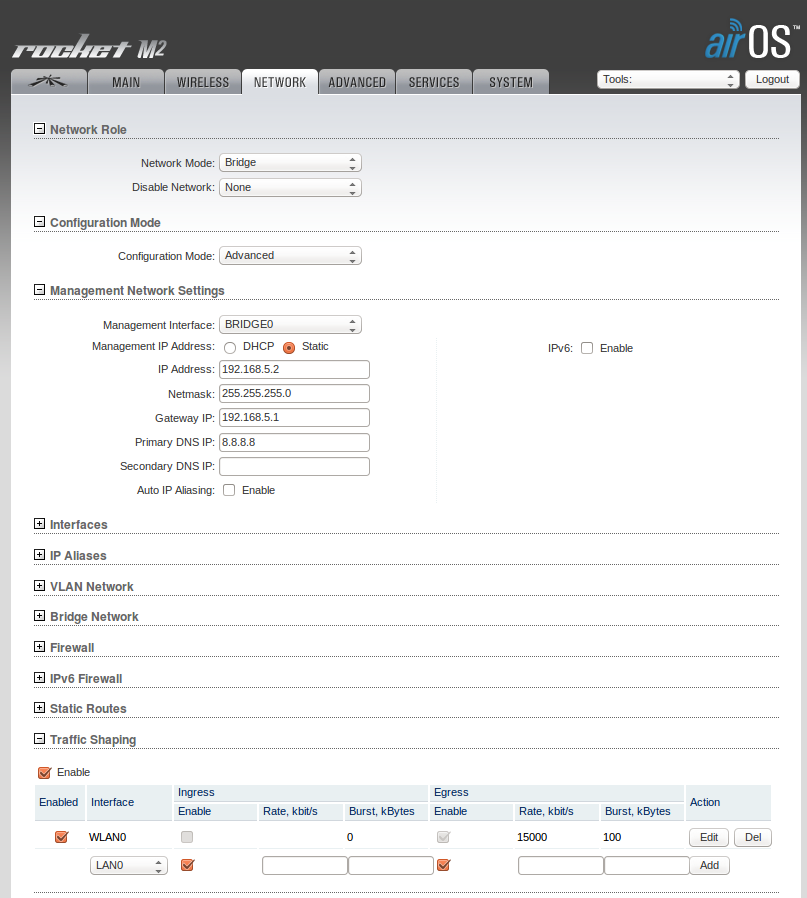


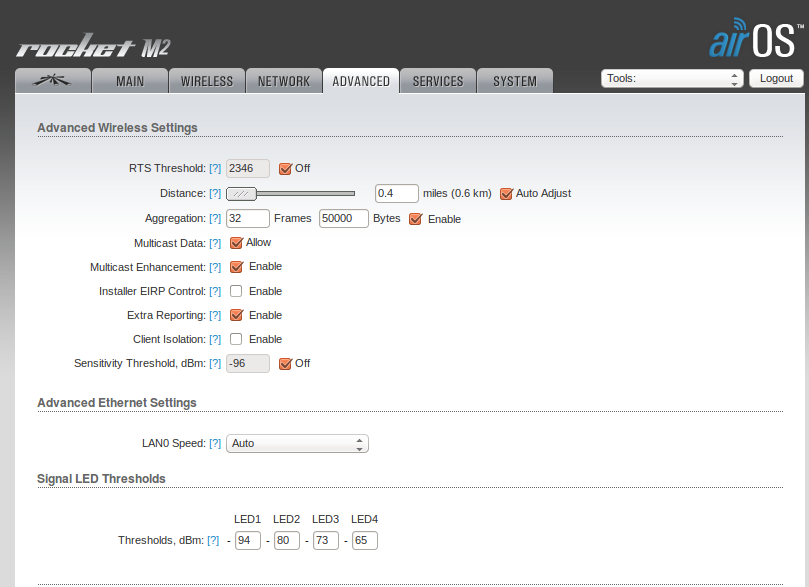
## 2.3 Configuration

* Antenna configuration to include traffic shaping
  + Solved the problem with iperf udp tests where links were allowing more data than can be handled leading to unacceptable losses.

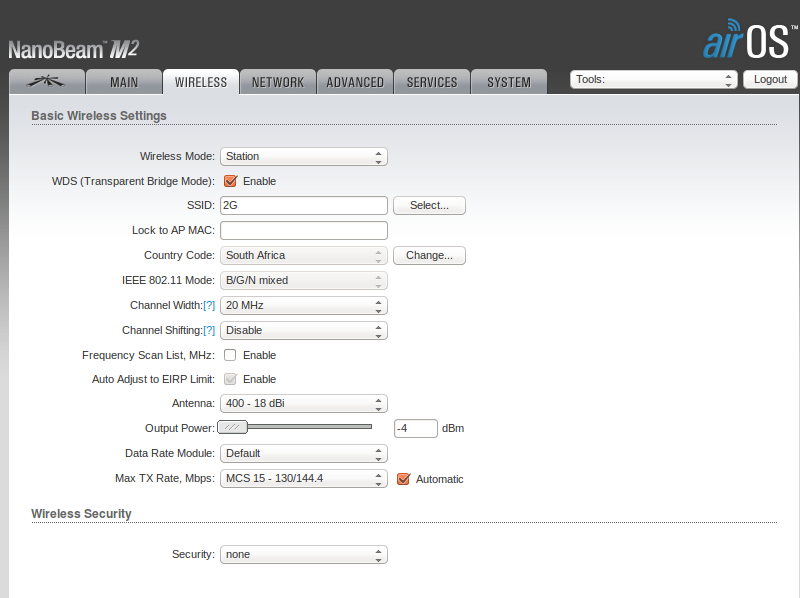
### 2.3.1 Rocket M radios configuration

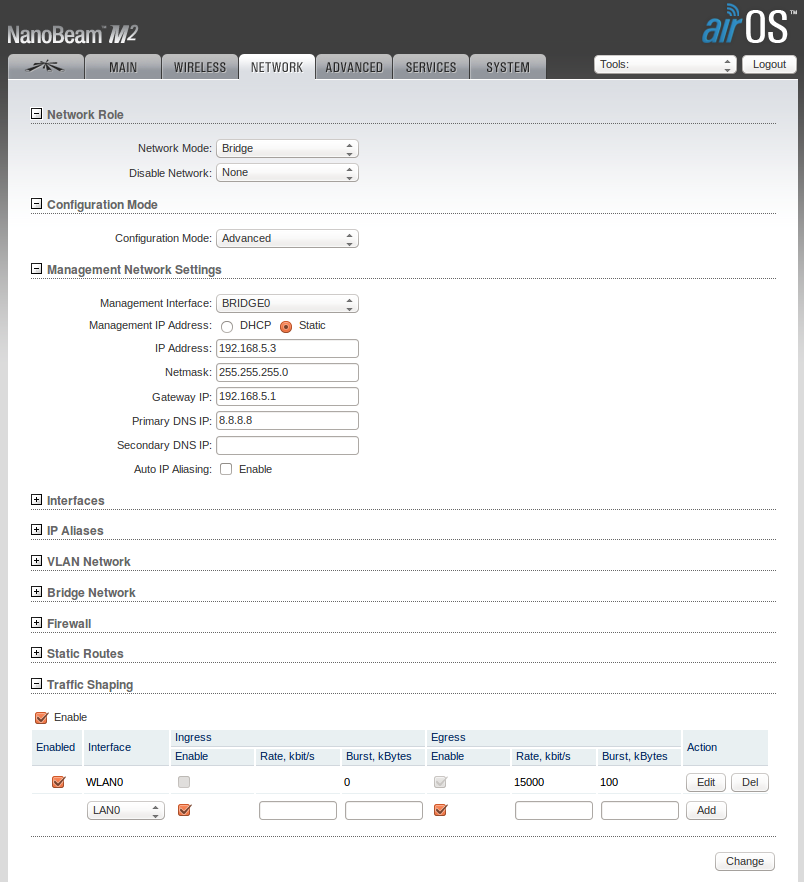






### 2.3.2Nanobeam antenna configuration





**Spider Server setup**

* cd setup
* sudo ./config2.sh

**Spider radio Setup**

1) configure routing tables

* cd bsol/ (vsagar@dsm1k3:~/bsol$)
* sudo ./setup.sh

-check that routing tables are added (rt1 & rt2)

* ip ru

-should look as follows:

*vsagar@dsm1k3:~$ ip ru*

*0: from all lookup local*

*32762: from all to 192.168.6.4 lookup rt1*

*32763: from 192.168.6.4 lookup rt1*

*32764: from all to 192.168.5.4 lookup rt2*

*32765: from 192.168.5.4 lookup rt2*

*32766: from all lookup main*

*32767: from all lookup default*