Hard-ware-in-the-loop (HIL) User Manual

Version 0.3

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Introduction to using Redpine WaveCombo boards in VENTOS-HIL Simulation

This manual outlines the implementation using a specific platform, Redpine Signals WaveCombo. However, due to the modular design of VENTOS, the concept can be easily extended to other platforms

We demonstrate how two Redpine WaveCombo boards can act as OBU and is installed on the vehicle and the other acts as RSU and is placed in the traffic control cabinet located in the intersection. The SNMP protocol is used as part of the application level of NTICP framework for Center-to-Field (C2F) communication between RSU and traffic light controller (e.g., Econolite Cobalt). The OBU announces the transit vehicle's heading to the RSU located on the intersection. In this example, RSU uses the heading information to dynamically adjust the traffic signal timing in the Cobalt controller using the SNMP protocol..

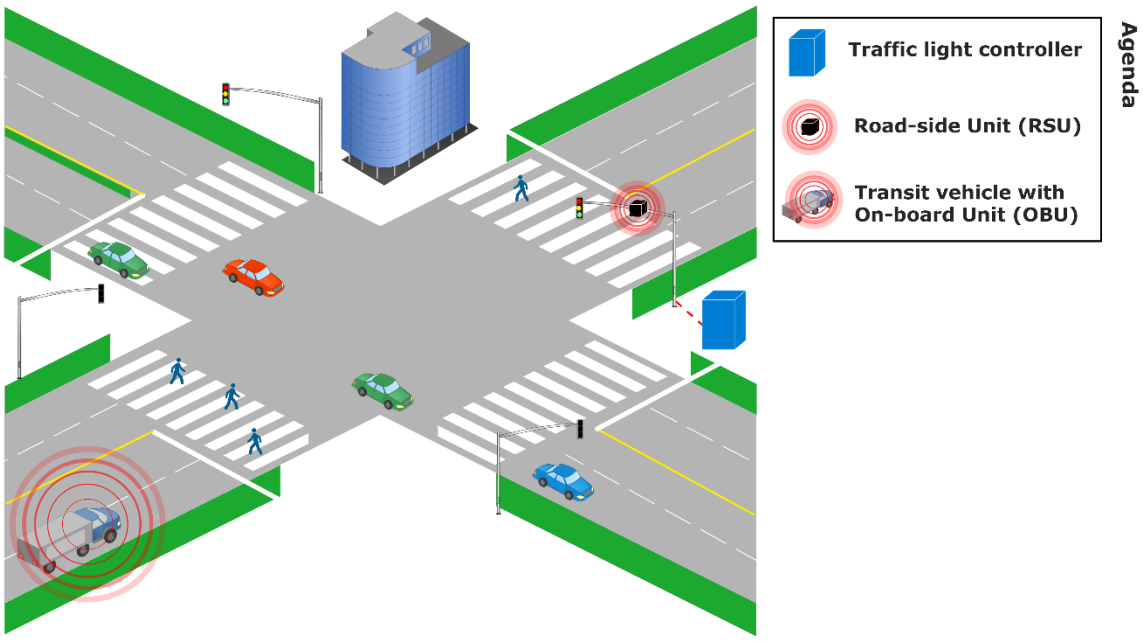

Figure 1: **Transit signal priority using V2I communication**

1 Preparing OBU and RSU boards

In this section, we describe how to prepare each board in the lab before the field testing. We assume that each WaveCombo board is already loaded with the Linux kernel (Ubuntu) and the latest host driver is installed in the '/home/release' folder.

1.1 Connecting the First Board (RSU)

Step 1: Fix up the two antennas on top of the board as shown in Figure 2 . Also connect the GPS receiver to the USB port.

Step 2: Plug in the 5v DC supply to power jack. A solid green LED indicates that the board is connected to the power. The blue LED turns on/off once the Linux kernel finishes booting.

Step 3: The Redpine board is assigned a static IPv4 address of 192.168.60.42/24 by default. Connect the board to the Ethernet port of your PC. Change the IPv4 address of your computer to **192.168.60.30/42**. To do this in Ubuntu, open 'Network Connections', select your Ethernet and click Edit. Go to 'IPv4 Settings' and change Method to Manual. Add IP address of 192.168.60.30 with Netmask of 255.255.255.0 (leave gateway address unchanged) as shown in Figure 3.

Figure 2: **11p Evaluation board**

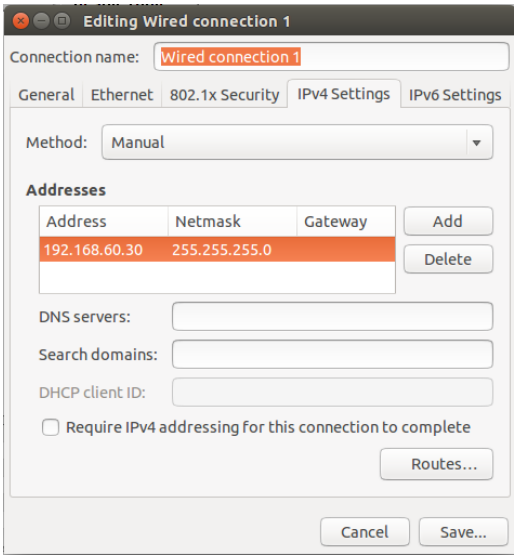

Figure 3: **Assigning static IPv4 to your NIC in Ubuntu**

Note: If you are running Ubuntu inside a virtual machine like 'Oracle VM VirtualBox', then you need to do three more steps (A, B and C):

Step A: Go to your virtual machine settings and click on Network (make sure the virtual machine is not running). On the Adapter 1 tab, change 'Attached to:' to Bridge Adapter[1] and change 'Name:' to your NIC card that the board is attached to. On the Adapter 2 tab, change 'Attached to:' to NAT and leave the rest of settings unchanged. Adapter 1 is used to connect the guest OS to the boards and Adapter 2 is used to connect the guest OS to the Internet.

Step B: Run the virtual machine. In the **guest OS** click on the 'Network Icon Manager' and you should be able to see two connections as shown in Figure 4. Click 'Edit Connections…' and select 'Wired connection 1'. Click on 'Edit', go to 'IPv4 Settings' and change method to 'Manual'. Change the IPv4 address of NIC to

[1] In Bridged mode the guest OS (Ubuntu) will get an IP address on the same subnet at your host OS.

192.168.60.30 with subnet mask of 255.255.255.0 and leave the gateway unchanged. Go to the 'Wired Connection 2' and make sure that 'method' is set to 'Automatic (DHCP)'.

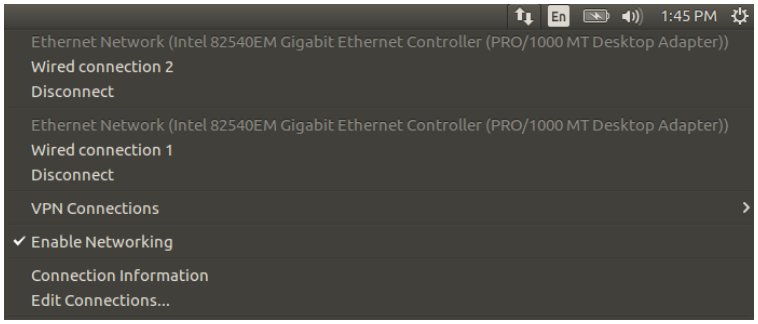

Figure 4: **Network icon manager in Ubuntu shows two connections**

Step C: In the **host OS**, change the IPv4 address of NIC to **192.168.60.31** and subnet mask to 255.255.255.0 and leave the gateway unchanged.

Step 4: Make a SSH connection to the board using the following command and use Redpine as password (password is case-sensitive):

```
ssh ubuntu@192.168.60.42
```

1.2 Connecting the Second Board (OBU)

You can use a 'network switch' to connect the second board to your PC. You need to make sure that the assigned IPv4 address to each board is unique.

Step 1: Connect the second board (only) to your PC and SSH to it using `ssh ubuntu@192.168.60.42`.

Step 2: Edit the following file by changing the IPv4 address to **192.168.60.43**. Save the file and close it.

/etc/network/interfaces

Step 3: Restart the board using:

```
sudo reboot
```

Step 4: Connect the two boards to the switch and then connect the switch to your PC. Then SSH to each board individually to make sure that all boards are connected properly.

1.3 Connecting a Board to the Internet

You need to connect the boards to the Internet in order to install the required libraries/packages. You can setup a proxy server on your computer and then configure the boards to connect to the proxy server.

[Ubuntu]

Step 1: To setup a proxy server on your computer that is running Ubuntu, install 'squid' as following:

```
sudo apt-get update
sudo apt-get install squid
```

Step 2: Configure the squid server by opening the squid.conf file located at '/etc/squid' folder.

Go to TAG: acl section and define an access list for each board that you need to connect to Internet:

```
acl board1 src 192.168.60.42
acl board2 src 192.168.60.43
```

Go to TAG: http_access and add the following lines:

```
http_access allow board1
http_access allow board2
```

Go to TAG: http_port and change http_port value to 3128

Step 3: Restart the squid server for the changes to take effect:

```
sudo service squid restart
```

Step 4: SSH to one of the boards and make sure that the proxy is working correctly. For example, you can download a file from the Internet using the following wget command:

```
wget -e use_proxy=yes -e https_proxy=192.168.60.30:3128 --no-check-
certificate <url_to_a_file_on_internet>
```

Step 5: To set a proxy for APT (to download packages), you need to open the apt.conf file located at '/etc/apt' folder on the board and append the following lines (create the file if it does not exist):

```
Acquire::http::Proxy "http://192.168.60.30:3128/";
Acquire::https::Proxy "http://192.168.60.30:3128/";
```

Repeat step 4 and 5 for the second board.

[Mac OS X]

Step 1: Install SquidMan from here. SquidMan is a Mac OS X graphical installer and manager for the squid proxy cache.

Step 2: Run SquidMan, and go to Preferences.

Step 3: In Tab General, set HTTP Port to be 3128.

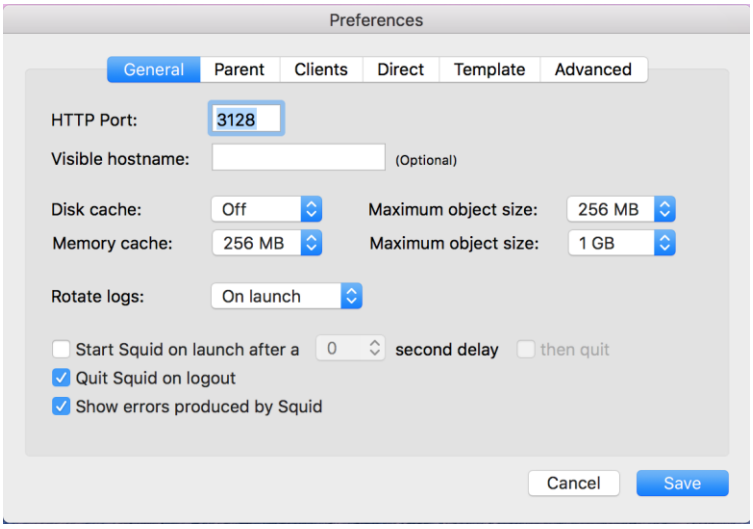

Figure 5: **General tab in SquidMan preferences**

Step 4: In Tab Clients, add two item “192.168.60.42” and “192.168.60.43”

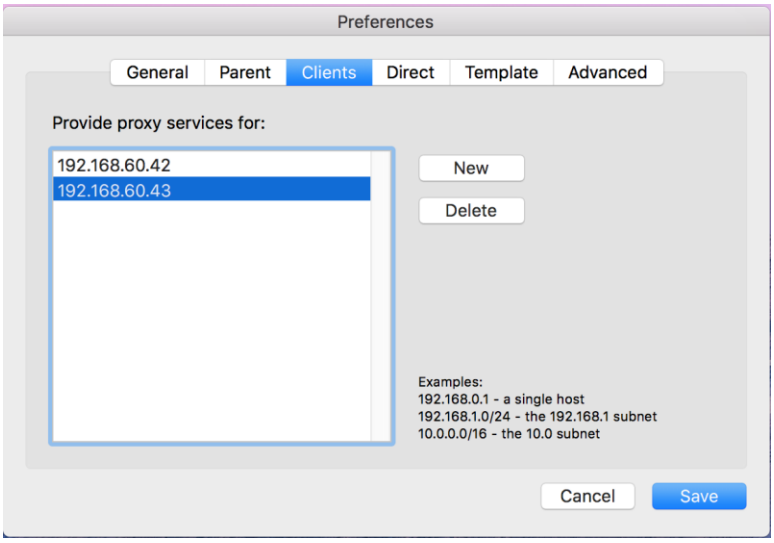

Figure 6: **Clients tab in SquidMan preferences**

Step 5: In Tab Template, add the following lines:

```
acl board1 src 192.168.60.42
acl board2 src 192.168.60.43
http_access allow board1
http_access allow board2
```

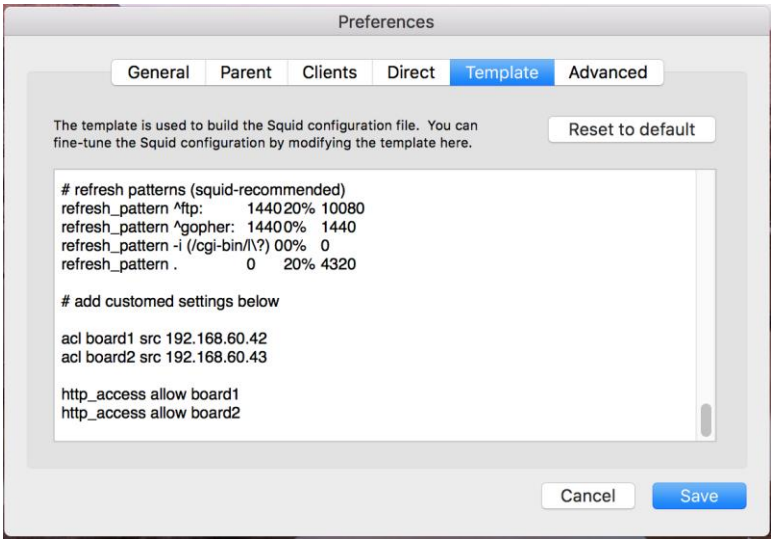

Figure 7: **Template tab in SquidMan preferences**

Step 6: Save all Preferences settings. Press button "Start Squid" to enable Proxy server.

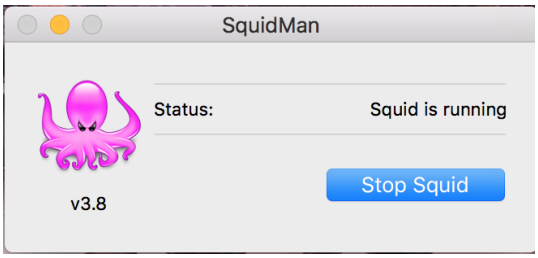

Figure 8: **Squid is running**

1.4 Sync the Board's Clock

There is no battery on the WaveCombo boards to save date/time. This means that you need to sync the OS time, every time the board is powered on. Out-of-sync clock will make problems such as:

- The 'make' command is used to compile new or modified code without the need to recompile unchanged code. The make command uses the clock of the machine it runs on to determine which source files need to be recompiled. If the OS running on your computer is unsynchronized with the OS running on the board, then, the make program might not produce the correct results.
- Server certificate verification is time-sensitive and might fail if the board's clock is off. This means that cloning the WaveTSP Git repository might fail.
- WaveTSP_OBU is sending periodic beacons that contain time-stamp. If the board's clock is off, the time-stamps are wrong.

Thus, the board's clock needs to be synced with a time server using the sntp application. If the sntp command hangs, then the IP address is not correct.

```
# sntp application is in the ntp package
sudo apt-get install ntp
sudo sntp -s 192.168.60.30
```

Make sure the clock is synced by using the 'date' command. If for some reason the sntp command did not work, then you can use the following commands:

```
export http_proxy=192.168.60.30:3128

httpdate="$(wget --no-cache -S -O /dev/null google.com 2>&1 | sed -n -e 's/
*Date: *//p' -eT -eq)"

sudo date -s "$httpdate"
```

The first command sets the http proxy for wget command. The wget command sends an http request to 'google.com' and then extracts the date from the response header. The result is saved in the httpdate variable and is later used to set the system clock using 'date -s' command. The above solution can sync the board's clock with 'second' accuracy.

Up to now, we have connected the two WaveCombo boards to a network switch and then connect the network switch to the PC. To interact with other hardware, such as traffic light controller, detailed specifications of the other handware are needed. For instance, to interact with Econolite Cobalt, one can attach an Ethernet cable to the first port of Cobalt's ENET-1 (WAN) labeled as 'Ethernet City Ports' and connect the other end to the network switch.