Airvine WaveTunnel™

Getting Started Guide

February 2024
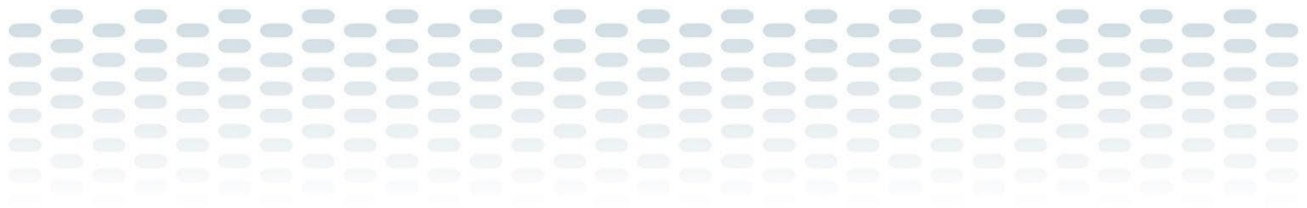
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Intended Audience

This document is written for and intended for use by technical engineers with some background in Ethernet networking, Wi-Fi design, and 802.11 wireless engineering principles.

For additional information on Airvine and Airvine products, go to https://airvine.com/

Overview

The purpose of this document is to provide guidance for the planning and implementation of an Airvine WaveTunnel™ wireless distribution backbone. Primary markets include multi-dwelling, multi-family, hospitality, large public venues, warehousing and more. Providing a wireless backbone alternative to the traditional horizontal cabling infrastructure opens many opportunities that may have been delayed or not feasible due to cost, environmental or disruptive roadblocks.

Before the actual design of an mmWave backbone can start, there are several considerations that can dramatically impact the final design, deployment, and performance. These include:
● What type of vertical wired infrastructure will or can be used?
● What are the devices that will need to be deployed with the WaveTunnel™ bridges?
● What is the expected network performance (SLA)?
● What network management topology will be used?

Answering these questions at the outset, planning carefully, and selecting Airvine Networks patented indoor mmWave technology will help tackle various deployment scenarios. This document discusses how to get started setting up and using the Airvine WaveTunnel™ bridges and some best practices for planning and deploying a mmWave network.

Finding Airvine Resources

General information and support for Airvine products can be found at:

https://airvine.com

https://airvine.com/support/

Support includes access to firmware downloads, documentation, warranty, product registration, and technical Q&A.

For Airvine Partners, once registered and have access to the Airvine Partner Portal, you will find many resources for marketing assets, sales tools and support resources including certification training and case escalations.

https://partner.airvine.com/wp-login.php

Pre-Testing Evaluation Gear

Received Equipment: Please take a moment to send support@airvine.com a message that you have received the equipment and that it is in good condition.

Please do not attempt to use evaluation units if the box or contents appear damaged. Immediately send a description of the damage to support@airvine.com and replacement evaluation equipment will be sent.

The Box contains the following:
- WaveTunnel™
- Mounting Bracket
- Power Supply and Cord

Before connecting to an Ethernet switch

If connecting a WaveTunnel™ to an Ethernet switch, connect to a non-PoE port or port that has the PoE disabled. Connecting a WaveTunnel™ to an active PoE switch port may cause damage to a WaveTunnel™!

Connecting to Power

When connecting power to a WaveTunnel™, connect the DC plug from the power brick into the WaveTunnel™ first. The circular connection is keyed for proper orientation. Once the DC plug is connected to the WaveTunnel™, plug the AC power cord from the power brick into an electrical outlet.
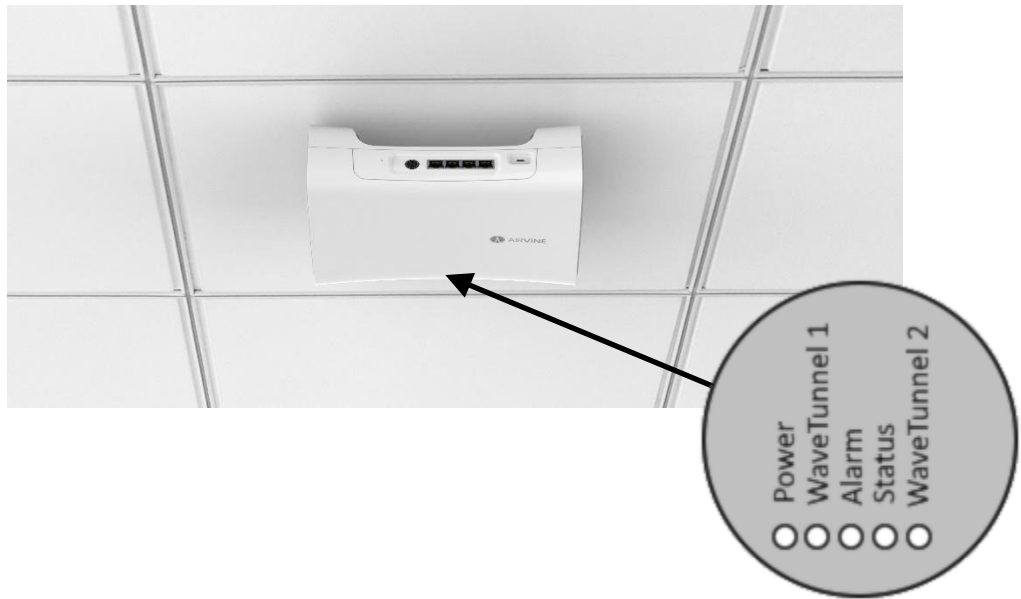
For model **2041SM**, the flat side of the power connector is down.
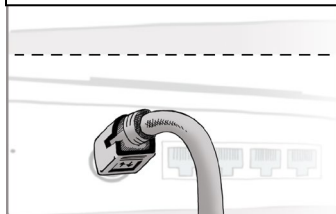
For model **2041DC**, the flat side of the power connector is up.

Initial Setup

In a staging environment, power on a WaveTunnel™ bridge. This can be on a desktop or lab area. For ceiling mount, refer to the instruction shown in the WaveTunnel™ Quick Setup Guide.

LED Activity

Once powered on, observe the LEDs on the WaveTunnel™ unit.

🟢	Power (Hardware)		
🟢	WaveTunnel™ 1 Upstream	Off → Blinking → Solid →	Not Configured Connecting / Waiting Connected
🔴	Alarm	Solid → Off →	Red if there are alarms generated. No Alarm, all alarms have been acknowledged by admin.
🟢	Status	Off → Blinking → Solid →	Off – Not Operational Blinking – System Initializing, Configuring Solid – Operational
🟢	WaveTunnel™ 2 Downstream	Off → Blinking → Solid →	Off – Not Configured Blinking – Connecting / Waiting Solid – Connected

Ethernet port LEDs

Green	Yellow	Behavior
Off	Off	No Ethernet Connection Detected
Off	On	Connected at 100 Mbps, No Traffic Passing
Off	On Blinking	Connected at 100 Mbps, Traffic Passing
On	Off	Connected at 1000 Mbps, No Traffic Passing
On Blinking	Off	Connected at 1000 Mbps, Traffic Passing

Reboot and Factory Reset

A Reboot/Reset pinhole button is located next to the power connector.

- Depress for < 5 sec for a soft reboot.
- Depress for > 5 sec for a factory reset.

NOTE THAT AT FACTORY DEFAULTS, WHEN CONNECTING THROUGH A WIRED ETHERNET CONNECTION, THE IP ADDRESS OF THE WAVETUNNEL™ GUI AND SSH IS: **192.168.0.253**
HTTP/SSH UN=admin PW= admin

THE IP ADDRESS FOR THE AIRVINEMOBILE APP AND 2.4GHz WAVETUNNEL™ WIRELESS INTERFACE IS: **192.168.3.1**
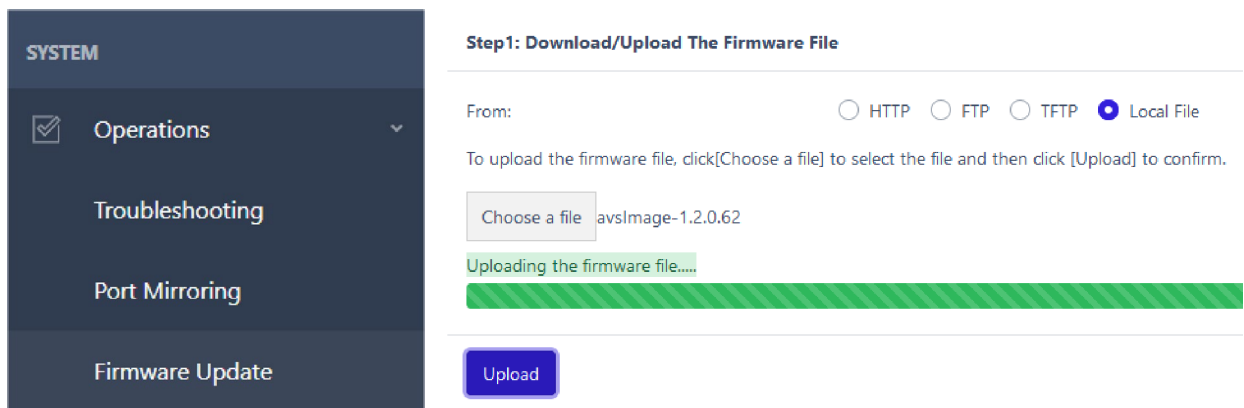**SSID WPA2 PASSWORD = airvine! with UN=admin PW=admin**

As a best practice, reset the WaveTunnel™ evaluation units to factory defaults and observe LED behavior during boot up.

The WaveTunnel™ configuration wizard will prompt the user to configure a new password. It is strongly suggested that a password with at least 8 characters in length using special characters be used for security purposes.

Updating Firmware

Typically, WaveTunnel™ units will not have the latest code version when they ship from the warehouse. Important feature updates and fixes that will benefit the user experience may not be available. To update, download the latest version from the Airvine support site https://airvine.com/support/ and refer to the "Airvine Tech Notes WaveTunnel™ Firmware Updates" for additional instructions on updating the WaveTunnel™ firmware.

Note other important links for Contact, Product Registration, Product RMA, and other available downloads.

From System > Firmware Update select the firmware file previously download and Upload to the WaveTunnel™. The Local File method may be the easiest. Once the firmware has loaded, check the Write Image button, and let the system update and reboot.
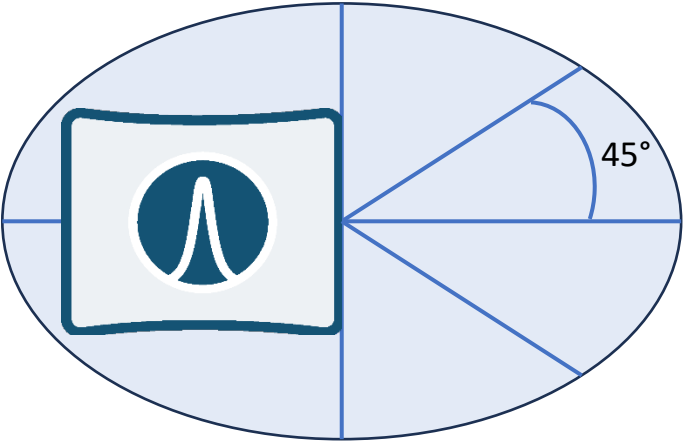
Installation Notes

Note that WaveTunnel™ bridges allow for Beam Steering in the horizontal axis up to ±45° while there is less tolerance to pitch and roll.
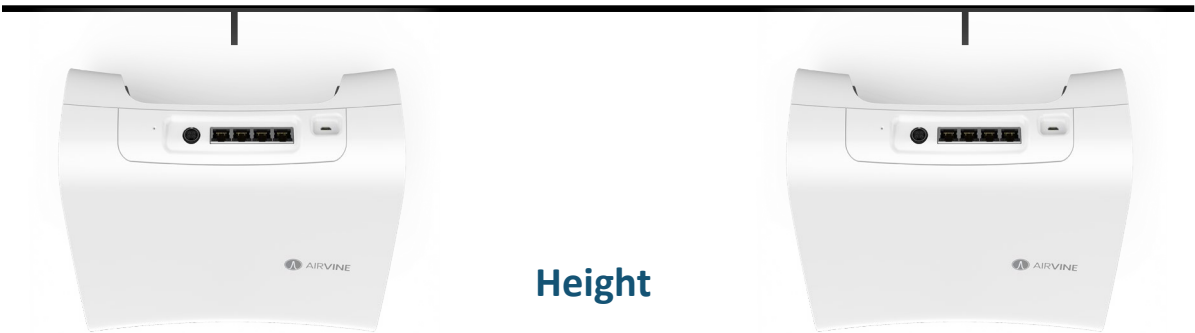

Pan, Tilt & Roll

Horizontal Axis: Pan/Yaw ±45°

Lateral Axis: Tilt/Pitch* = 0

Longitudinal Axis: Roll* = 0

Increasing Distance = Higher Sensitivity

WaveTunnel™ Bridges should be mounted at the same vertical height from the ceiling. Using the included mounting brackets will also ensure Fresnel zone clearance at up to 100 meters.

Height

Hop Distance	Bracket Setting
0-24 meters	4"
24-48 meters	6"
48-100 meters	8"
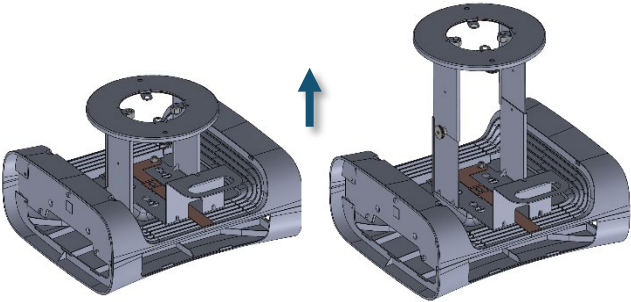
Walls and other materials will attenuate a WaveTunnel™ signal. Some typical attenuation numbers are listed below. Airvine includes a VineCalculator to assist with estimating WaveTunnel™ signal strength in various scenarios. To use the VineCalculator, please visit https://services.airvine.com/calculator/
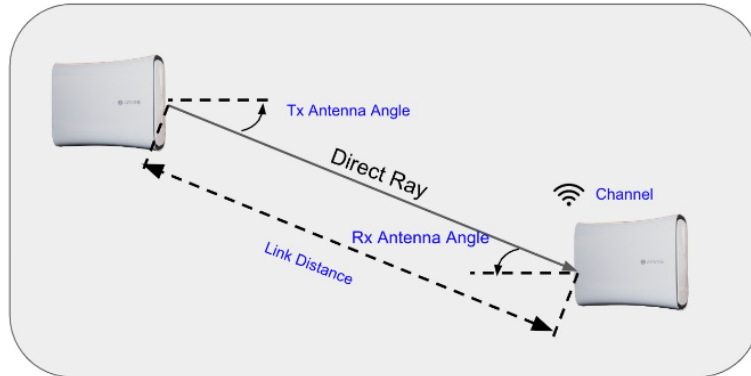
Please input the following parameters to calculate the Link Margin.

Link Distance (feet)		
100		
Enter the link distance between two Wave Tunnels		

Channel 1 (Default) ▾

Select the channel

Tx Antenna Angle (degree) ———●———— 0

Rx Antenna Angle (degree) ———●———— 0

Walls Between These Two WaveTunnel Devices

Select	Wall Material	Thickness(inch)	Sheets	Actions
☐	Drywall	1.25	1	✎
☐	Drywall-Semigloss	1.25	1	✎
☐	Drywall-Flat Paint	1.25	1	✎
☐	Ceiling Tile	1	1	✎
☐	Plywood	1.25	1	✎
☐	Glass	0.5	1	✎

Items per page: 10 ▾   1-6 of 6 |< < > >|

CALCULATE   **RESET**

Pre-Configuration

Collect the following hardware:

- Mobile device running Android or iOS operating system.
  - Or computer installed with one of the following web browsers.
    - Google Chrome
    - Microsoft Edge
    - Safari
    - Firefox
- Ethernet cable if connecting via an Ethernet port.
- Serial console cable (Optional)
  - 2.0 USB A Male to Micro USB

If you are going to use the mobile App for configuration, download the **AirvineMobile** App to your mobile device.

Decide on how the WaveTunnel™ units will be staged either in a chain or ring topology and the proper orientation of the units. A section on staging is included later in this document.

WaveTunnel™ Topology

This document will take you through the process of configuring a 4-node network ring as shown in the figure below. Once connected to your WaveTunnel™, enter the username and password to log in. Browser configuration, iOS, and Android configuration steps are outlined below.

The Root bridge is always configured first and the WaveTunnel™ network is created. Once the network is created, additional Leaf bridges can be joined to the network.
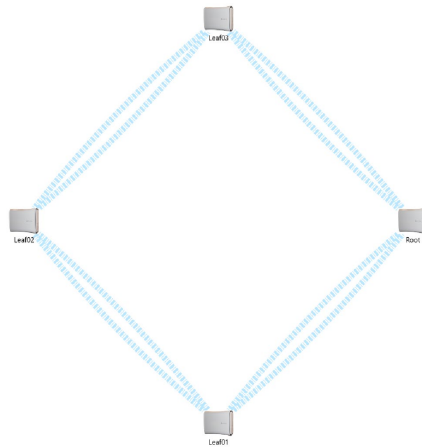
Browser Configuration

WaveTunnel™ Ethernet IP address = **192.168.0.253** and for connecting to the 2.4GHz wireless interface **192.168.3.1**. Connecting to the Wi-Fi interface will provide the client with a DHCP address.

SSID WPA2 password = airvine! with UN=admin PW=admin

Root Bridge Configuration

1. To configure the initial Root bridge, login to the management interface of the WaveTunnel™ and select "Create a new network" and give the network a name. In this example, "VineNet" is used. When subsequent nodes are added to the network, the option "Join the existing network" will be used.
2. Select "Next"

3. Configure a Node Type and Node Label for this WaveTunnel™
4. Select "Next"

5. Configure the IP management setting to either DHCP or Static
6. Select "Next"

7. Create a new password.
8. Select "Next"

9. Review the configuration.
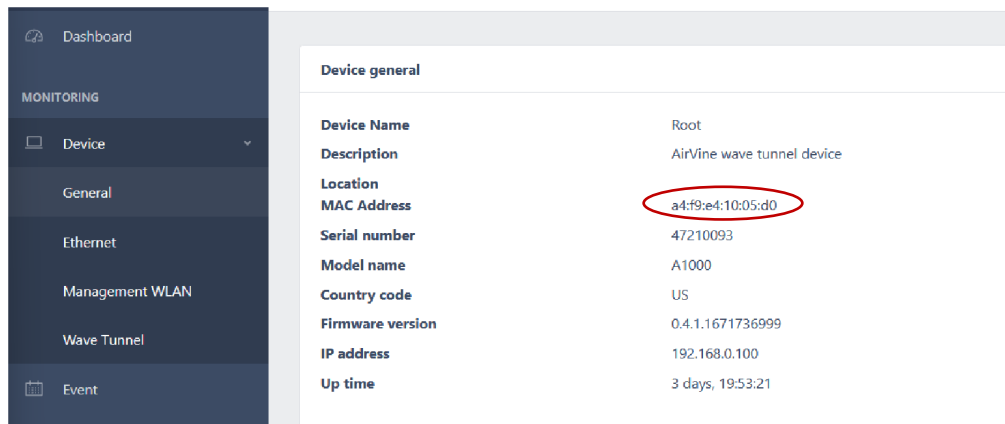10. Verify the configuration is correct, select "Submit".

11. Login to the newly configured Root bridge.
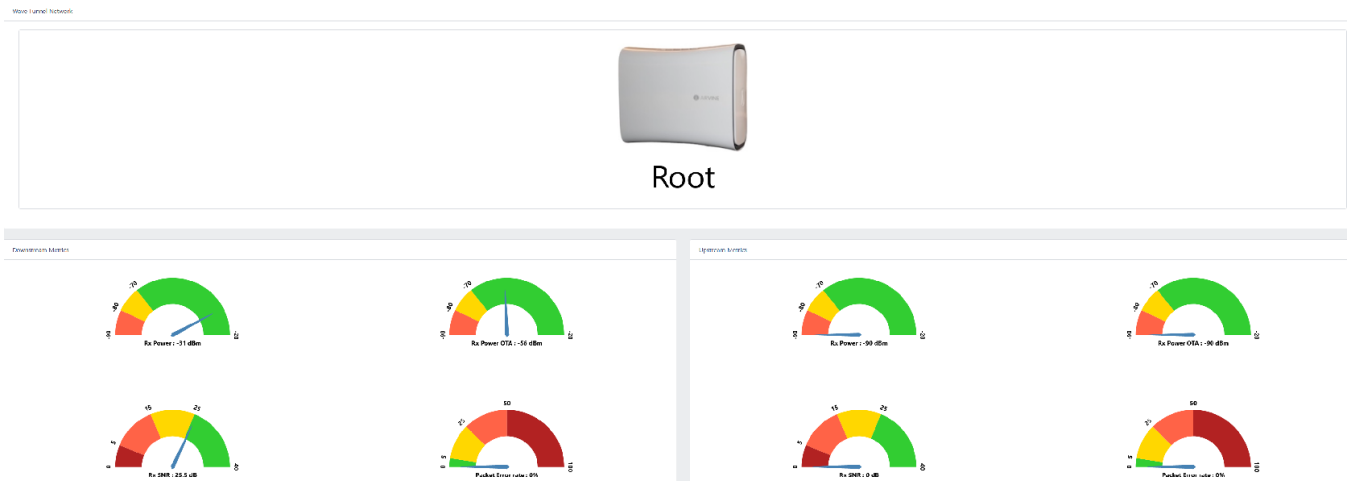
Leaf Bridge Configuration

1. Make note of the upstream node MAC address that the Leaf node will be connecting to. In this case, the MAC address of the Root bridge.
    a. To find the MAC address of the upstream bridge, see the label on the unit.
    b. Or log into the WaveTunnel™ bridge and go to Monitoring > Device > General and view the MAC Address.

2. Log into the WaveTunnel™ to be configured using a browser or the AirvineMobile App using UN= admin PW=admin for the browser. The SSID WPA2 password for the Mobile App and 2.4GHz wireless interface is = airvine!
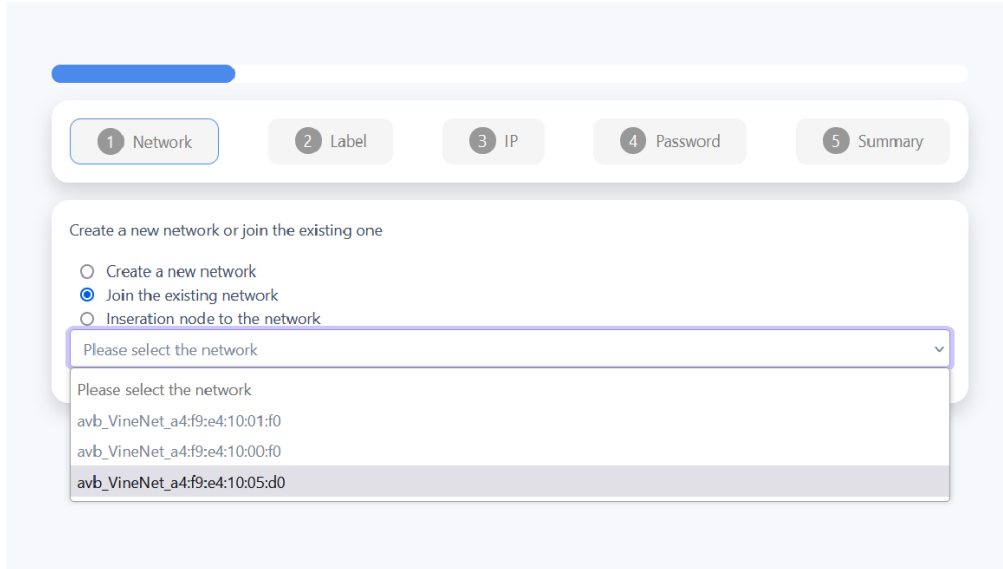
3. Select "Join the existing network" and use the drop-down menu to select the correct upstream node.
4. Click "Next"

5. Configure the Node Type and Node Label
6. Click "Next"
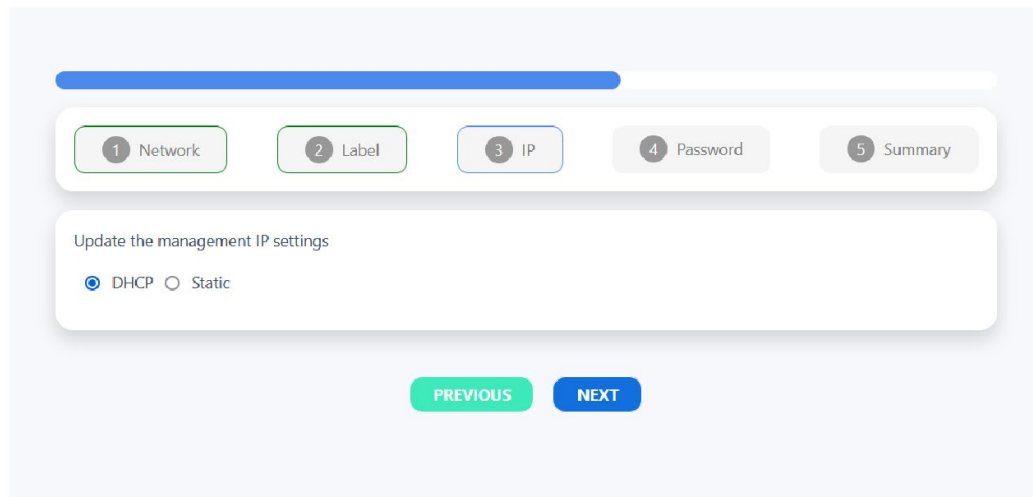
7. Configure the management IP settings.
8. Click "Next"
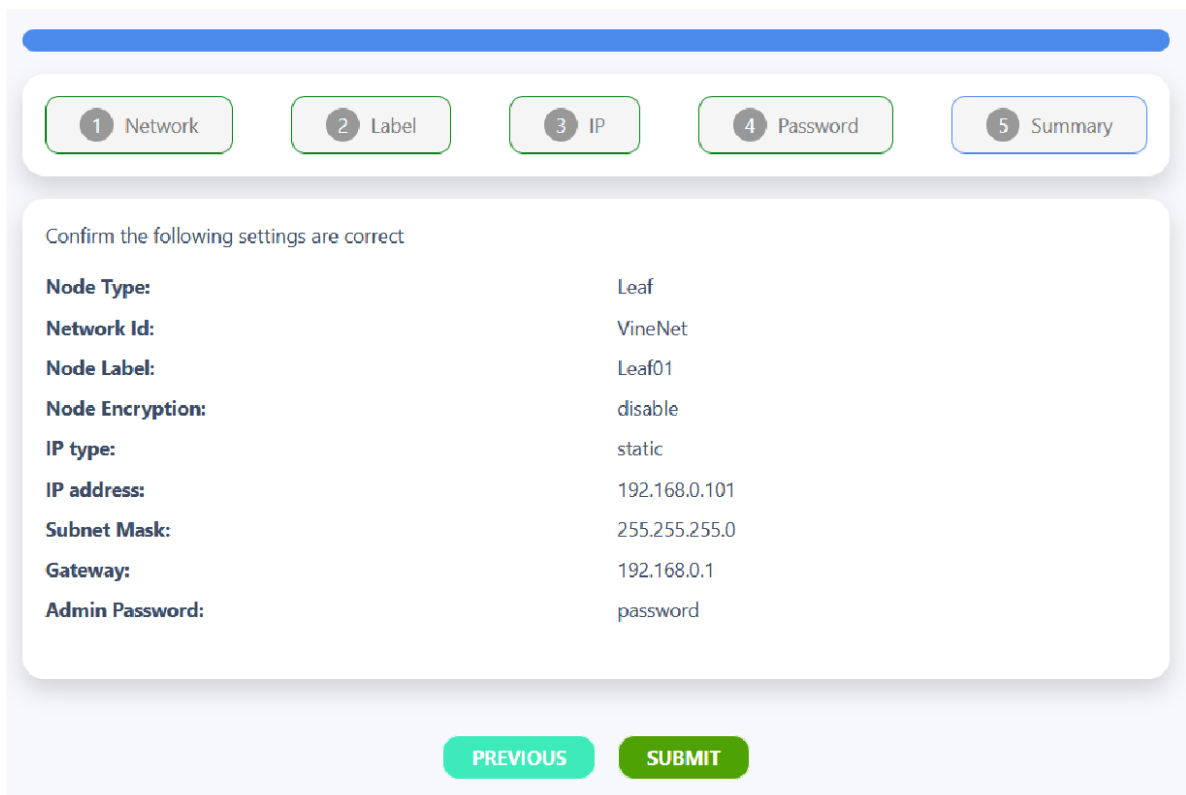
9. Configure a new password with a minimum of 8 characters.
10. Click "Next"

11. Review configuration and select "Submit" if no changes are needed.

12.Log into WaveTunnel™ with the new network credentials.

13.For Leaf Nodes 3 and 4, perform the same Leaf Bridge Configuration steps as Leaf Node 2.
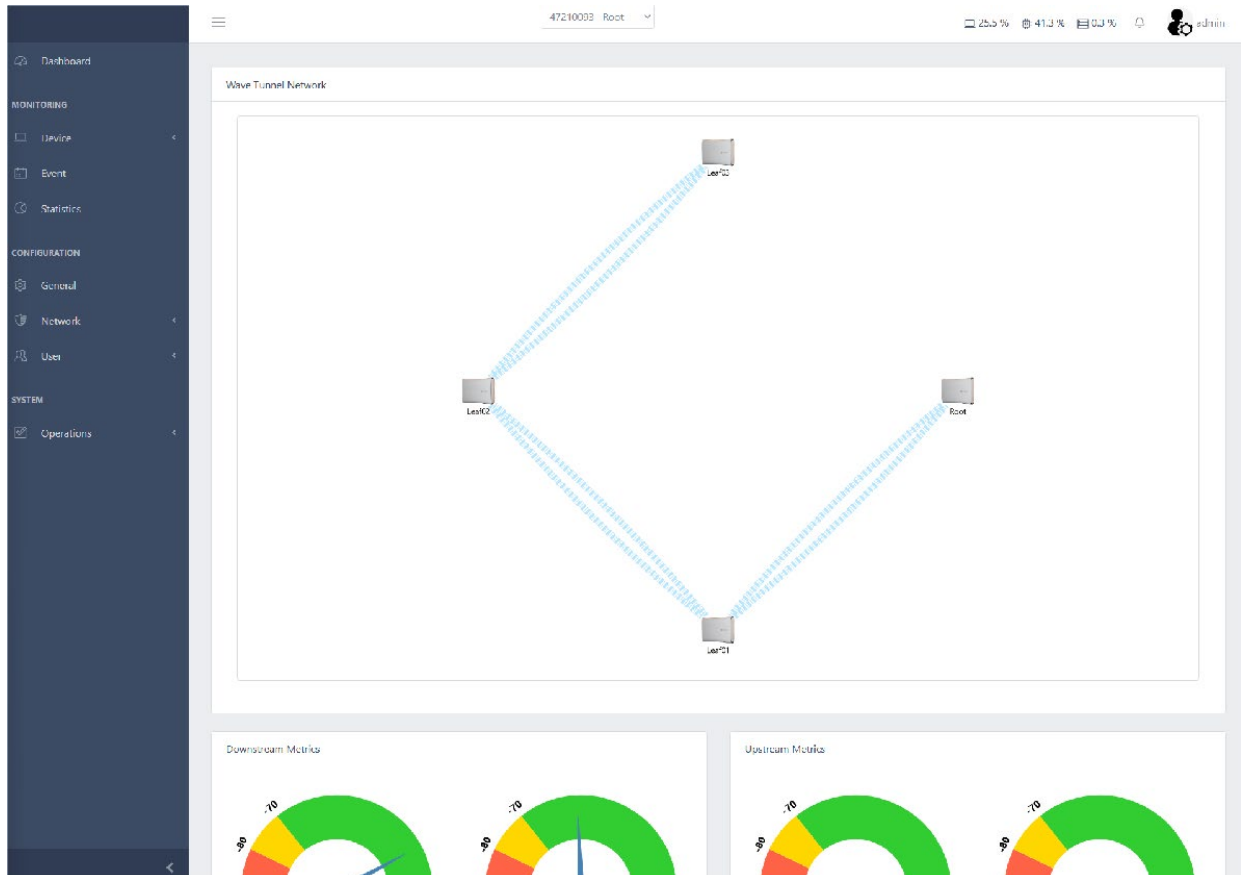
14. To close the loop on the WaveTunnel™ network, log into the Root bridge and go to Configuration > Network > WaveTunnel™ and Enable the Upstream Tunnel Connection if it is not already enabled.

15. Configure the Connection Name and select "Save".
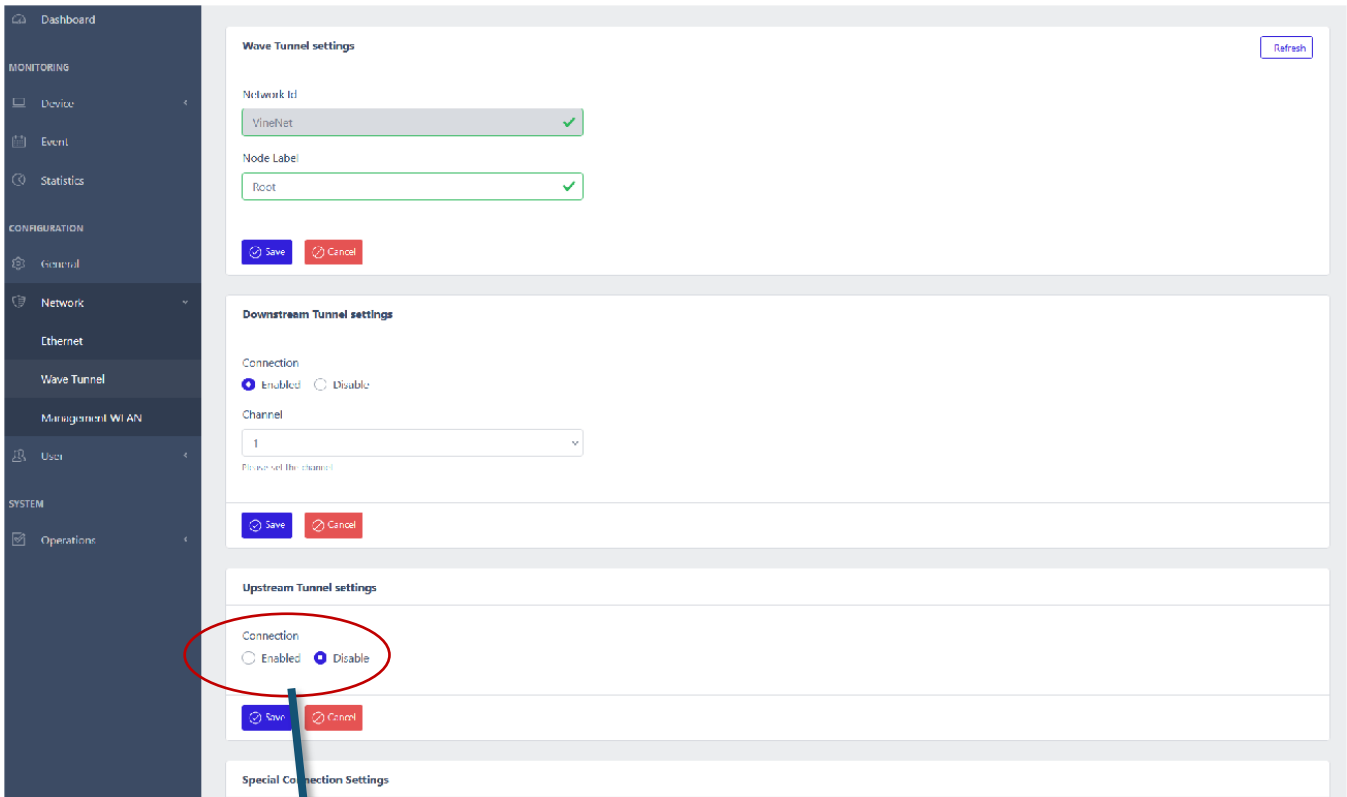
Upstream Tunnel settings

Connection

● Enabled ○ Disable

Connection Name

VineNet Ring ✔

[Save] [Cancel]

16. Just below this setting, under Special Connection Settings select Close Ring Network

17. Click "Close" and "Yes" to Confirm
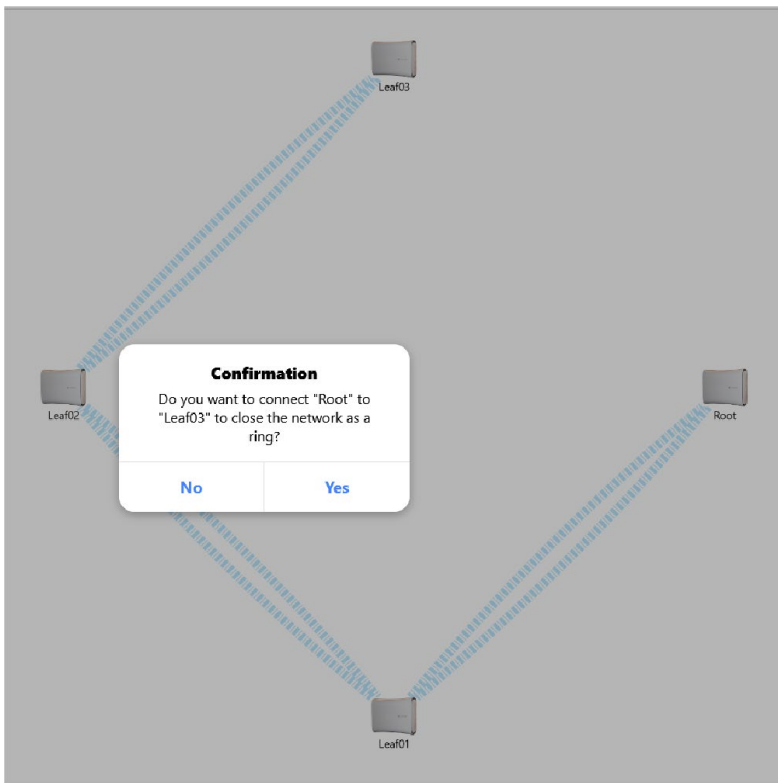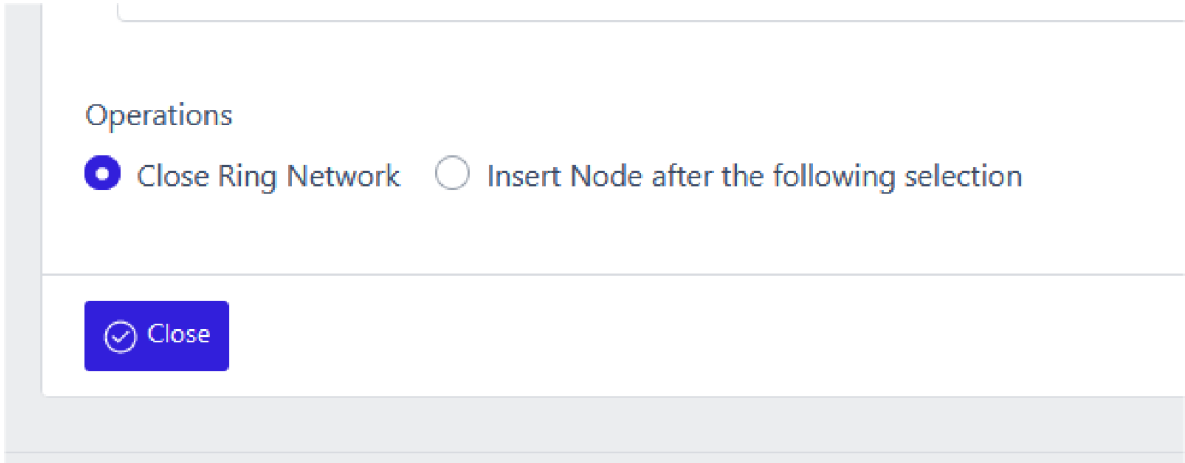
18. Congratulations! Your network is configured.

19. Have fun evaluating the gear and please let us know if there is anything that we can do to assist support@airvine.com
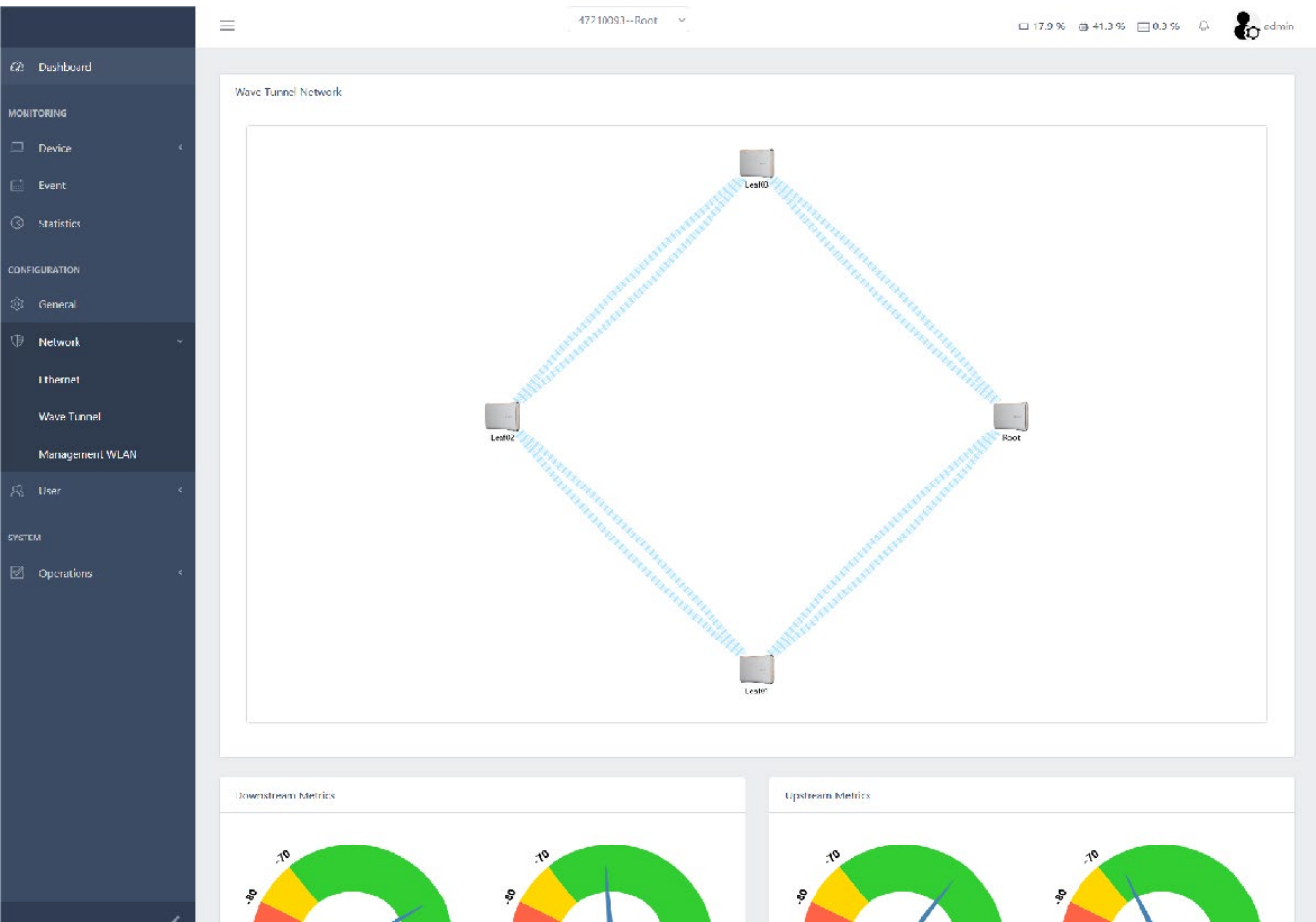
iOS Mobile App Configuration

1. Note the MAC Address of the WaveTunnel™ that is to be configured. A label is located on top of the WaveTunnel™ or under configuration > Monitoring > Device > General and view the MAC Address
2. If the WaveTunnel™ is to be configured as a Leaf bridge, note the MAC address of the upstream Root or Leaf bridge to be connected to.
3. Open the AirvineMobile App and you should see the Wi-Fi Network SSID that you are connected to.
4. Click "Select Device Wi-Fi" and the list of Wi-Fi Services menu will appear.
5. Select the SSID that matches the MAC address of the WaveTunnel™ to be configured.
6. Enter "airvine!" as the SSID WPA2 password and click "Join".
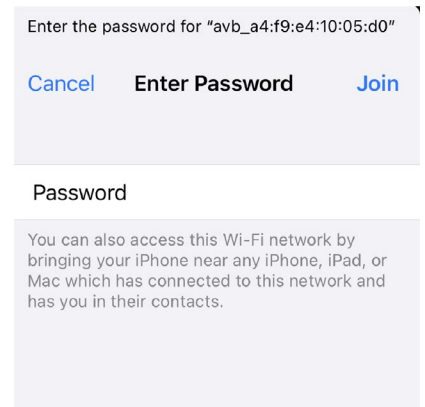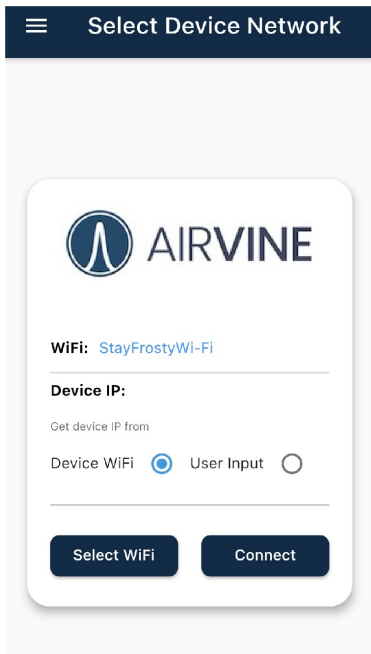
7. Go back to the AirvineMobile App
8. Click on "Connect"
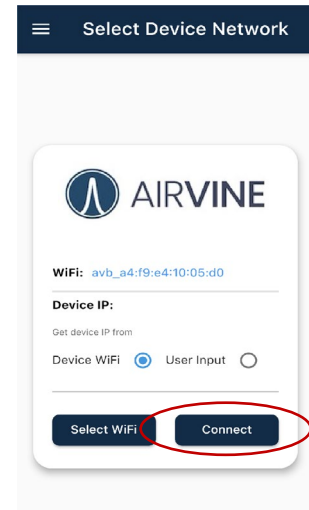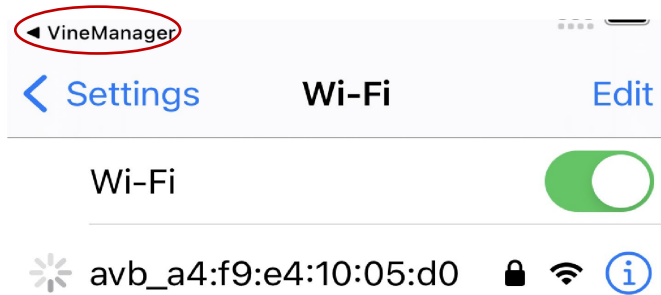
9. For a new network, select "Create a new network" then click on "Next".
   a. "Join the network" can be used to configure additional nodes onto an existing network.
10. Configure a Node Type and Device Label for the WaveTunnel™, click "Next".
11. Configure network settings for the WaveTunnel™, click "Next".
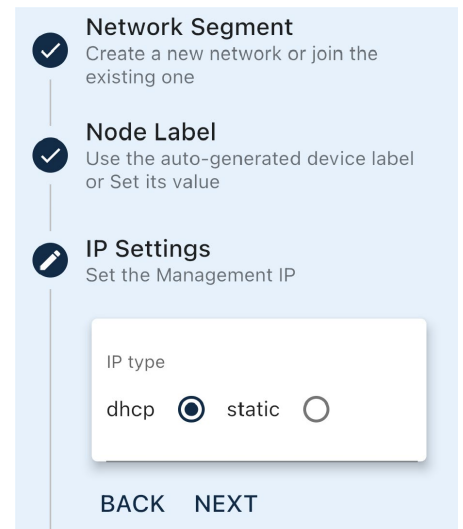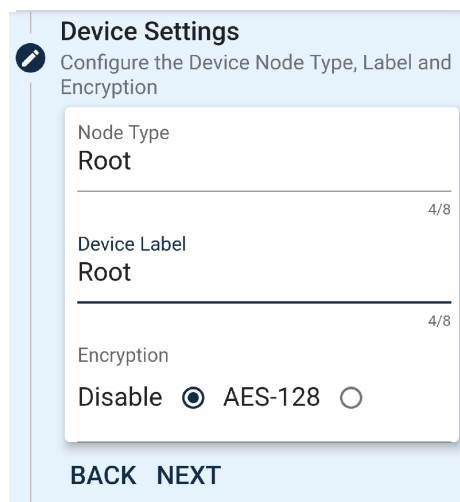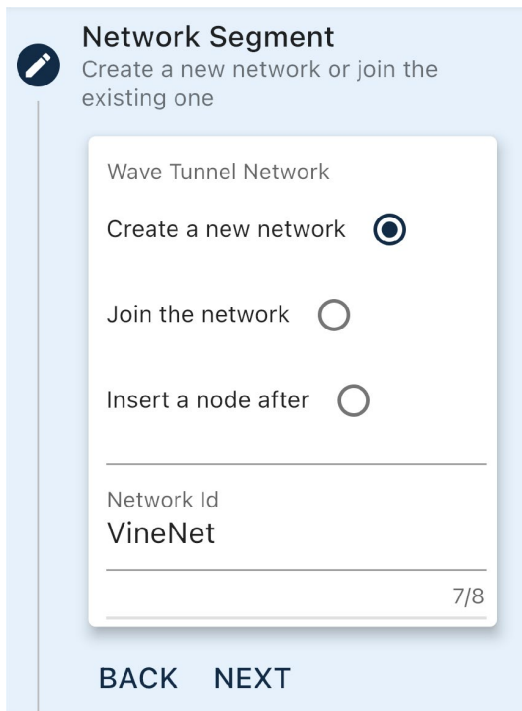
12. Configure an Admin Password for the WaveTunnel™, click "Next".

13. Review Summary, click "Next".

14. The WaveTunnel™ bridge will now initialize.

15. Note the new management SSID.

16. Click "Continue"

Network Segment
Create a new network or join the existing one

Node Label
Use the auto-generated device label or Set its value

IP Settings
Set the Management IP

Admin Password
Change the Admin Password

Password
admin

5/16

BACK   NEXT

Summary
Please confirm the following settings are correct

Node Type:	Root node
Network Id:	VineNet
Device Label:	Root
Password:	admin
IP Type:	Static
IP Address :	192.168.0.100
Subnet Mask :	255.255.255.0
Gateway :	192.168.0.1

BACK   NEXT

The Initialization is completed

Please logout and switch to the new management SSID"
avb_VineNet_Root"

Continue   Cancel

17. Click "Select Wi-Fi"
18. Click on the new management SSID, in this case avb_VineNet_Root
19. Go back to the VineManager App
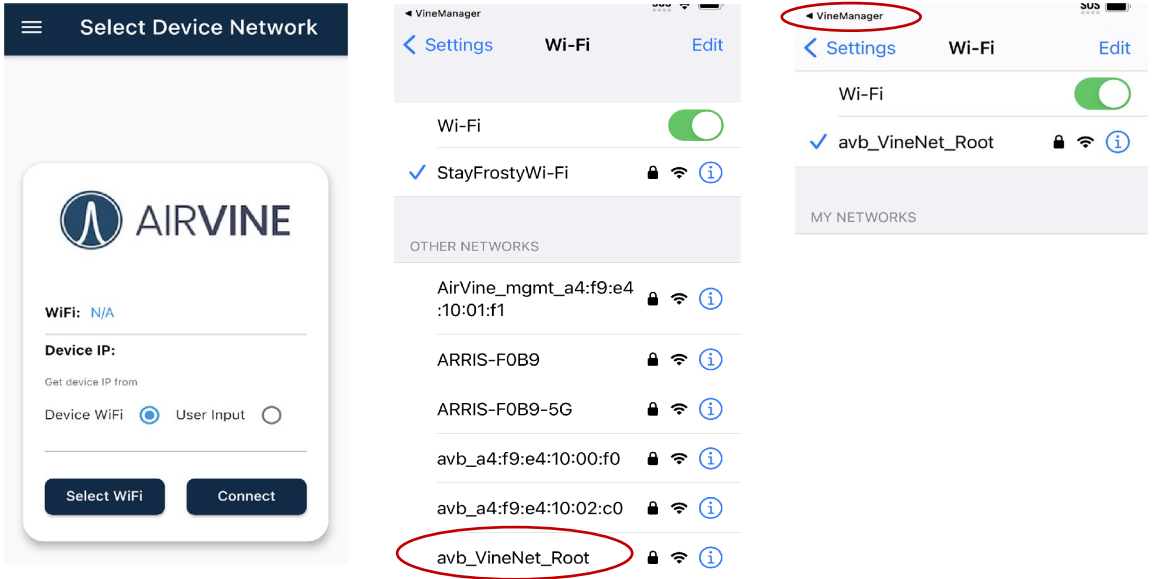
20. Click "Connect"
21. Enter the configured username and password and select "Log In".
22. Congratulations!
23. For Leaf node configuration and connecting the ring, see Leaf Bridge Configuration.
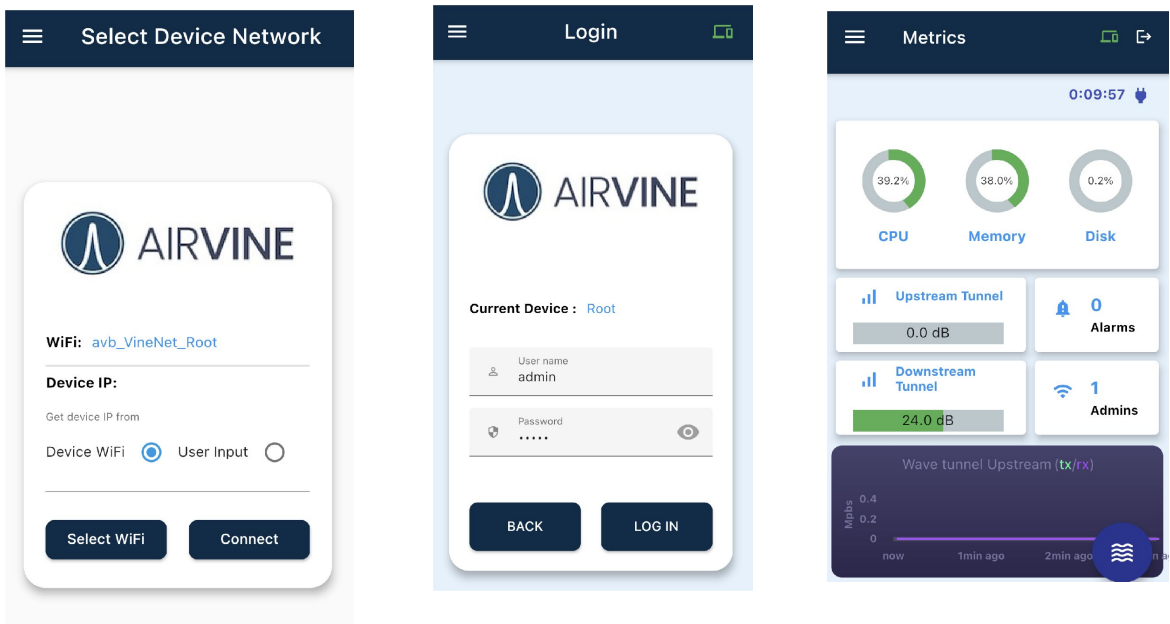
Android Configuration Mobile App

1. Note the MAC Address of the WaveTunnel™ bridge that is to be configured.
2. If the WaveTunnel™ is to be configured as a Leaf bridge, note the MAC address of the upstream Root or Leaf bridge to be connected to.
3. Open the AirvineMobile App and you should see the Wi-Fi Network SSID that you are connected to.
4. Click "Select Wi-Fi" and the list of Wi-Fi Services menu will appear.
5. Select the SSID that matches the MAC address of the WaveTunnel™ to be configured.

6. Enter the SSID WPA2 password "airvine!" and select "Connect".
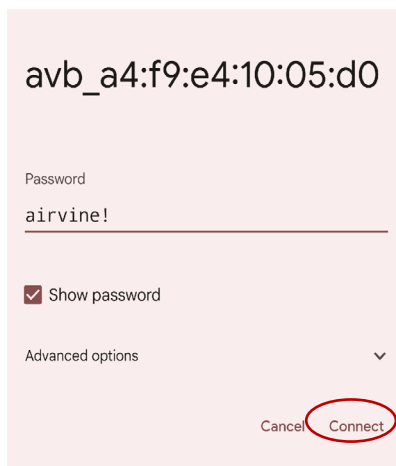
7. The Android device will obtain an IP Address from the WaveTunnel.

8. If the "Tap for options" & "no internet access" notifications pop up, click on "Yes".
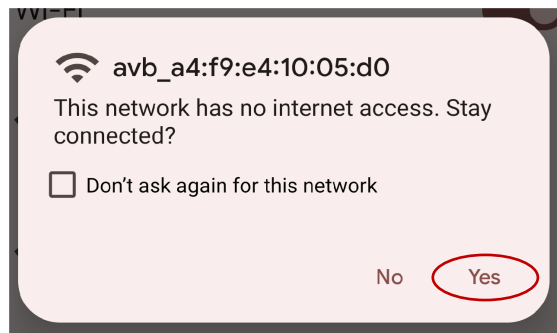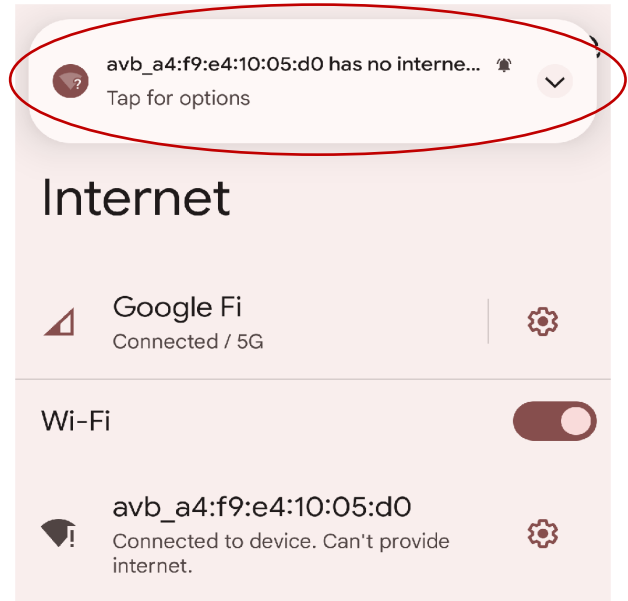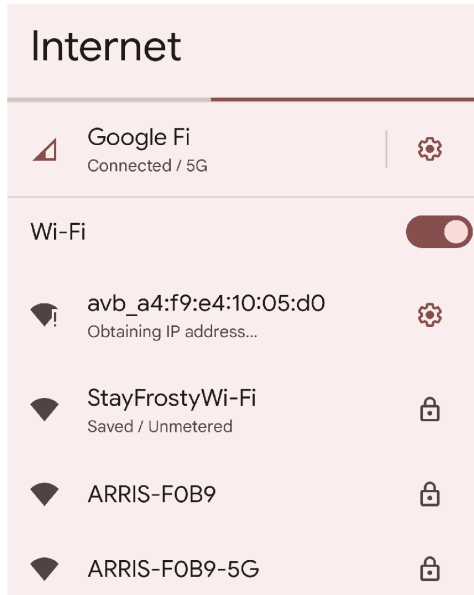
9. Go back to the AirvineMobile App
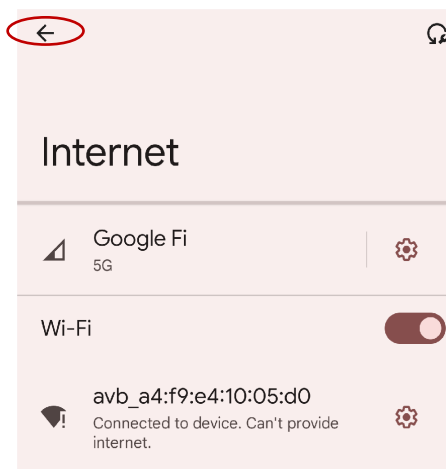
10. For a new network, select "Create a new network", click "Next".
    a. "Join the network" can be used to configure additional nodes onto an existing network.
11. Configure the name for the WaveTunnel™, click "Next".
12. Configure network settings for the WaveTunnel™, click "Next".

Network Segment
Create a new network or join the existing one

Wave Tunnel Network

Create a new network ⦿

Join the network ◯

Insert a node after ◯

Network Id
VineNet

7/8

BACK   NEXT

Device Settings
Configure the Device Node Type, Label and Encryption

Node Type
Root

4/8

Device Label
Root

4/8

Encryption
Disable ⦿   AES-128 ◯

BACK   NEXT

Network Segment
Create a new network or join the existing one

Node Label
Use the auto-generated device label or Set its value

IP Settings
Set the Management IP

IP type
dhcp ⦿   static ◯

BACK   NEXT

13. Configure an Admin Password for the WaveTunnel™, click "Next".
14. Review Summary, click "Next".
15. The WaveTunnel™ bridge will now initialize.
16. Note the new management SSID.
17. Click "Continue"

Network Segment
Create a new network or join the existing one

Node Label
Use the auto-generated device label or Set its value

IP Settings
Set the Management IP

Admin Password
Change the Admin Password

Password
admin
5/16

BACK   NEXT

Summary
Please confirm the following settings are correct

Node Type: Root node

Network Id: VineNet

Device Label: Root

Password: admin

IP Type: Static

IP Address :   192.168.0.100

Subnet Mask : 255.255.255.0

Gateway :   192.168.0.1

BACK   NEXT

The Initialization is completed

Please logout and switch to the new management SSID"
avb_VineNet_Root"

Continue   Cancel
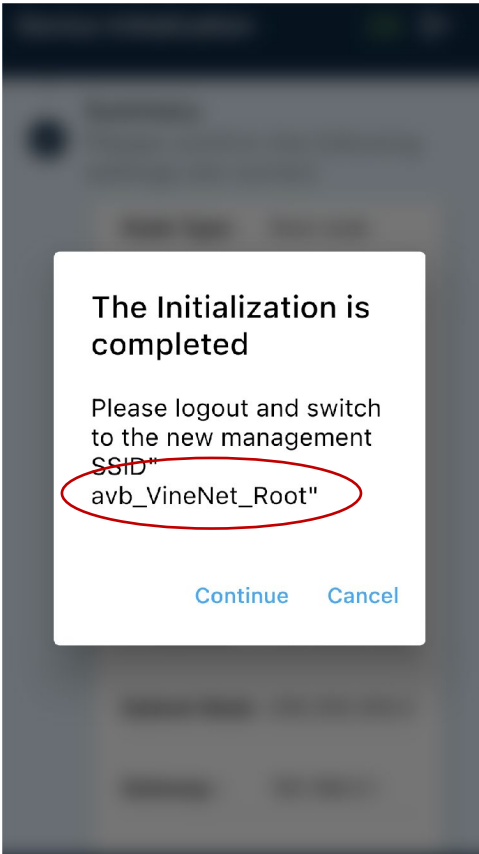
18. Click "Select Wi-Fi"
19. Click on the new management SSID, in this case avb_VineNet_Root
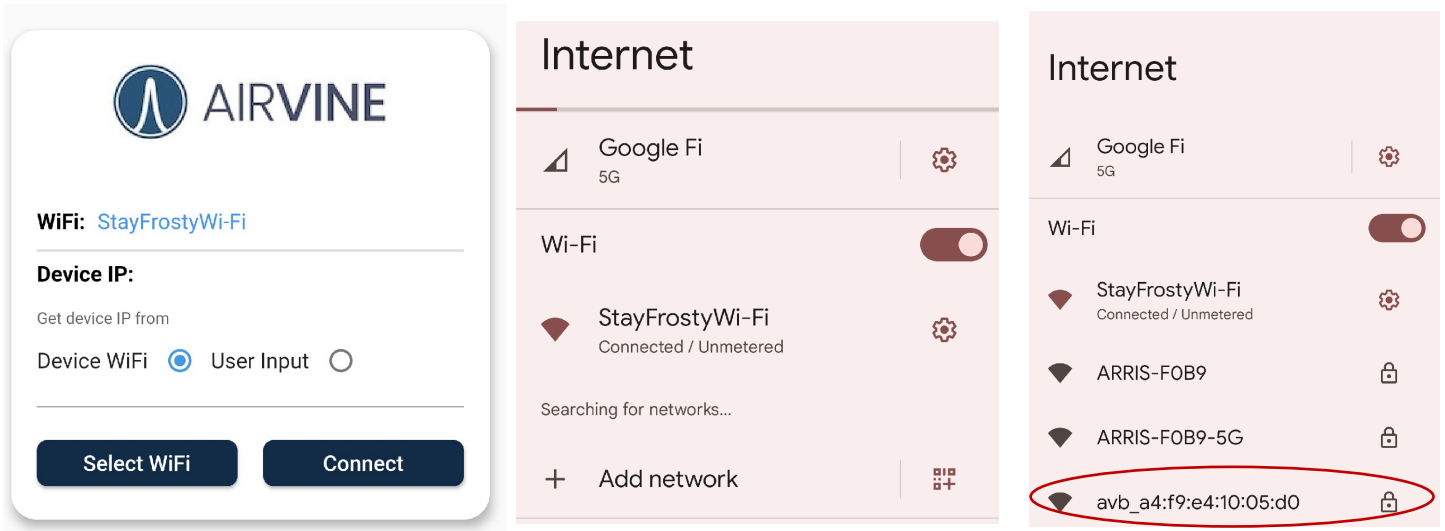20. Go back to the AirvineMobile App
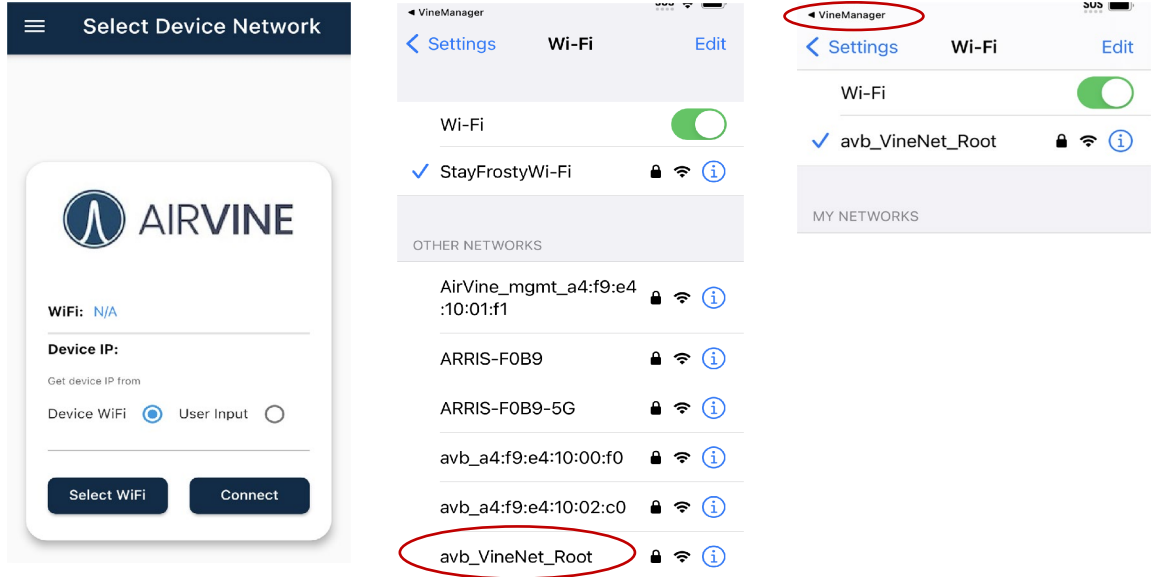
21. Click Connect
22. Enter the configured username and password, click "Log In".
23. Congratulations!
24. For Leaf node configuration and connecting the ring, see Leaf Bridge Configuration.
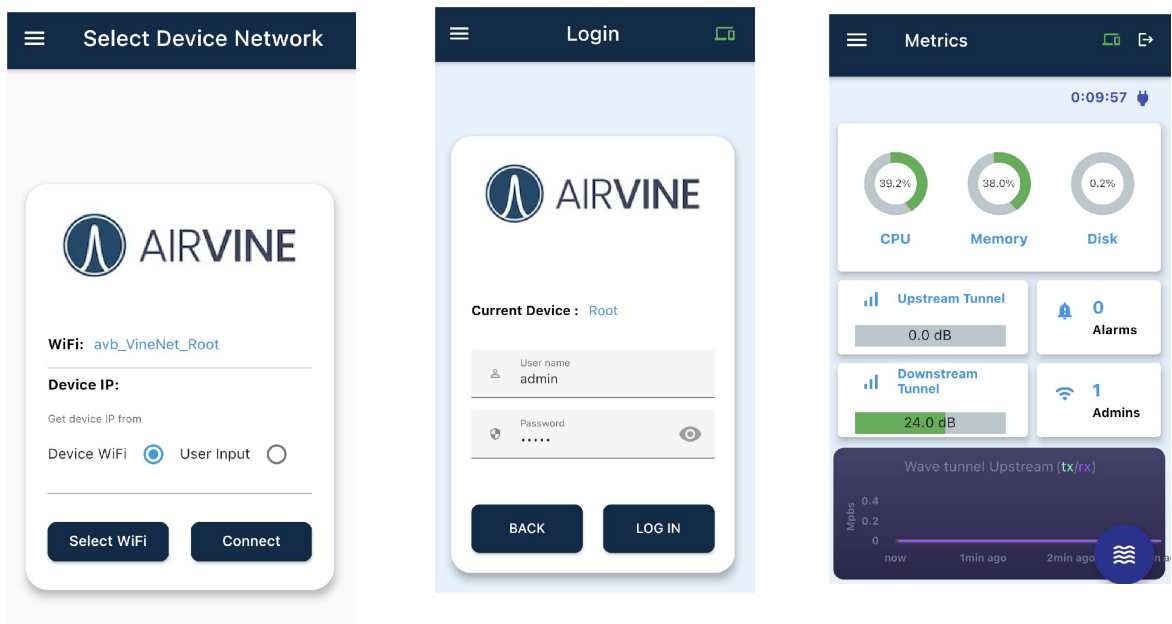
WaveTunnel™ Orientation

The correct physical placement of the WaveTunnel™ bridge is critical for link communication. Orientating the Downstream antenna of the Root node to the Upstream antenna for the Leaf node is shown in the diagram below.
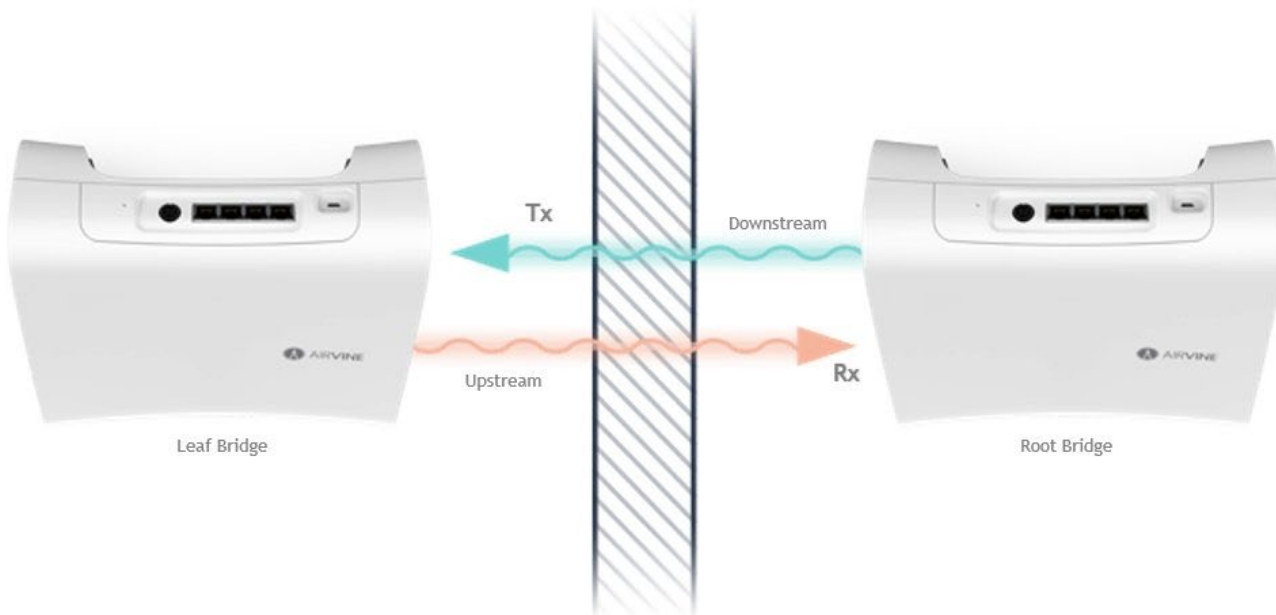
Each WaveTunnel™ unit contains two 60 GHz radios on either side of the WaveTunnel.

Downstream Radio: The 60 GHz Radio Located on the side furthest from the Airvine Logo is referred to as Downstream Radio. The WaveTunnel™ 2 LED corresponds to the Downstream Radio.

Upstream Radio: The 60 GHz Radio Located on the side closest to the Airvine Logo is referred to as Upstream Radio. The WaveTunnel™ 1 LED corresponds to the Upstream Radio.
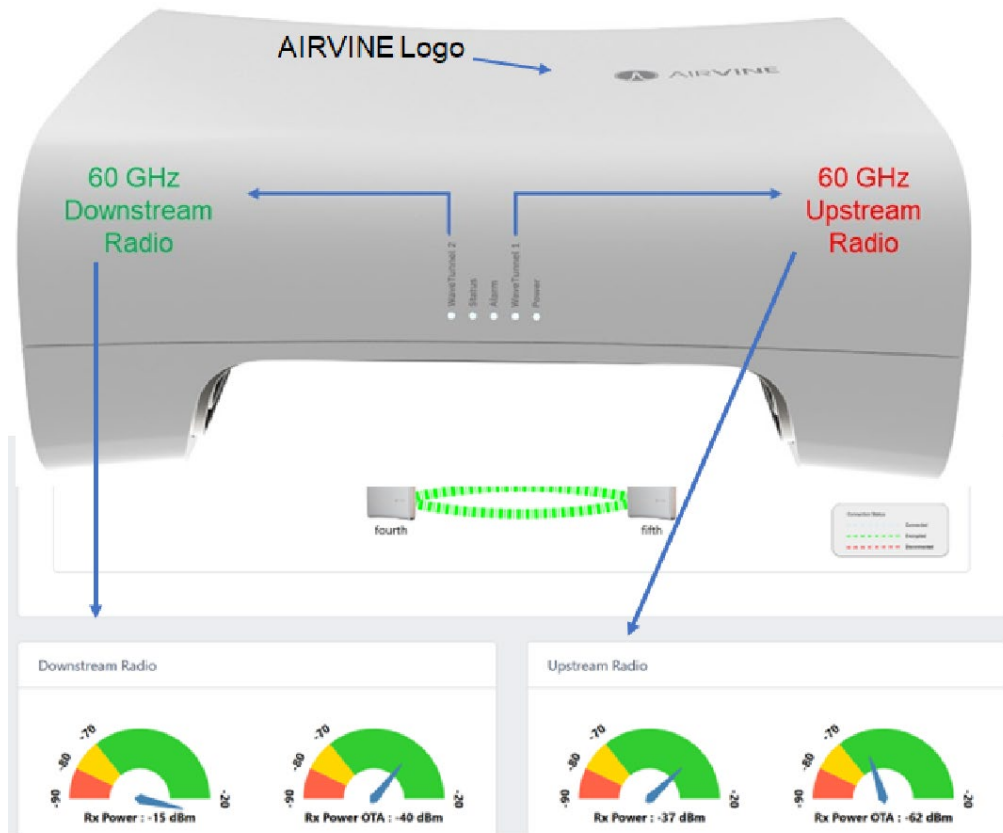
The Downstream Radio is responsible for initiating the wireless connection to an Upstream Radio. Using Wi-Fi terminology, the Downstream Radio is analogous to an Access Point while the Upstream Radio is analogous to a Client. Configuring and/or obtaining status of the Downstream Radio and Upstream Radio is performed using the Web GUI, Mobile App, or CLI.

Connecting WaveTunnel™ Units Together

To wirelessly connect WaveTunnel™ units together into a daisy chain or a ring topology, the physical orientation of the radio must be such that a Downstream Radio is always communicating an Upstream Radio.
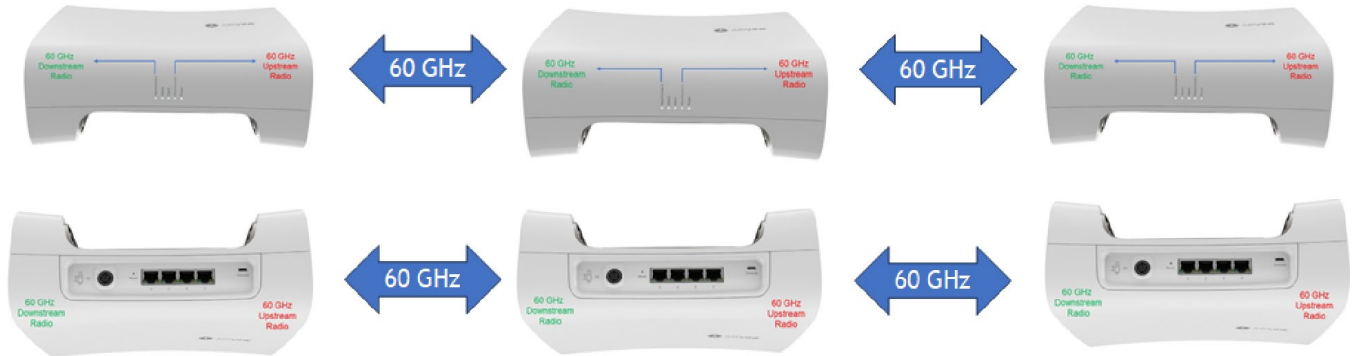
Note: Having one of the WaveTunnel™ units in an upside-down orientation (not common) IS INDEED valid so long as the Downstream-to-Upstream radio wireless connection rule is followed.

Invalid WaveTunnel™ Connections

The following physical orientations Invalid Downstream-to-Downstream Radio Connections and Upstream-to-Upstream radio connections are **NOT** supported.
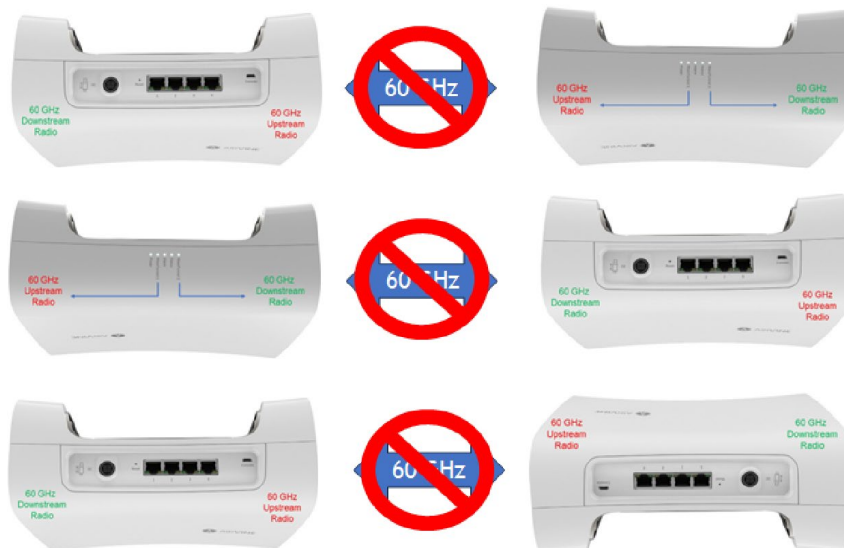
Evaluation: WaveTunnel™ Staging

Staging for a WaveTunnel™ evaluation can be as simple as placing two WaveTunnel™ bridges on a tabletop, powering up, and configuring the units as a simple two node chain topology. For advanced staging and evaluation testing, the WaveTunnel™ bridges can easily be placed on tripods.

> *Note: mark the WaveTunnel™ bridges for correct orientation, this is especially useful if the WaveTunnel™ nodes will be moved to multiple locations.*

- Two WaveTunnel™ node chain topology staged on a tabletop.

- Four WaveTunnel™ node ring topology staged on a tabletop.

- WaveTunnel™ node cluster configuration staged on portable tripods.

Evaluation: Network Configuration

Shown below is a suggested network configuration for a two-node evaluation. If the WaveTunnel™ bridges will be connected to a host network, modification of the static network setting may be required.
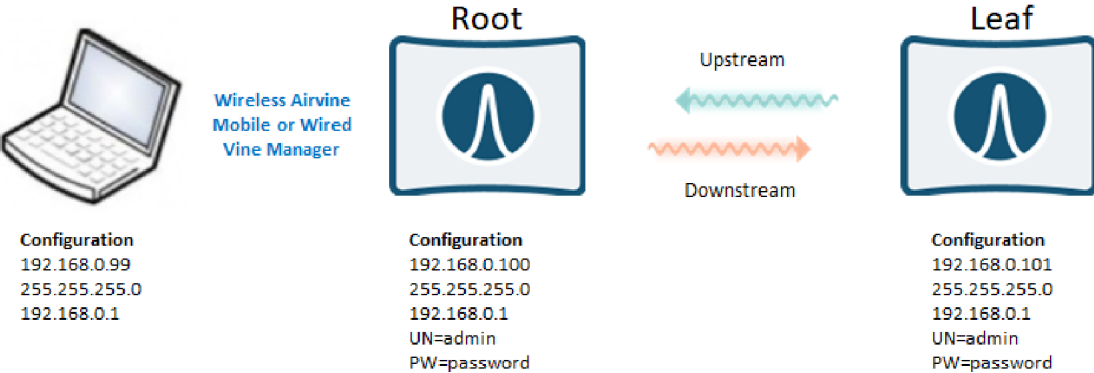
For monitoring link connectivity throughout the evaluation process, a continuous ping may be useful.

> *Note: for evaluation and testing in a corporate, education or other secured network setting, check with your IT staff about testing and disabling port security on the network port(s) connecting to the WaveTunnel™ cluster. Also check on VLAN setting as needed. WaveTunnel™ bridges will pass VLAN tagged traffic by default and are not configured to block any network traffic.*

```
C:\Users\chris>ping 192.168.0.100 -t

Pinging 192.168.0.100 with 32 bytes of data:
Reply from 192.168.0.100: bytes=32 time=3ms TTL=64
Reply from 192.168.0.100: bytes=32 time=1ms TTL=64
Reply from 192.168.0.100: bytes=32 time<1ms TTL=64
```

```
C:\Users\chris>ping 192.168.0.101 -t

Pinging 192.168.0.101 with 32 bytes of data:
Reply from 192.168.0.101: bytes=32 time=15ms TTL=64
Reply from 192.168.0.101: bytes=32 time=1ms TTL=64
Reply from 192.168.0.101: bytes=32 time=1ms TTL=64
```

Evaluation: Test Tools

In addition to WaveTunnel™ connectivity, users may want to optimize the link between WaveTunnel™ bridges. There are several useful built-in tools that can assist with getting an optimized connection for the highest data throughput.

Dashboard Gauges are a quick way to see the status and link integrity of a WaveTunnel™ connections. There are four gauges that are included in the dashboard.

Rx Power: Received Power after the Automatic Gain Control (AGC) at the Analog to Digital Converter (ADC) input. Best performance and tuning from -20 to -70 dBm.
> *Note: While other performance gauges may show yellow or even orange readings, if the Rx Power gauge is in green, link performance should be good.*

Rx Power OTA (Over the Air): Received Power after the Rx Antenna and before AGC. Optimum range is from -20 to -70dBm.

SNR: Signal to Noise ratio of the link connection. Optimum range is from 40 to 25dB.

Packet Error Rate (PER): Rate of error packets that are received and typically is less than 5%. Other conditions should be noted and addressed.
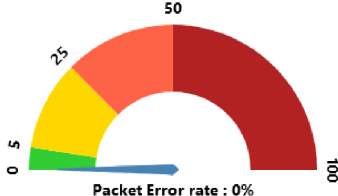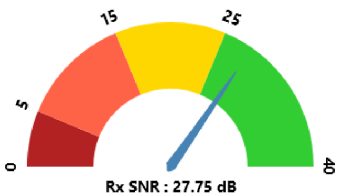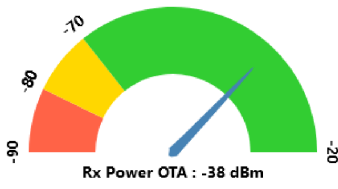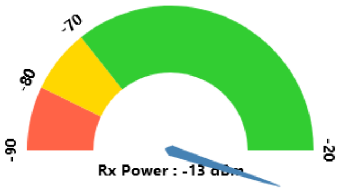
In addition to the dashboard gauges, take notice of the statistics at Monitoring > Device > WaveTunnel. The same stats displayed on the dashboard are listed here as well as several other performance tuning states.

Downstream Radio Status

Rx Power	-12.50 dBm
Rx Average Signal to Noise Ratio	25.75 dB
Rx Power OTA	-37.50 dBm
Rx Packet Error Rate (PER)	0.12 %
Tx MCS	10
Rx MCS	9
Tx Beam Index	23
Rx Beam Index	27
Modem Temperature	55 °C
Radio Temperature	59 °C

Tx and Rx MCS Rate are the modulation and coding scheme index values. Higher MCS index offers a higher spectral efficiency that translates to a higher potential data rate at higher SNRs. The range of MSC is 1-10 with 7-10 MSC
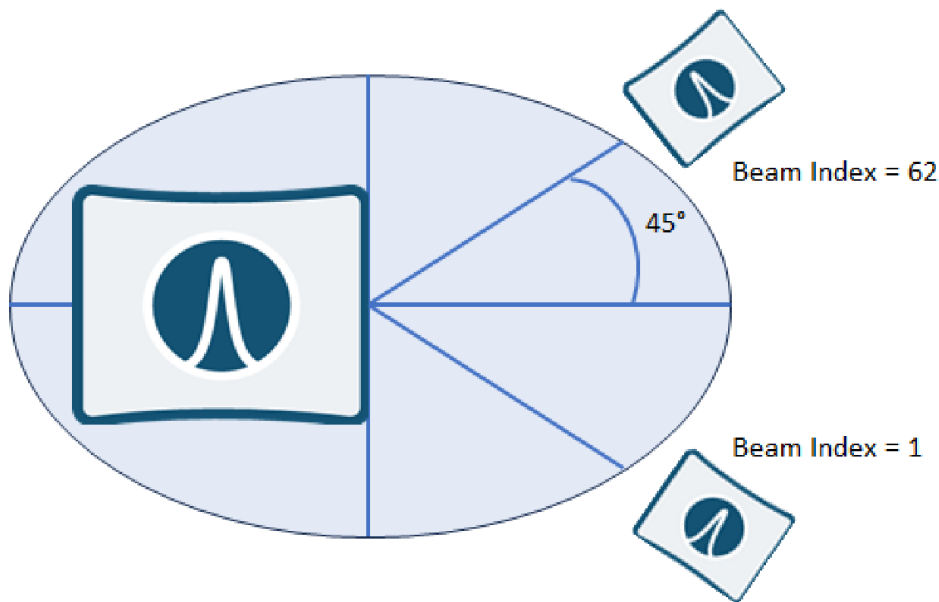
Evaluation: Scenarios

Provided below are some typical test scenarios for a WaveTunnel™ evaluation. A predictive WaveTunnel™ VineCalculator is provided on the Airvine website at https://services.airvine.com/calculator/

Open Air Connectivity
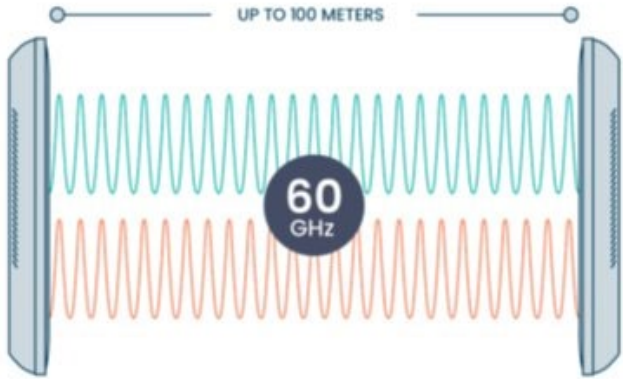
Example Test Results

Test: 1m clear line of sight	
Rx Power	-13dBm
SNR	25.25dB
Rx Power OTA	-38dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps

Test: 144m clear line of sight	
Rx Power	-50.50dBm
SNR	7.25dB
Rx Power OTA	-75.50dBm
PER	0.51
Tx MCS	8
Rx MCS	6
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.2Gbps

Single / Multiple Drywall
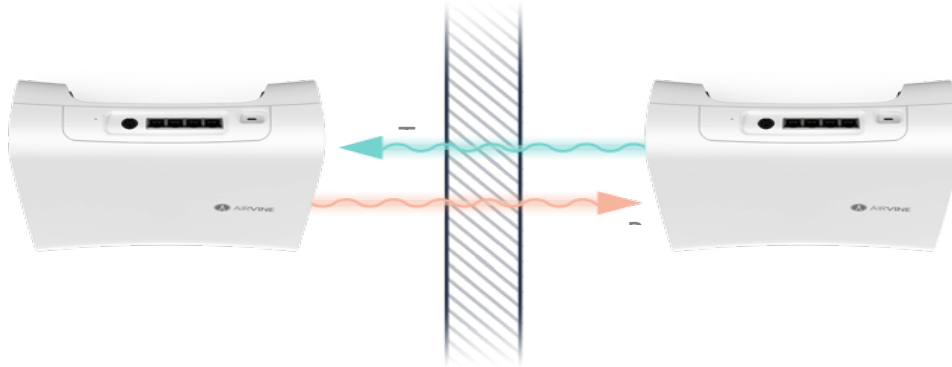
Example Test Results

Test: One Interior Wall 10' distance	
Rx Power	-27dBm
SNR	26.00dB
Rx Power OTA	-52dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps
Test: Two Interior Walls 15' distance	
Rx Power	-30dBm
SNR	23.50dB
Rx Power OTA	-54.5dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	32
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps

Test: Three Interior Walls 23' distance	
Rx Power	-39dBm
SNR	21.50dB
Rx Power OTA	-64.5dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	33
Rx Beam index	33
Traffic sent from Leaf to Root	1.5Gbps

Wood Door

Example Test Results

Test: Wood Door	
Rx Power	-31dBm
SNR	23.75dB
Rx Power OTA	-57dBm
PER	0%
Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.4Gbps

Glass Wall

Example Test Results

Test: Glass Wall	
Rx Power	-28dBm
SNR	25.00dB
Rx Power OTA	-53dBm
PER	0%

Tx MCS	10
Rx MCS	10
Tx Beam Index	31
Rx Beam index	32
Traffic sent from Leaf to Root	1.5Gbps

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	

Worksheet

Test: _____   Test: _____

Test: _____   Test: _____

Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	
Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	
Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	

Traffic sent from Leaf to Root	
Test:	
Rx Power	
SNR	
Rx Power OTA	
PER	
Tx MCS	
Rx MCS	
Tx Beam Index	
Rx Beam index	
Traffic sent from Leaf to Root	