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EdgeLink II mmW Transport System User Manual

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List of Acronyms

BH	Backhaul
FH	Fronthaul
FW	Firmware
GUI	Graphical User Interface
IP	Internet protocolIndicators
KPI	Key Performance
mmW	millimeter wave
NC	Network Controller
Node	Antenna unit
OVS	Open Virtual Switch
PM	Performance Monitor Application
SDN	Software Defined Network
USB	Universal Serial Bus
VESA	Video Electronics Standards Association
WiGig	Wireless Gigabit Alliance
5G	Fifth Generation

1 Scope

This document describes InterDigital's mmW Mesh L2 Transport Network (EdgeLink) and includes high level desciptions of it's hardware and software components, capabilities, installation procedure,system operating instructions and common troubleshooting notes.

Release Notes will include:

1. List of installed SW/version
2. List of delivered HW equipment/serial number
3. Network Setup Diagram with actual MAC addresses of delivered EdgeLink Nodes

2 Introduction

InterDigital's mmW Mesh Transport is a wireless 5G solution that can deliver high capacity links with very low latency. It is capable of multiplexing packetized Fronthaul and Backhaul traffic on a unified network under the control of Software Defined Networking (SDN) mesh controller over long range (>200m) mmW links using high gain fixed antennas installed with Edgelink nodes . The system can be installed indoor or outdoor to provide network connectivity over an unlicensed 60 GHz data link.

EdgeLink I and EdgeLink II are the two versions of EdgeLink Nodes that are available. The EdgeLink I & II Antenna Units are interchangeable and additional details of each version will be described. This User Manual will focus on instructions for the EdgeLink II Mesh configuration and setup. MA82734_EdgeLink mmw Transport System Model I User Guide will provide the instructions for the EdgeLink I Mesh configuration and setup.

System components will include the following:

EdgeLink mmW Mesh SW and Network Controller capabilities:

- Automated mesh topology
- SDN framework (ONOS)
- End to End low-latency
- Traffic routing algorithms
- Link failure recovery via alternate path

EdgeLink mmW Mesh Nodes capabilities:

- Network discovery and neighbor Selection
- OpenFlow Virtual Switch (Open vSwitch)
- mmW - 802.11ad (WiGig)
- Supports the following GHz frequencies:
  - Ch1 – 58320 GHz
  - Ch2 – 60480 GHz
  - Ch3 – 62640 GHz
  - Ch4 – 64800 GHz

An EdgeLink I Node will require the EdgeLink I Processor Unit (Figure 1) and at least one EdgeLink I Antenna Unit (Figure 4) to operate with 1 sector. A second EdgeLink I Antenna Unit can be attached to the EdgeLink I Processor Unit to operate as the second sector.

An EdgeLink II Node will require only the the EdgeLink II Processor Unit (Figure 2) to operate with 1 sector. The Antenna Unit has been integrated into the EdgeLink II Processor Unit. A second EdgeLink I (Figure 4) or EdgeLink II (**Error! Reference source not found.**) Antenna Unit can be attached the the E dgeLink II Processor Unit to operate as the second sector

Processor Unit Types– EdgeLink Processor Units are available in two different versions (e.g. EdgeLink I and EdgeLink II).

1. Figure 1 – EdgeLink I - Processor Unit contains a LS1043A reference design board. It is an off the shelf unit that has been modified with a new linux kernel, root file system and uboot. It is also configured with proprietary SW and is referenced as the Edgelink I Processor Unit. This unit is used for indoor deployment only.
2. Figure 2 – EdgeLink II Processor Unit contains the same LS1043A reference design board used in EdgeLink I with additional enhancements. These include a Wi-Fi debug subnet, integrating the Antenna Unit and LS1043A-RDB into a weatherproof enclosure and Power over Ethernet (PoE) support to the unit. These enhancements were implemented to support rapid outdoor deployment and have been field tested.

Antenna Unit Types – EdgeLink Antenna Units are available in two different versions (EdgeLink I and EdgeLink II).

1. **Error! Reference source not found.**Figure 2 – EdgeLink II Processor Unitcontains a 28dBi high gain directional antenna and the EdgeLink USB dongle which are all housed in a weather proof enclosure. The weather proof enclosure is attached to an articulating mounting assembly. Power to the Antenna Unit is supplied from the Processor Unit via the USB cable connection.
2. **Error! Reference source not found.** contains the same 28dBi hghi gain directional antenna and t he EdgeLink USB dongle which are all housed in a weather proof enclosure. The weather proof enclosure is attached to an articulating mounting assembly. Power to the Antenna Unit is supplied from the Processor Unit via the USB cable connection. The only difference between the EdgeLink I and EdgeLink II Antenna Unit is the form factor, therefore they are interchangeable.

Figure 1 – EdgeLink I - Processor Unit

The following table provides the mapping between the FSL Procesor Unit Front Panel as shown in Figure 1 and the corresponding interface networks that will be used in the EdgeLink System.

Table 1 - FSL Front panel mapping

FSL front panel	Port name	Type	Usage
QSGMII.P0	fm1-mac1	100M/1G ethernet	Debug subnet
QSGMII.P1	fm1-mac2	100M/1G ethernet	NC control
10G	fm1-mac9	10G ethernet	Point of Access
USB1	wlan0	USB 3.0	mmW wireless
USB2	wlan1	USB 3.0	mmW wireless

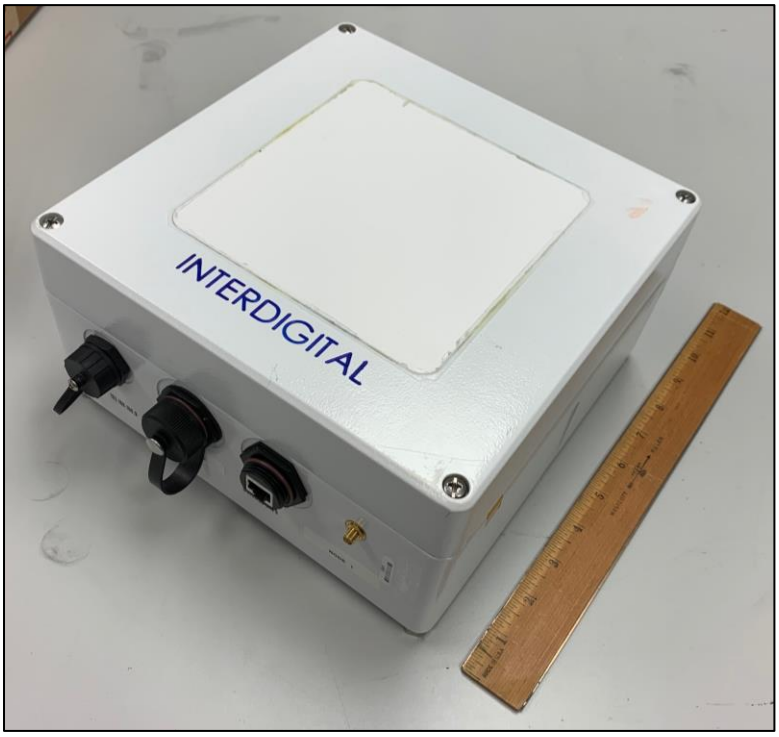


Figure 2 – EdgeLink II Processor Unit

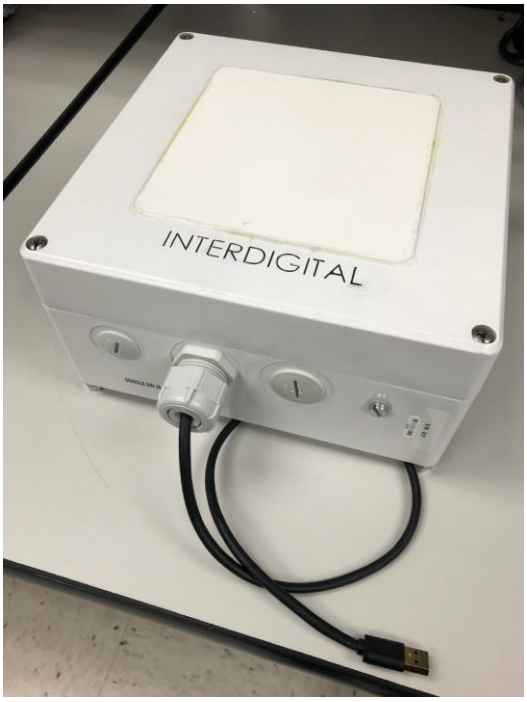


Figure 3 – EdgeLink II Antenna Unit

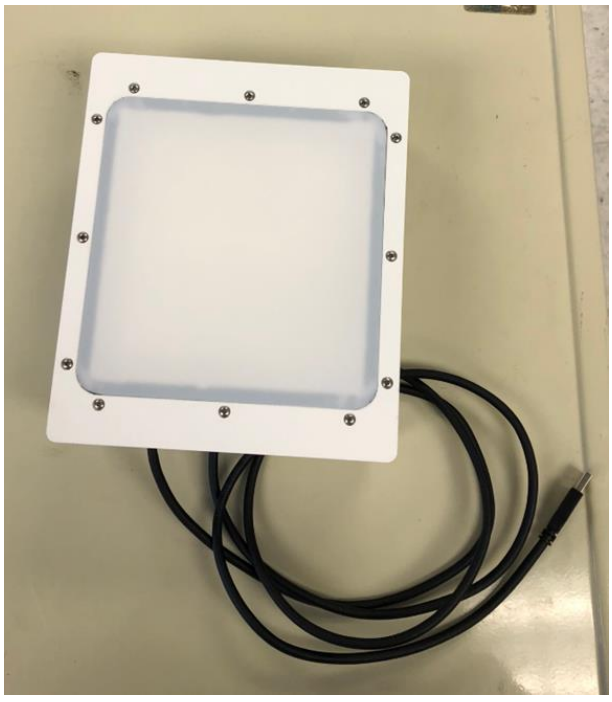


Figure 4 – EdgeLink I Antenna Unit

3 Deliverables

- Deliverables will include a combination of hardware that has been pre-preloaded with the necessary software executables, drivers, images and scripts to facilitate system bring up and operation.
- Traffic Generator laptops for data performance testing **will not** be supplied.
- Testing and verification of the EdgeLink system will be successfully performed prior to delivery. Upon delivery, support and training will be available to successfully bring up the EdgeLInk system.
- Refer to Release Notes for the "Hardware Equipment List and Serial Numbers" that will be included in the delivery.

3.1 Hardware Equipment List

An example list of hardware equipment that may be supplied can be found in Table 2 – Example of HW required for a 2 node mesh setup*. This example represents the quantity for each item that is required to bring up a 2 Node/1 link Mesh system.*

Table 2 – Example of HW required for a 2 node mesh setup

Item	Quantity	Purpose
Edgelink I Antenna Unit	2	Antenna
EdgeLink II Processor Unit	2	Processor Unit & Antenna
Wi-Fi Antenna	2	Debug network
Mounting hardware/2 in. pipe U bolt clamps	4	To attach the Antenna Unit
POE Injector	2	Power over ethernet for devices
USB 3.0 cables for 2nd Sector	2	Connecting Antenna to Processor

Note: Outlet power for all equipment provided is 110V /220V compatible, the Edgelink antenna units are powered by the EdgeLink II processor unit.

3.2 Software Items and Versions

Software items delivered as part of the EdgeLink Nodes will include a combination of open source code, in-house developed tools, binaries, scripts and vendor firmware images and driver which will be pre-loaded onto the hardware equipment that is to be delivered.

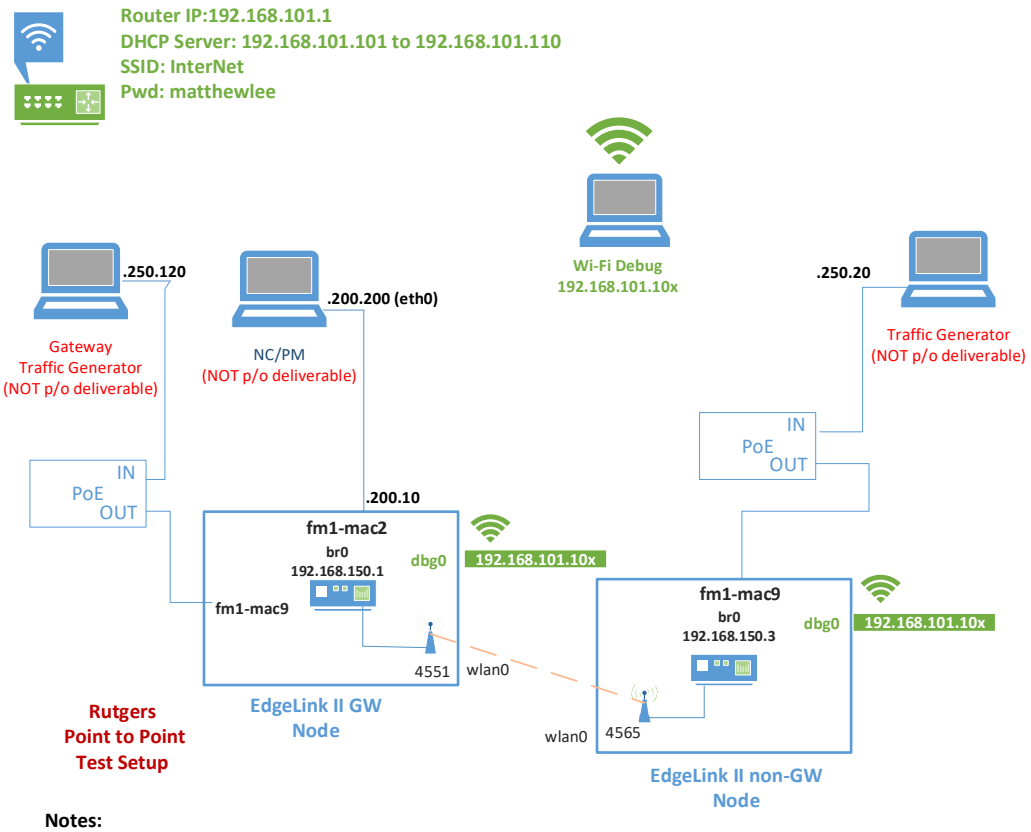
Network Controller and Orchestrator source code will be available for download on the public GitHub location:

https://github.com/InterDigitalInc/EdgeLink (PROVIDE THE PUBLIC GitHub)

Table 3 – Example of Software Deliverables

Item	Host	Purpose
Mesh SW binary	Freescale platform	Mesh agent for communication to NC
ONOS	computer	Open source SDN controller
OVS	LS1043Ardb platform	Open Virtual Switch
Iperf	LS1043Ardb platform	Tool for T-Put testing
Startup scripts	LS1043Ardb platform	System bring up scripts
Linux kernel	LS1043Ardb platform	OS
Peraso FW	EdgeLink dongle	firmware
Peraso Driver	LS1043Ardb platform	USB dongle HW communication with OS

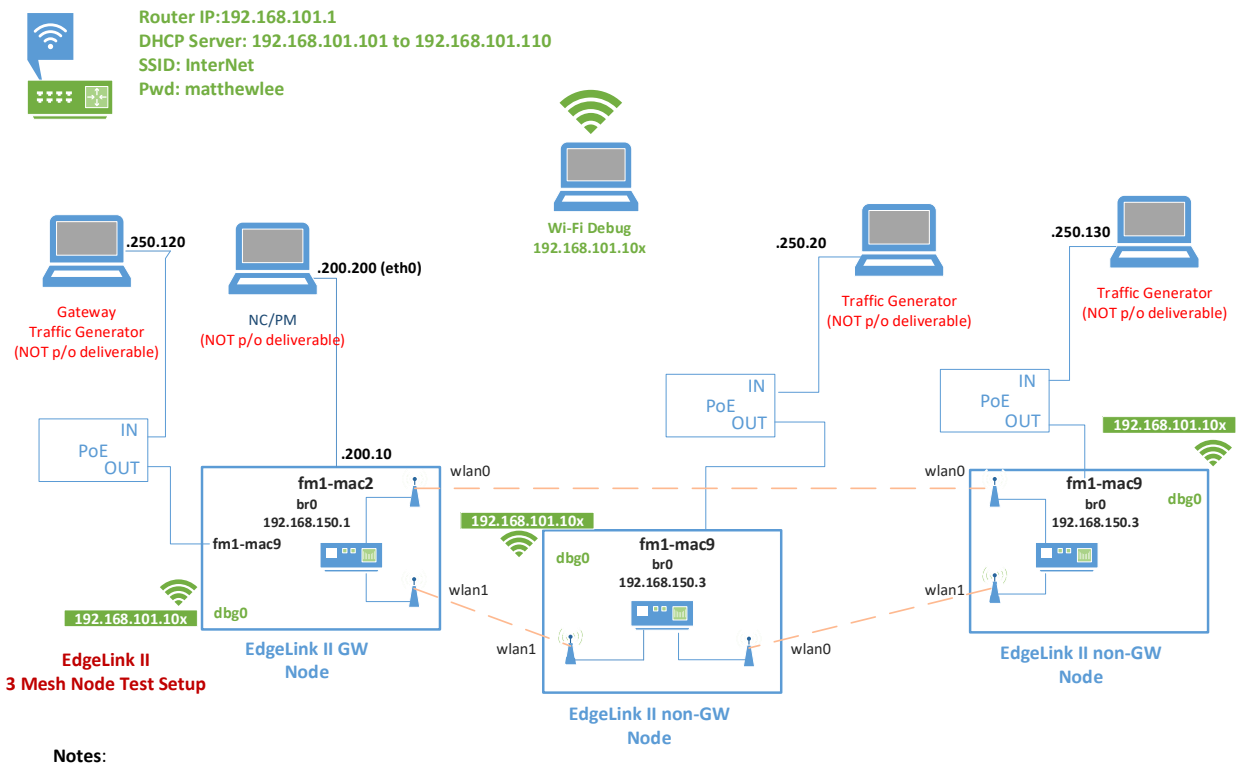
4 Getting Started with Edgelink



Notes:

- IP address of laptops and Nodes are for reference only except for the IP connection between the NC LT and GW Node which should remain as shown.
- MAC GW address: 1e cc 45 51 41 00
- MAC NonGW address: 1e cc 45 65 41 00
- dbg0 are Wi-Fi interfaces that will connect to a WiFi router
- Wi-Fi router is DHCP configured to provided IP addresses for up to 10 devices

Figure 5 – Example of a Point to Point Mesh Network Setup



Notes:

- IP address of laptops and Nodes are for reference only except for the IP connection between the NC LT and GW Node which should remain as shown.
- dbg0 are Wi-Fi interfaces that will connect to a WiFi router
- Wi-Fi router is DHCP configured to provided IP addresses for up to 10 devices

Figure 6 - Example of a 3 Mesh Node Network Setup

4.1 Assumptions

1. EdgeLink II Nodes have been pre-loaded with software tools, binaries, scripts, firmware, driver and operating system as required to execute the EdgeLink mmW Mesh transport system.
2. The Edglink II Nodes have been installed and aligned as per Section 9.3 thru 9.6
3. The EdgeLink II nodes are connected via PoE and thus executing the Mesh SW startup routines at each power cycle. See Figure 7 – GW Node PoE & NC ethernet connection and Figure 8 - nonGW Node PoE ethernet connection.
4. The Mesh network has been successfully setup as either a Point to Point configuration (See Figure 5 – Example of a Point to Point Mesh Network Setup) or as a 3 Mesh Node configuration. (See Figure 6 - Example of a 3 Mesh Node Network Setup).

5. The Network Controller and Orchestrator software has been installed on a machine and the executables have been built from the GitHub Public repository. (*Go to the Github Public repository to download the open source code for the Mesh NetworkController and Orchestrator. Follow the instructions in the README file to build the Mesh Controller & Orchestrator executables*).
    a. https://github.com/InterDigitalInc/EdgeLink (provide the actual public Github link)
6. The NC machine is connected via ethernet to the GW Node as shown in Figure 7.
7. The debug subnet is accessed over a Wi-Fi connection to the nodes as shown in Figure 5 or Figure 6. The Wi-Fi connection is required only for debug purposes. See Section 7.1 for instructions on how to access the Wi-Fi debug subnet.

The EdgeLink system utilizes static IP addresses to communicate with peer devices. Components have been re-configured with the static IP addresses as per the Actual Network Configuration diagram located in the Release Notes that are delivered with the hardware. Figure 5 reflects an example of the OVS bridge subnet that is used in the Mesh system and is for reference only.

4.2 System Start-Up Procedure for EdgeLink II

- The following start-up steps are provided and apply to a 3 Node/3 links (i.e. 6 Antenna Units) Mesh configuration test bench or an alternate Point to Point (2 Nodes/1 link) Mesh configuration test bench.
- The list of Assumptions identified in Section 4.1 should be verified as complete
- The MESH SW and Controller can be used to bring up the Point to Point configuration, however not all Mesh/NC features (such as Link Recovery) will be possible with a Point to Point setup.

4.2.1 Configuration #1 – Full Mesh test bench with 3 EdgeLink II Nodes & 3 mmW links

See Figure 6 for an example of a 3 Mesh Node configuration.

4.2.2 *Configuration # 2 - Point to Point EdgeLink II Mesh test bench with* 1 mmW link

See Figure 5 for an example of a 2 Mesh Node configuration.

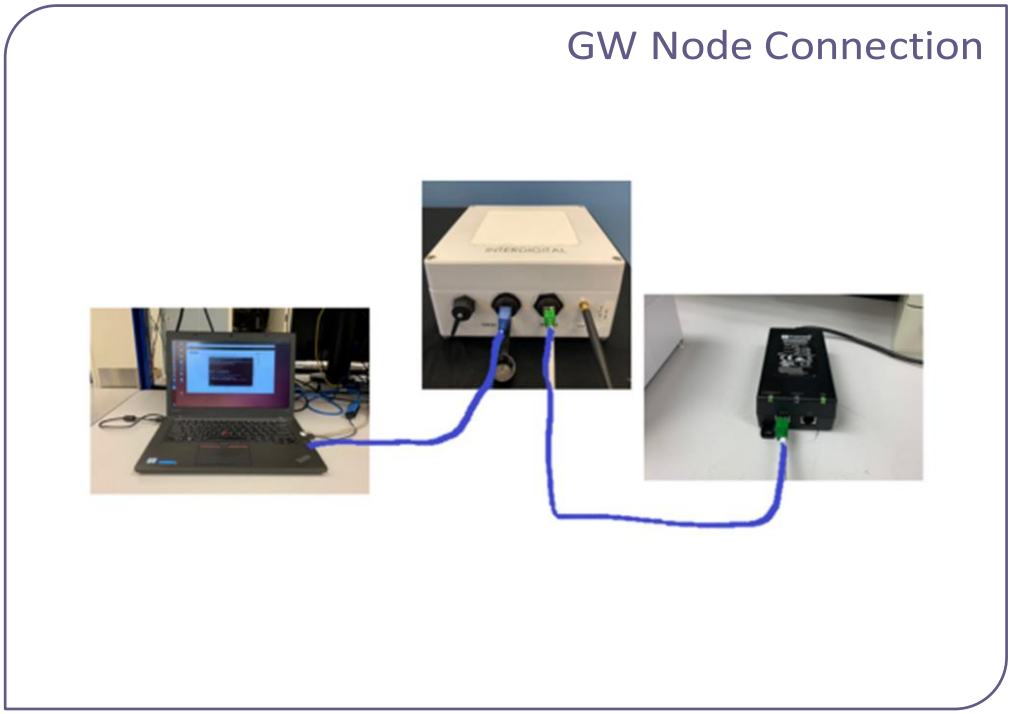


Figure 7 – GW Node PoE & NC ethernet connection

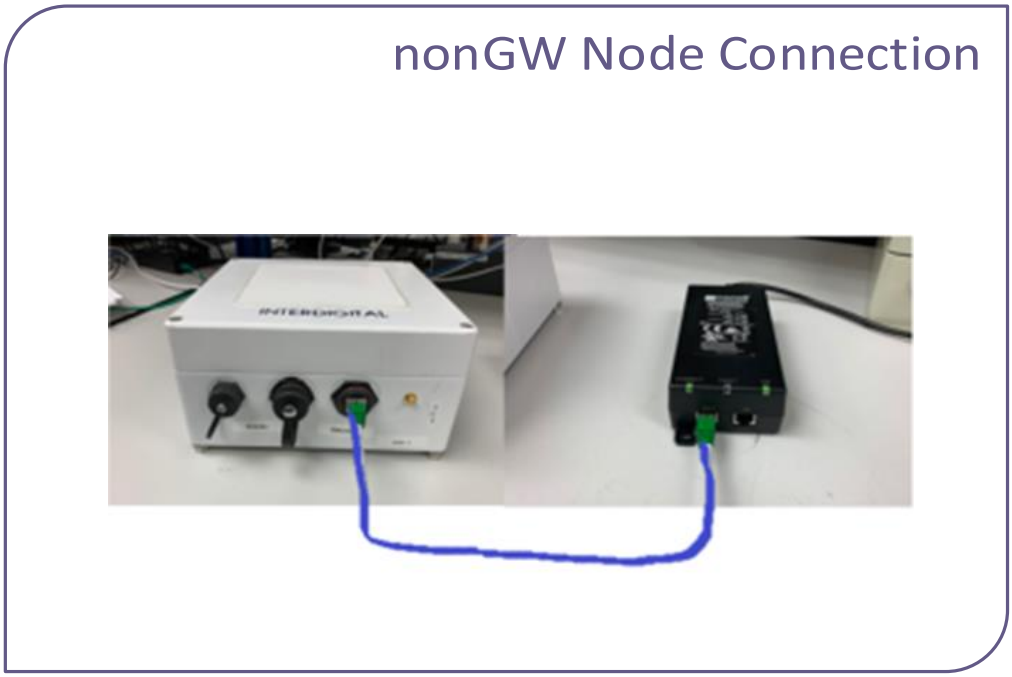


Figure 8 - nonGW Node PoE ethernet connection

4.2.3 Start-Up Steps

1. Verify Connections
    a. Verify the GW Node and nonGW Node(s) are connected to the PoE injector as shown in Figure 7 & Figure 8
    b. Verify the GW Node is connected to the NC machine as shown in Figure 5
    c. From the NC machine you should be able to ping the GW Node

2. Start the ONOS Network Controller
    a. Open a terminal window on the NC machine
    b. Move to the onos executable directory and run the ONOS executable
        i. native>cd /opt/onos/onos-1.9.0
        ii. native>sudo ./bin/onos-service start
    c. Once the ONOS NC controller is successfully executing it will return a display as shown in Figure 9 indicating that it is ready to detect the GW Mesh Nodes and nonGW Mesh nodes.
3. Access the ONOS GUI
    a. Open a Google Chrome or FireFox browser and enter the url of your NC machine, for example if the URL of your machine is 10.10.3.220 then enter the following in the browser:
        i. http://10.10.3.220:8181/onos/ui
    b. You should see the ONOS login page as shown in Figure 10
    c. Enter ONOS credentials:
        i. User: onos
        ii. Password: rocks
    d. ONOS topology will display the GW node and the non-GW node as shown in Figure 11 when the network controller detects and registers the nodes.
4. Access the Orchestrator GUI
    a. If a device such as a WiFi AP, Laptop or LTE small cell is attached to the Point of Access POA port on any of the Nodes then the MAC address of the attached device must be made known to the Network Controller. This can be configured via the Orchestrator application.
    b. Please refer to MA82841_Network Controller Orchestrator_User Manual which is located in the GitHub EdgeLink/docs folder for instructions on how to provision a network slice using the MAC address of the attached device.

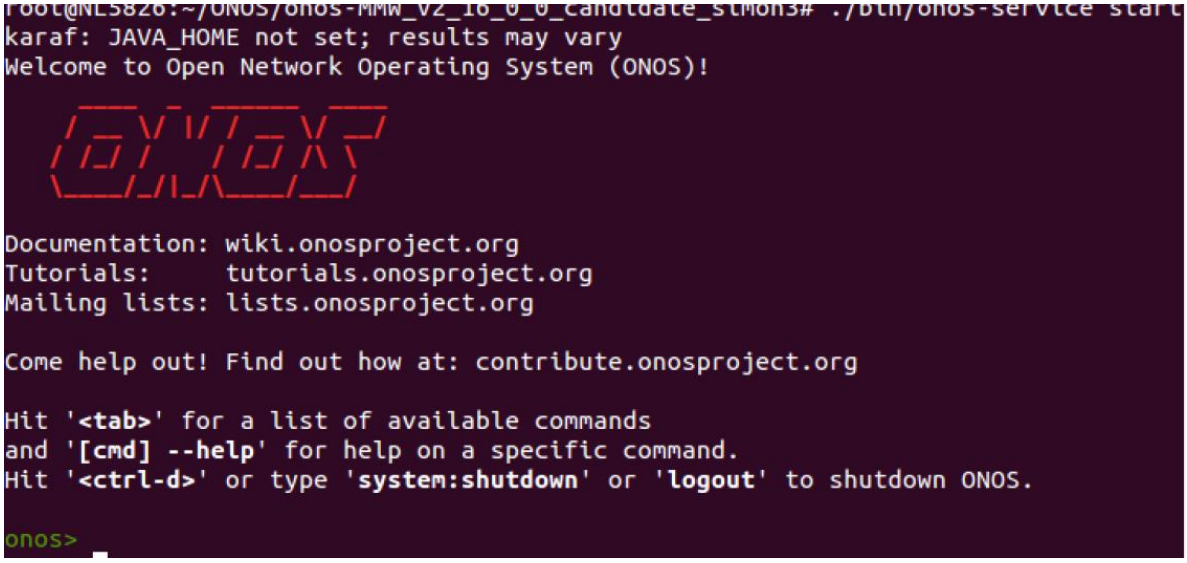


Figure 9 - ONOS NC Controller Display

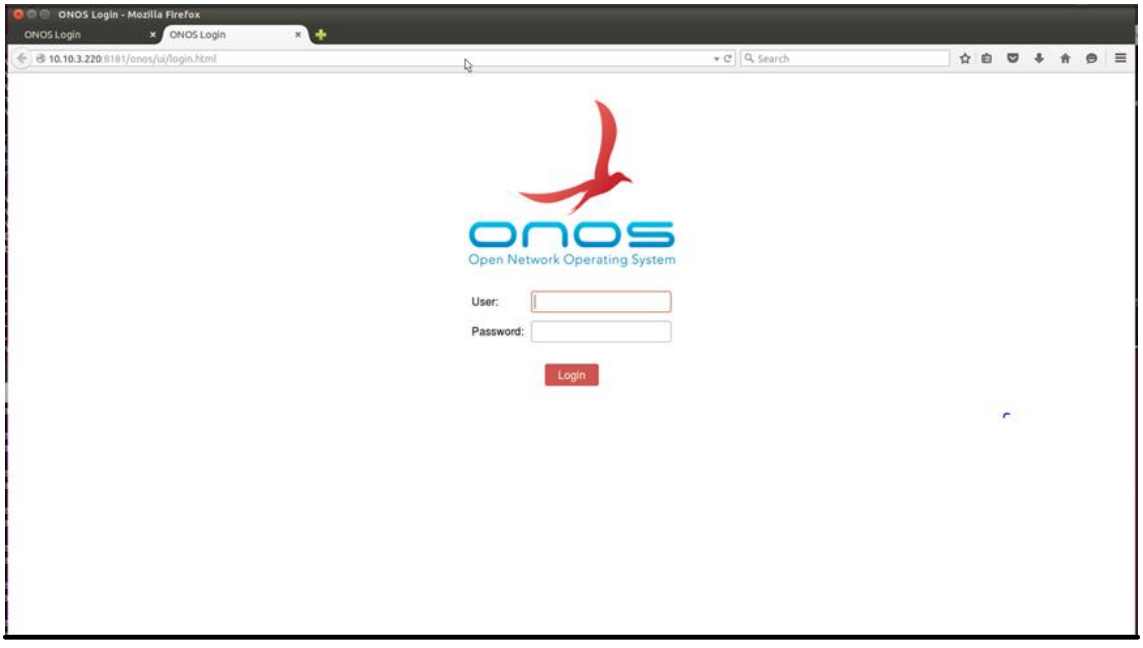


Figure 10 ONOS login window

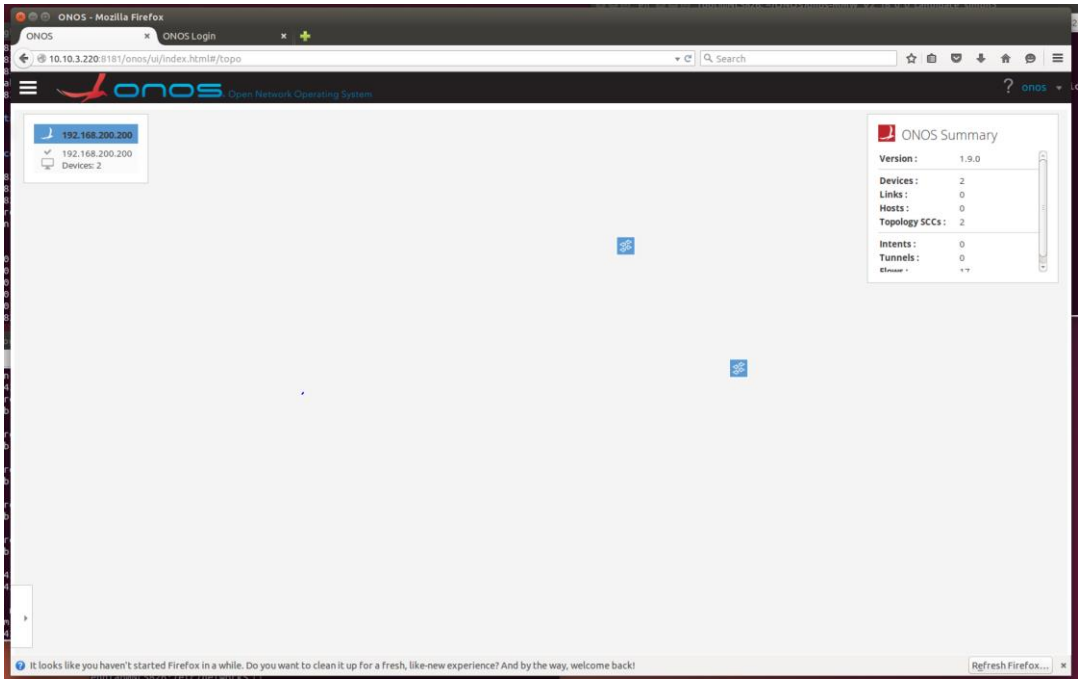


Figure 11 – ONOS topology view indicating 2 Mesh nodes detected

5 Data Throughput Testing

Data testing can be performed in a number of ways, the following are a few examples:

1. Iperf data sent from Node to Node
2. Iperf data sent between Traffic Generator laptops that have been connected to the access port of a Node.
3. Streaming video between Traffic Generator laptops that have been connected to the access port of a Node

Notes:

- Data testing using method #1 will require access to the Wi-Fi debug subnet. Instructions for accessing this network is provided in Section 7.1
- Data testing using method #2 or #3 will require an additional configuration setup, where the MAC address of the connected device(s) must be made known to the controller. This can be configured via the Orchestrator application. See MA82841 Network Controller Orchestrator User Manual (located in the GitHub EdgeLink/docs folder) for instructions on how to create a network slices for connected devices.
- Iperf 2.0 has been pre-installed on each Node in the /usr/bin directory.
- Traffic Generator laptops have not been provided as part of the EdgeLink System and are to be supplied by the user if data throughput testing via method #2 or #3 will be performed.
- Pingable paths in the EdgeLink system:
    1. Between each Node Bridge IP address (i.e., 192.168.150.1, 192.168.150.2, 192.168.150.3)
    2. Between connected devices

6 System Configuration Parameters

System parameters have been made available in various components of the EdgeLink system which can be configured by the user. **This is not recommended for inexperienced users.** Support from InterDigital personnel is strongly advised before making any system configuration changes.

6.1 Mesh SW Configuration file – located on each Node

Different mesh configuration parameters will be loaded depending on whether the test bench configuration will be a 3 Node/3 link Mesh or a Point to Point Mesh.

Filename => 'msm_config.txt' (The mesh software will call upon this file for configuration parameters)

Directory location => root@ls1043ardb:~/msm_fsl/mesh_sw/conf#

Config files used for 3Node/3link Mesh test bench

GW Node Filename => 'msm_config_gw_1610.txt' (The contents of this file is loaded into the 'msm_config.txt' file at the start of the mesh SW executable on the **Gateway Node**)

Non-GW Node Filename => 'msm_config_nongw_1610.txt' (The contents of this file is loaded into the 'msm_config.txt' file at the start of the mesh SW executable on each of the **Non-Gateway nodes**)

Config files used for Point to Point Mesh test bench

GW Node Filename => 'msm_config_gw_1610_P2P.txt' (The contents of this file is loaded into the 'msm_config.txt' file at the start of the mesh SW executable on the **Gateway Node**)

Non-GW Node Filename => 'msm_config_nongw_1610_P2P.txt' (The contents of this file is loaded into the 'msm_config.txt' file at the start of the mesh SW executable on each of the **Non-Gateway nodes**)

7 System tools, diagnostics and log files

Several debug and analysis tools are provided as part of the EdgeLink System that can be used to provide in-depth system statistics and logging of messaging sequence of system events. These tools can be used to retrieve KPIs for system performance and/or debug analysis and create test scenarios for the collection of experimental data.

7.1 Accessing the Wi-Fi Debug Subnet

The Wi-Fi debug subnet is only available on the EdgeLink II Mesh Nodes and replaces the wired debug subnet that was available on the EdgeLink I Mesh Nodes.

1. Configure a Wi-Fi Access Point (See Figure 5 for a reference example of Wi-Fi AP configuration). The Wi-Fi client on all EdgeLink II nodes have been pre-configured to automatically connect to the following:
    a. SSID: InternNet
    b. PWD: matthewlee
2. It is therefore **strongly recommended** that the same SSID and PWD be used in your initial setup of the Wi-Fi AP so that the WI-Fi debug subnet on the EdgeLink II nodes will automatically connect to your Wi-Fi AP when the nodes are powered up. After accessing the Wi-Fi debug subnet you will have the ability to change the SSID, password & subnet the Wi-Fi on the node will automatically connect with. Section 7.1.2 will describe this procedure.
3. Enable Wi-Fi on the host machine that will be used as your debug machine and connect to the SSID that was configured on the router and connect with the required credentials.

7.1.1 Locate the DHCP IP address assigned to the EdgeLink II nodes

It is assumed that the EdgeLink II nodes are connected via Wi-Fi to the Wi-Fi AP

1. Open up a browser to the IP address of the Wi-Fi AP to access the setup page.
2. Provide the required credentials to access to the setup page
3. From the “Status” tab maneuver to the Local LAN tab to view the DHCP clients that are connected to the Wi-Fi AP. There should be a display of the IP address for each DHCP client allocated for each Wi-Fi connected node (i.e. the IP address for the debug subnet of the node) and the Wi-Fi connected host machine.
4. Use the Wi-Fi IP address from the DHCP client list to access the node
    a. From the debug host machine open a Cygwin terminal window to ssh to each node.
    b. Example: >ssh root@192.168.101.xxx
5. The following prompt should return to indicate you are ssh into the node:
    a. root@ls1043ardb:#
6. From this prompt you can perform several functions. (e.g. ping the other node using the OVS bridge IP address, restart the mesh nodes, manually restart the mesh sw or reconfigure the node to connect to a different AP

7.1.2 Change the Wi-Fi SSID the EdgeLink II node will automatically connect with

1. Reboot the EdgeLink II node
2. Follow the steps in Section 7.1.1 to ssh into the EdgeLink II node
3. Execute the following command
    a. wpa_passphrase <AP SSID> >> /etc/wpa_supplicant.conf
    b. wpa_passphrase is waiting for your input: just enter the AP passphrase and return
4. Reboot the EdgeLink II node and it will automatically select the new SSID using the credential that was stored.
    a. The EdgeLink II node should connect to the new AP SSID and an IP address ahould be assigned to the wlan interface of the node

7.2 Command Line Interface (CLI)

A command line interface (CLI) tool is available to artificially inject link failures within the system for testing. It is recommended that the PM application is started to operate in parallel with the CLI application so that the PM GUI can display link status and the re-routing of data during a link failure. The link status can be used as an indication to whether the artificially injected link failure and recovery were triggered successfully.

7.2.1 Procedure to artificially inject a link failure

1. Artificially inject a link failure

    a. Access the Wi-Fi Debug subnet as described in Section 7.1, SSH to the mesh node on the STA side of the desired link failure

    b. Start the CLI
    cd /home/root/msm_fsl/cli
    ./mesh_cli_armfsl_debug_normal.exe

    c. Enter '**?**' for a list of commands

    d. Retrieve the link information
    meshcli> **get msmAssocConfigTable**

    e. Trigger a link failure on the desired link
    meshcli> **artificial_event link_failure** <own sector STA MAC address> <peer sector PCP MAC address>

    f. Verify the intended link is down and data has been re-routed to backup path as seen in PM GUI

2. Trigger a link recovery on the desired link
    meshcli> **artificial_event link_recover** <own sector STA MAC address> <peer sector PCP MAC address>

NOTE: Link recovery is dependent on PCP Scan timer settings. It may take some time before the link is reestablished.

a. Verify the intended link has recovered and data is transmitted on recovered link (see PM GUI)

b. The link failure and recover can be repeated.

7.3 System Log Files

A variety of log files with configurable trace levels are available for in-depth debugging of the EdgeLink system. These log files and their locations are as follows:

1. Mesh log files located on each Node
    - Filename: idcc-xx.log (self-enumerating files)
    - directory location => root@ls1043ardb**:~/msm_fsl/mesh_sw/idcc_logs**#
2. NC log file located on NC laptop
    - Filename: karaf.log
    - directory location => root@NL5859**:/opt/onos/onos-1.9.0/apache-karaf-3.0.8/data/log**
3. Kernel, driver, modem log files located on each Node
    - Filename: kern.log
    - Filename: syslog
    - Filename: messages
    - directory location => root@ls1043ardb**:/var/log**#

By default the trace level will be configured for minimal logging but can be updated to provide detailed logging information for purposes of debug.

8 Troubleshooting Notes:

8.1 Login, Password and Credentials

8.1.1 ONOS

Username: onos

Password: rocks

8.1.2 Node platform

login: root (no password)

8.2 Common Debug Issues

InterDigital will provide support to help troubleshoot system issues but some of the more basic issues have been listed here that may be useful to resolve some more commonly seen problems.

8.2.1 Unexpected link failure

Restart the NC controller and Mesh Nodes

8.2.2 Nodes do not associate

After running the startup script for the MESH SW, links between Nodes should form.

1. Identify which link did not form an association.
2. After determining which link did not associate, verify the Antenna Units for the unassociated link was properly aligned. See Section 9.6 for alignment procedure.
3. Restart the system

8.2.3 Nodes do not register with NC

8.2.3.1 Verify path from NC machine to GW node

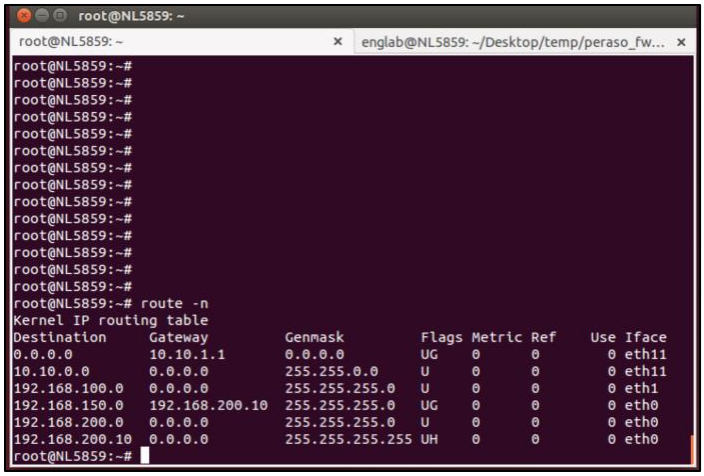
From NC laptop, ping the 'fm1-mac2' interface should return successfully. If ping is not successful then verify the IP addresses on NC laptop interface and Node1 fm1-mac2 interface are both configured for the same subnet as follows:

NC eth0 interface : 192.168.200.200

GW Node1 fm1-mac2 interface: 192.168.200.10

8.2.3.2 Verify IP routing table from NC machine to GW node

From NC laptop enter command "route -n" to display the routes for the NC laptop



Verify that bridge subnet address 192.168.150.0 is the destination for the gateway 192.168.200.10 as shown above.

If the IP routing table is not correctly setup, perform the following step:

1. verify that the ethernet interface name on the NC machine is reflected correctly in the EdgeLink/scripts/setup_routes.sh script file
2. ./setup_routes.sh (execute the setup script)
3. route -n (verify the bridge subnet address is correct for the ethernet interface name of the NC machine)

8.2.4 Cannot ssh to the Node

1. Verify the Ethernet connection by pinging the Node from the Wi-Fi Debug laptop. See Section 7.1 for instructions on accessing the Wi-Fi debug subnet.
    a. Ex. ping 192.168.101.102
2. After successfully pinging each platform you should now be able to ssh to each of the platforms:
    a. Ex. ssh root@192.168.101.102
3. If you cannot successfully ssh into any of the Nodes then verify that the Wi-Fi router has assigned an IP address to the Debug machine and the the Nodes. See Section 7.1.1 for instructions on how to locate the DHCP client list and verify the IP address assignments.

8.2.5 NC Controller does not instantiate correctly

1. Verify that another instance of the controller is not running in the background by entering the following command on the NC laptop.
    a. >ps -ef | grep onos
2. If another instance of the controller is running then kill the process and restart the NC executable.

8.2.6 Data transfer fails between the connected devices

Examples of connected devices can be Traffic Generator laptops, RRU, BBU, small cell,…

1. Verify that the MAC address of the connected devices has been made known to the controller.
    a. Verify a network slice has been created correctlyfor the MAC address of the connected device as per the Orchestrator application (See MA82841 Network Controller Orchestrator User Manual)
2. Verify the UL path of the connected devices by sending a ping command from the connected device back to the device connected to the GW node.
3. If the ping command fails then tcpdump should be used at each of the nodes to verify the ping path.

8.2.7 Manual Association of a P2P Link

The NC and Mesh SW together provide network discovery and neighbor selection to autonomously associate the mmW links in the mesh topology. However, the same links can also be manually associated without the NC and Mesh SW by the use of iw commands entered at the command line.

From the NC LT, ssh to the GW Node1:

1. ssh root@192.168.100.1
2. Change directory to location of Peraso driver:
    a. root@ls1043ardb:~# cd msm_fsl/peraso
3. Run batch file that will set modem parameters, load driver and register device for US
    a. root@ls1043ardb:~/msm_fsl/peraso# ./insprsfalcon.sh
4. Verify USB device(s) (wlan0) have been detected:
    a. root@ls1043ardb:~/ifconfig
5. Each USB device will have its own directory structure and parameters that can be manually updated.
6. Locate and Manually change attributes for wlan0
    a. root@ls1043ardb:~# find /sys/devices -name prs_attrs
    b. /sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs
7. Change directory to the location of the prs attributes for wlan0
    a. cd /sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs/
    b. root@ls1043ardb:/sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs#
8. Change Node 1 station_mode to PCP
    a. # echo 0 > station_mode
9. Change active channel
    a. # echo 2 > active_channel
10. Issue iw command at PCP to transmit beacon signal
    a. root@ls1043ardb:~# iw dev wlan0 ibss join mmh 60480

From the NC LT, ssh to the Node2:

1. ssh root@192.168.100.2
2. Change directory to location of Peraso driver:
    a. root@ls1043ardb:~# cd msm_fsl/peraso
3. Run batch file that will set modem parameters, load driver and register device for US
    a. root@ls1043ardb:~/msm_fsl/peraso# ./insprsfalcon.sh
4. Verify USB device(s) (wlan0) have been detected:
    a. root@ls1043ardb:~/ifconfig
5. Each USB device will have its own directory structure and parameters that can be manually updated. (e.g. wlano and wlan1)
6. Locate and Manually change attributes for wlan0
    a. root@ls1043ardb:~# find /sys/devices -name prs_attrs
    b. /sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs
7. Change directory to the location of the prs attributes for wlan0
    a. cd /sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs/
    b. root@ls1043ardb:/sys/devices/platform/soc/2f00000.usb3/xhci-hcd.0.auto/usb2/2-1/prs_attrs#
8. Change Node 1 station_mode to STA
    a. # echo 1 > station_mode
9. Change active channel
    a. # echo 2 > active_channel
10. Change channel mask
    a. # echo 2 > dmg_enabled_channels_mask
11. Setup IP address for wlan0
    a. ifconfig wlan0 192.168.102.6 up
12. Issue iw command to scan for beacon which will return SSID, frequency, RSSI if a beacon is detected
    a. root@ls1043ardb:~# iw dev wlan0 scan
13. Issue iw command at STA to associate to a detected beacon parameters
    a. root@ls1043ardb:~# iw dev wlan0 ibss join mmh 60480
14. If the association is successful you should be able to ping the GW Node from Node 2

9 Appendix

9.1 Indoor Installation

It is recommended that the Antenna Units for each point to point link are spaced at least 25 ft apart from each other. For an initial start, it is also recommended to begin with an indoor deployment which involves minimal preparation and affords a rapid setup allowing a user to become familiar with the EdgeLink system before moving to an outdoor deployment.

Figure 12 – Indoor deployment on a speaker stand

A laser sight or scope can be mounted to the top of the antenna unit for antenna alignment and mounting clamps will be supplied for Antenna Unit attachment to a pole as shown in **Error! Reference source not found.** which shows how 2 antenna units have been attached to the pole.

9.2 Outdoor Installation

The EdgeLink system can theoretically support point to point links that are up to 700 meters apart. However, the system has been characterized at distances up to 200 meters.

An outdoor deployment will require additional up front preparation which includes some of the following:

1. Placement of 2 Ethernet cables for the GW Node
    - To provide connectivity between the GW Node and the NC machine
    - To provide PoE connectivity to the GW Node from a PoE injector residing indoor
2. Placement of 1 Ethernet cable for each nonGW Node locations (such as roof tops of different buildings to a network)
    - To provide PoE connectivity to the nonGW Node from a PoE injector residing indoor
3. Identify a structure at each location for mounting the Antenna Units and Processor Units
4. Verify the availability of power (Edgelink is supplied by PoE injector)
5. Antenna alignment over greater distances

6. Verified method of Antenna Unit attachment (U-bolt clamps that have been supplied or customer to supply alternative attachment device)
    - **NOTE:** The Antenna Unit Mount was designed with the VESA 75mm x 75mm standard mounting hole pattern which can attach to a VESA compatible mounting plate. See Figure 18 – VESA 75mm x 75mm standard mounting holes and dimensions. The backview of the Antenna Unit bracket is also shown in Figure 19 – Backview of Antenna Unit mounting bracket with VESA 75**Error! Reference source not found.**
7. 2 person operation to support antenna alignment is recommended.

Figure 13 – Outdoor deployment on a handrail

If outdoor mounting will be to a railing as shown in Figure 13 – Outdoor deployment on a handrail then the supplied U-bolt clamps may not be sufficient to firmly attach the Antenna Units then another method should be investigated and may be required.

Figure 14 – Outdoor deployment on a mast

If mounting to a pole or an outdoor mast as shown in Figure 14 – Outdoor deployment on a mast then the pole/mast diameter must be less than 2 inches in order to use the 2 inch U-bolt clamps that will be supplied.

9.3 EdgeLink II Installation

The EdgeLink I or EdgeLink II Antenna Unit attaches to the EdgeLink II Processor Unit via a 6ft USB 3.0 cable and must be co-located together. Suggested maximum cable length for USB 3.0 is 6ft. and should be maintained. Use of longer USB cables is not recommended and can result in performance issues. It is recommended that the USB 3.0 cable that has been supplied be used for attachment.

The EdgeLink II Processor Unit alone can support 1 sector. Attaching the EdgeLink Antenna Unit (either version I or II) to the EdgeLink II Processor Unit will provide support for the maximum of 2 sectors.

Each Node can be configured to be either a Gateway Node (GW) or a non-Gateway Noded (NonGW). For the current EdgeLink configuration there will be no more than 1 GW Node in the system.

9.4 Additional tools and equipment

The following is a list of additional items that will be required for installation and is not included in the deliverables:

- Binocular - if using laser sight method for an outdoor installation

- Laser sight, riflescope or sighting scope - for antenna alignment, Figure 15 – Riflescope Example and Figure 16 – Laser Sight Example. Examples are provided for reference only with the requirement that they are compatible to the built-in rail that is located on top of the Antenna Unit for attachment.
- 1/2” Socket wrench – use to adjust antenna
- 1/2” Box wrench – used to adjust antenna
- Philips Screwdriver – if there is a need to open the Antenna Unit cover

Figure 15 – Riflescope Example

Figure 16 – Laser Sight Example

9.5 Pre-Installation check list

1. Before installation, identify the locations where the Antenna Units and/or Processor Units will be mounted.
2. Verify that there will be a clear line of sight between each pair of Antenna Units and/or Processor Units that will form a link.
3. For each location, Identify the structure that the Antenna Unit will be attached to:
    - For an outdoor installation, verify that each Antenna Unit can be securely fastened to the support structure with the clamps provided. The structure should be stable enough to support the Antenna Unit which is about 12 lbs and withstand any possible movement caused by wind.

- For an indoor installation, verify that the object that you are attaching each Antenna Unit to can securely support the Antenna Unit and bracket which is a combined 17 lbs with minimal movement.

4. For each location , Verify that the Processor Unit can be placed within 6 linear ft. of the Antenna Unit. Note: This is because the USB 3.0 cable that is used to connect the Antenna Unit to the Processor Unit has a maximum length of 6ft.
5. For each location,
   - Ethernet cable is available from the Node to the location of the PoE injector that will be located indoor
   - Verify that electrical outlet power is accessible to the location of the PoE injector. The PoE requires a standard 110-240V AC power.
   - For the GW node only, a 2nd additional ethernet cable is required from the GW Node to the location of the NC Controller that will be located indoor.
6. For each location, Verify that conduit or a comparable method is available to run Ethernet cables from the GW Processor Unit to wherever the NC laptop will be located:
   - In a typical outdoor deployment the Antenna Unit and/or Processor Unit will be located on a roof top building or window balcony and the NC laptop will be located in an indoor office.
   - For an indoor deployment the Ethernet cables from the location of the GW Processor unit just needs to be long enough to reach the NC laptop. Conduit for the Ethernet cables is not required and can be run along the floor when indoors. .
7. If all of the above check list items can be met, then installation can be started.

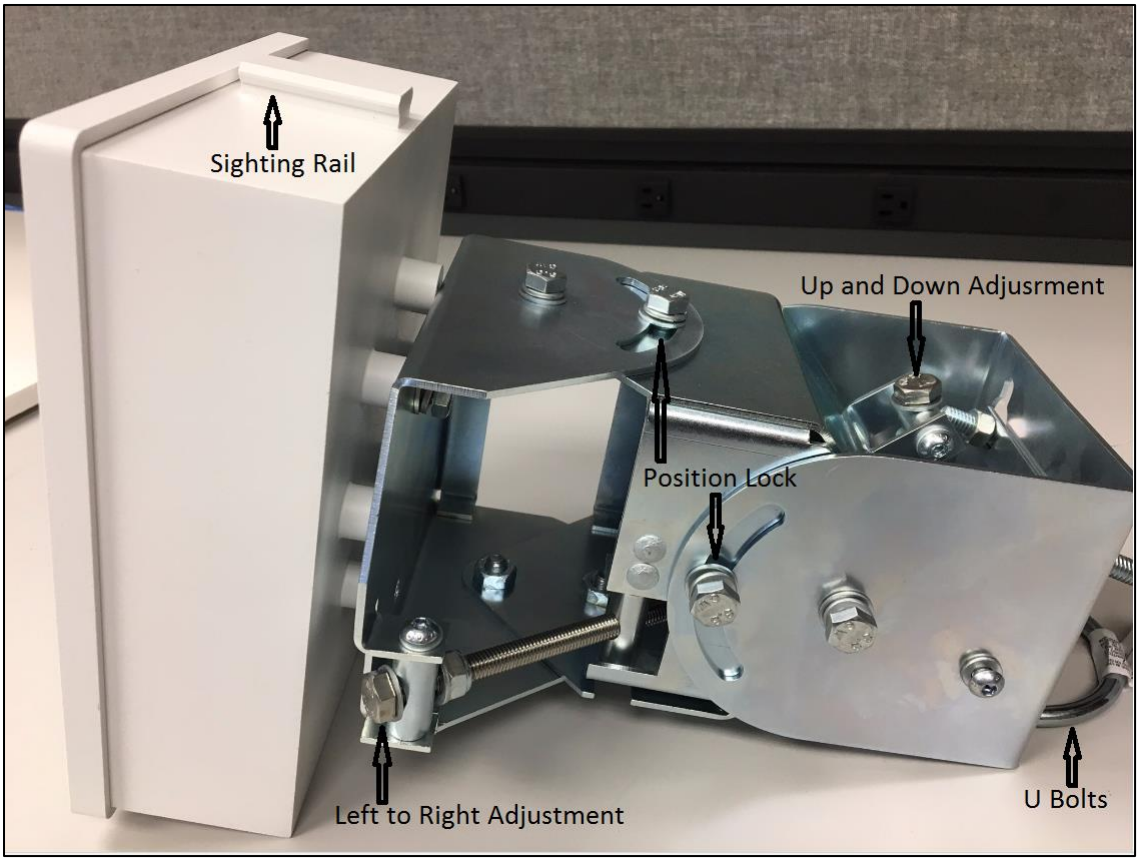


Figure 17 – Antenna Unit - Mechanical Adjustment Screws

9.6 Installation Procedure

The Antenna Units and Processor Units have each been labeled so that specific Antenna Units have been paired with a specific Processor Unit. All Antenna Units are interchangeable but because each Antenna Unit has a unique MAC address that is used by the MESH and NC to create flows any swapping of Antenna Units would required an update to the configuration files that have been supplied. The actual network configuration diagram depicting the (MAC addresses and wlan interfaces of the delivered system to be installed will be as reflected in the Release Notes. The Release Notes will be delivered with eth EdgeLink nodes.

1. Install the EdgeLink II Processor Units and/or Antenna Units
    a. 2 inch U-bolt clamps will be provided as a means to attach the Unit to a mast or similar fixture. If another form of attachment is required the customer will have to supply the solution.
    b. The face of the Unit should be mounted facing towards the 2nd Unit that will complete the point to point mmW link.
    c. The Unit should be mounted in its upright position such that the sighting rail is always on top as shown in Figure 17 – Antenna Unit - Mechanical Adjustment Screws
2. Align the 2 Units that will be forming the point to point link.

a. Riflescope with 1” Scopetube and built in Standard mount, Sighting scope or Tactical Laser Sight with Picatinny Rail will be required to align the Antenna Units.
b. Either the riflescope or the laser sight should be mounted on top of the Antenna Unit and fasten securely.
c. Use scope or laser sight to target towards the Antenna Unit that will complete the mmW link association.
d. The Antenna Unit positioning can be adjusted from “left to right” or “up and down” by adjusting the the appropriate bolts. Location of the bolts for adjustments are shown in Figure 17 – Antenna Unit - Mechanical Adjustment Screws
e. Verify the Position Lock bolts are not tight before making adjustments.
f. Locate target Antenna Unit (eyeball for indoor or use binoculars for outdoor alignment) and use the ½” socket wrench to adjust the Antenna Unit so that the target Antenna Unit is within the scope sight. Crosshair or laser beam does not have to be in the exact center and can be anywhere on the face of the Antenna Unit.
g. Alignment between each point to point link must be performed on both ends, i.e. step 2a thru 2f must also be repeated at the targeted Antenna Unit side as well.

3. If the EdgeLink Node will be utilizing a 2nd sector then verify the USB cable from the Antenna Unit can reach the Processor Unit from where it will be installed. **Note:** This step is only necessary if setting up a 2 sector node
4. Connect the cable from the Antenna Unit to the USB interface on the EdgeLink II /Processor Unit.

Repeat Steps 1 through 4 for each mmw link that will be formed.

9.7 Additional Diagrams

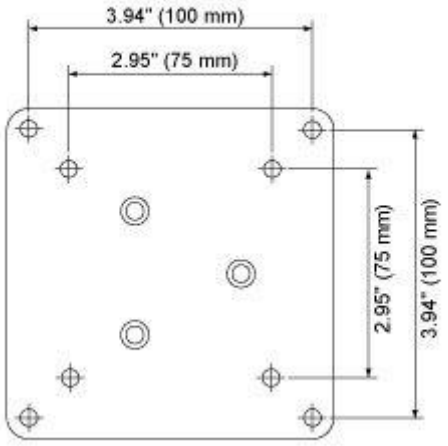


Figure 18 – VESA 75mm x 75mm standard mounting holes

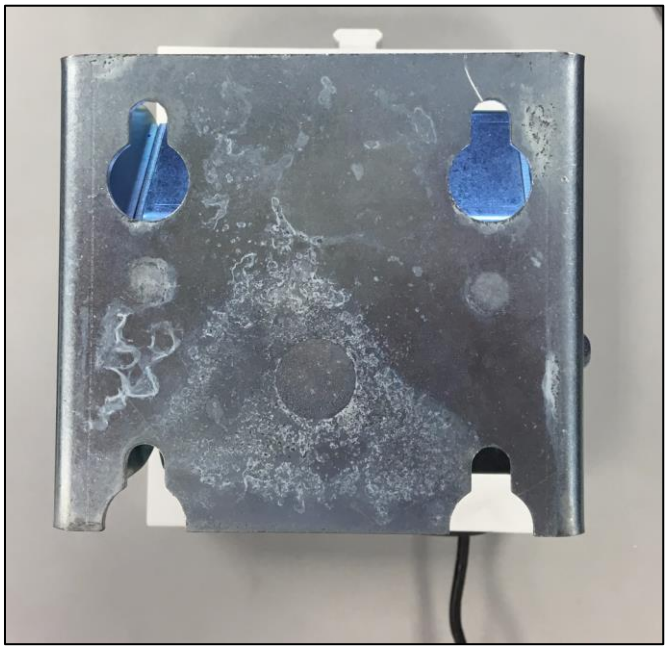


Figure 19 – Backview of Antenna Unit mounting bracket with VESA 75

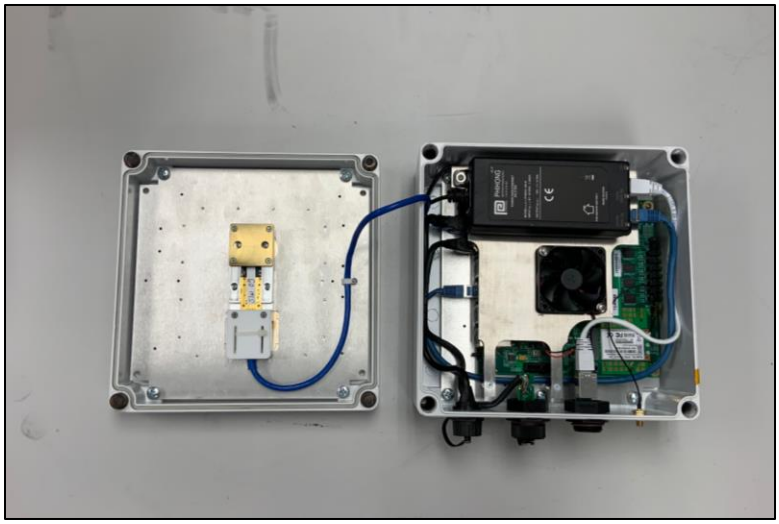


Figure 20 – Interior view of EdgeLink II Processor Unit