Application Notes

3eTI Wireless Mesh Network Installation and Setup Notes

This guide applies to the following 3eTI products with the latest firmware:

- **525C-3**
- **525A-3**
- **527A-3**
- **523-3**
- **523-F2**

Overview

There are two types of nodes in 3eTI mesh networks, Root Node and Mesh Node. There can only be one Root Node in a given mesh network. The rest of the nodes are simply called Mesh Node.

Typically a Root Node should be where the wireless mesh network connects to the wired network, although this connection can be made through any Mesh Node in the network. Using Root Node to connect to the wired network gives the best performance.

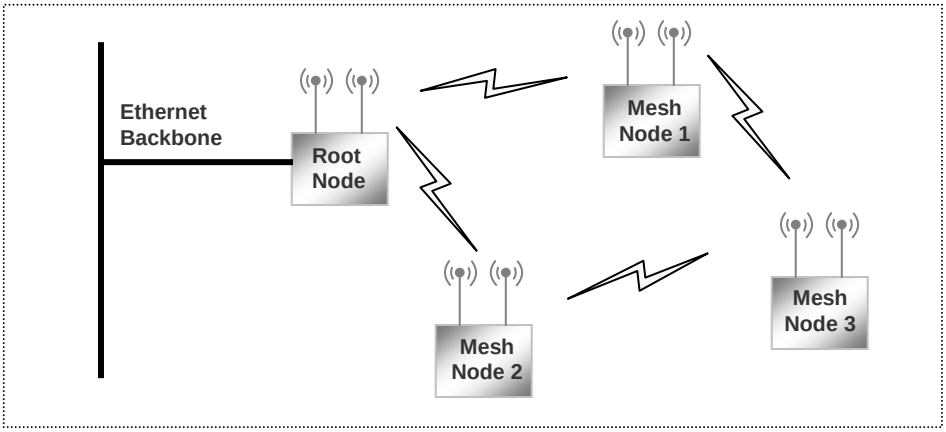


Figure 1, Backbone connection should be connected to the Root Node if possible

All Mesh Nodes in the mesh networks continually optimize its communication path by looking for the best path to the Root Node. See the "Bridge Priority" section for how to set a node as Root Node.

The quality of a link is quantified by the signal strength between the two nodes. Therefore, the signal strengths distribution in the network determines the formation of the mesh network.

For example, in the following 4-node network, Mesh Node 3 will reach the Root Node via Mesh Node 1 because the path quality of (90%+100%) is better than (50%+100%).

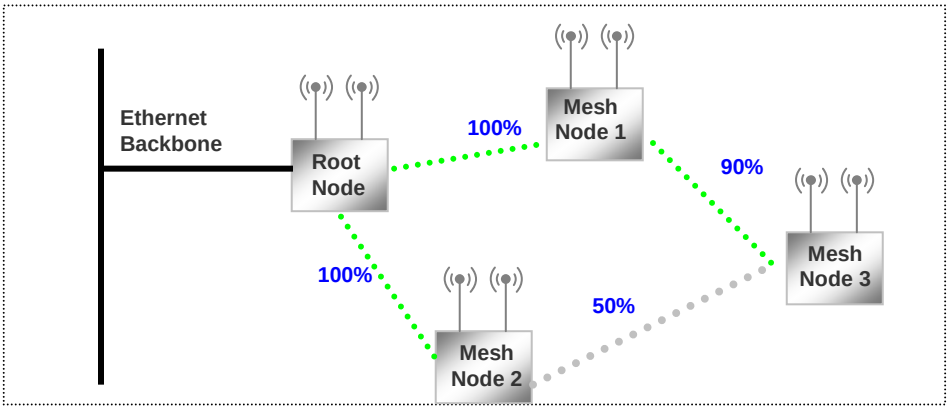


Figure 2, An example of 4-node mesh network and its active topology

Now if Mesh Node 3 moves away from the Mesh Node 1 and its connection to Mesh Node 2 becomes better than to Mesh Node 1, the system will automatically start using Mesh Node 2 for Mesh Node 3 to reach the root node.

Now consider the following case where Mesh Node 3 has a direct link to the Root Node.

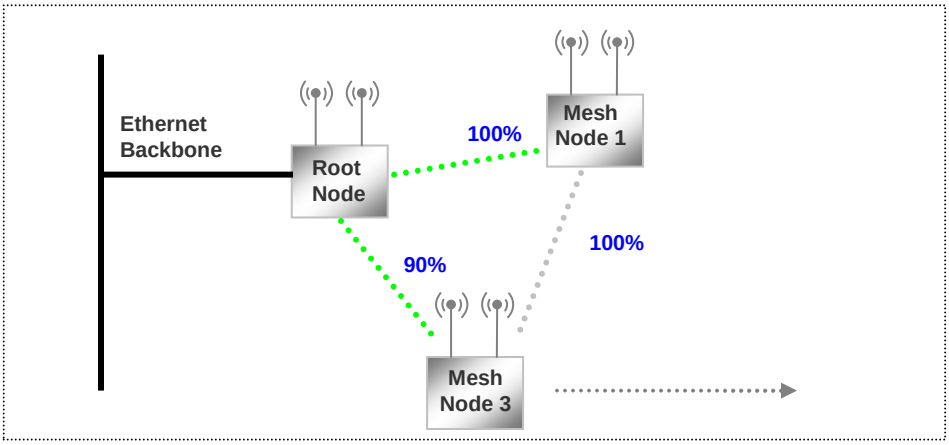


Figure 3, An example of 3-node mesh network with a mobile mesh node

In this case, Mesh Node 3 will go directly to the Root Node instead of going through Mesh Node 1.

Now consider that Mesh Node 3 starts moving away from the Root Node but still maintains a good connection with Mesh Node 1, when will Mesh Node 3 start using Mesh Node 1 to get to the Root Node instead of using it possibly poor connection to go direct to the Root Node? Now it is a good time for us to examine the underlying rules that determines the mesh topology.

Mesh Routing Rules

First we classify links by the RSSI values in the following:

RSSI Quality	Link Type
100%	A
60% - 100%	B
45% - 60%	C
30% - 45%	D
<30%	E

Then the following rules govern which mesh path is chosen:

A >B >2A >C >3A >2B >4A >3B >5A >4B >D >2C >3C >4C >2D >3D >4D >E

Where X > Y means X is preferred over Y, and nX means n hops of links with link type X.

Other mesh combinations will be automatically calculated based on these rules by the system.

Now let's go back to the last example. According the above routing rules, Mesh Node 3 will start using Mesh Node 1 as a relay once its connection to the Root Node drops to type B and its connection Mesh Node 1 remains type A.

Therefore, it should be stressed that every Mesh Node optimizes its path by looking for the best path to the Root Node, not necessarily to the neighbor node with the best link quality.

Site Survey

Site survey should always be performed prior to any wireless equipment installation. Site survey should include, at the minimum, the following steps:

1. RF spectrum analysis on 2.40-2.49 GHz band and 5.7-5.9 GHz to detect any potential RF interference. Strong interference sources should be dealt with (removed or avoided) before an installation.
2. Use a point-to-point 2-node mesh setup in various locations to quantify the RF propagation ability in this particular environment. Received Signal Strength Indicator (RSSI) can serve as one indicator of the RF environment. TCP/IP throughput testing and UDP/IP throughput and packet drop rate testing should be conducted in all selected locations to quantify the quality of the environment.
3. Site survey should be conducted when the environment system is operating so that maximum possible interference is measured and considered.

Radar Signal

802.11b/g uses the unlicensed 2.4GHz band. 802.11a uses the unlicensed 5GHz band. In many countries, 5GHz is also used by radars. In most countries regulations state that radar has higher priority in using the 5GHz band and 802.11a devices are required to detect the existence of radar(s) and not interfere with radar(s) once detected.

It is important to validate the presence of radar on any wireless mesh deployment. If during operation, a Mesh Node detects a radar event over the Radio Frequency (RF) channel that the mesh network uses, it must immediately stop operation or change to another available RF channel. This is dictated by Federal Communications Commission (FCC) and European Telecommunications Standards Institute (ETSI) standards, and is established to allow the sharing of the 5 GHz spectrum between wireless LAN (WLAN) and military or weather radars that use the same frequencies.

In the U.S., the upper bands (5.725 - 5.825 GHz band) do not require DFS and are the preferred channels for deployments. DFS is supported in all European countries, and therefore technical notes in this section should be closely followed when Mesh Nodes are deployed in Europe.

Before firmware version 4.2, the mesh radio will stop its operation when a radar signal is detected. For firmware 4.2 or newer, the mesh radio will try to automatically select a new channel and form a new mesh in the new channel.

It is advisable that before you plan and install, contact the local authorities in order to obtain information if there is any known radar installation nearby, such as weather, military, or an airport. Also, in harbors, it is possible that passing or incoming ships might have radar that affects the mesh network, which might not be present during the survey phase.

In case that severe radar interference is detected, it is still possible to build the network using the 802.11g 2.4GHz band instead of using 802.11a 5GHz band. The mesh radio will share the 2.4GHz band with the Access Point radio. They should be configured to use distinctly separate channels. This represents a technical alternative for sites too close to a powerful radar source.

Antenna

Antenna Type

Depending on the site survey result and the specifics of the installed environment, proper antenna type (omni-directional vs. directional, low-gain vs. high gain, etc) should be selected. Antennas play critical roles in the setup and operation of wireless mesh systems, just like any other wireless systems.

Antenna Positioning

Study has shown that the 5.8GHz band is particularly sensitive to the positioning of antennas. Lab testing has shown that a simple tilt of the receiving antenna can vary the received signal strength by up to 14dbm. Therefore, carefully positioning the mesh antennas during deployment can make a big difference in the performance of the mesh network.

Mesh Node has a built-in tool to report the received signal strength of all wireless devices it can hear. The tool is called “Adjacent AP List”, accessible via the web management console. Below is a screenshot of the tool:

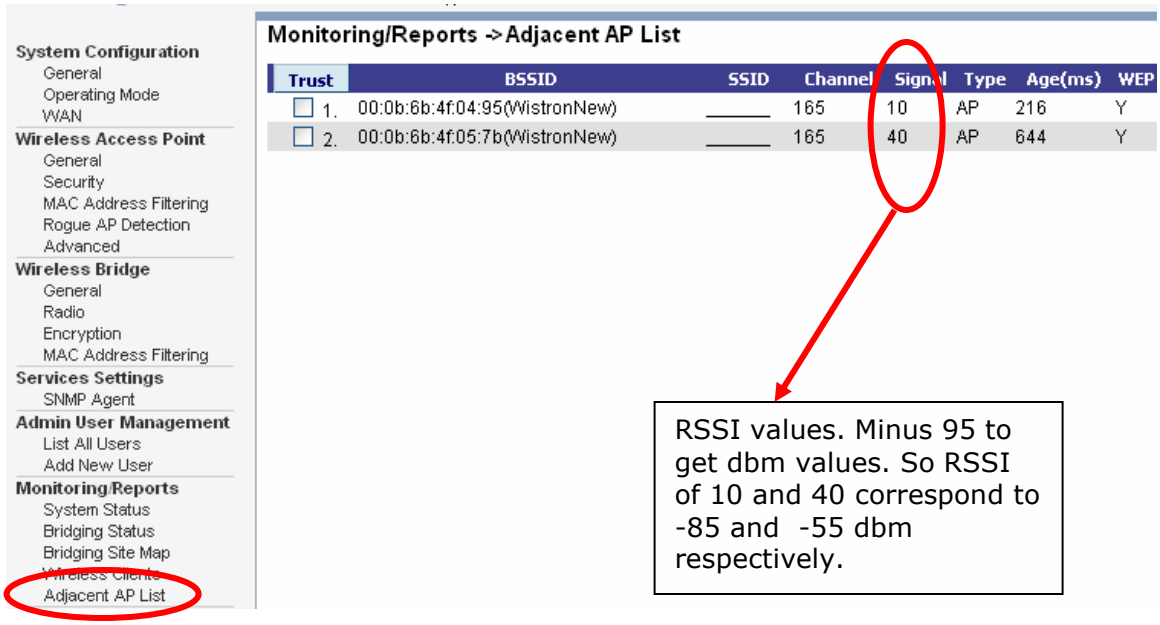


Figure 4, Mesh Node's built-in site-survey tool indicates RSSI of neighbor mesh nodes

This tool should be used during site-survey and deployment time for optimal antenna positioning. Simply refresh the page to get the most update-to-date readings of RSSIs.

Mesh Tuning

Due to the wide range of the variety of installation environments, the default configuration/parameter settings of the mesh network may not be the optimal settings for your site. There are a few important parameters you can adjust to customize the mesh to its optimal performance.

Mesh Link RSSI Threshold

The RSSI threshold value is checked when a node tries to establishes a link with another node. Both nodes will check the RSSI of its partner against its configured threshold value. If the RSSI is lower than the threshold value in either side, the link between them will not be established.

If the RSSI threshold is too small, the node will establish links with all nodes it can see even though some link quality is not good. Too many links in the mesh network can result in unnecessary frequent change of the topology.

If the RSSI threshold is too large, the node may not link with any other nodes and therefore isolates itself. This is an undesired situation.

The proper RSSI threshold should guarantee 2-4 links on each node.

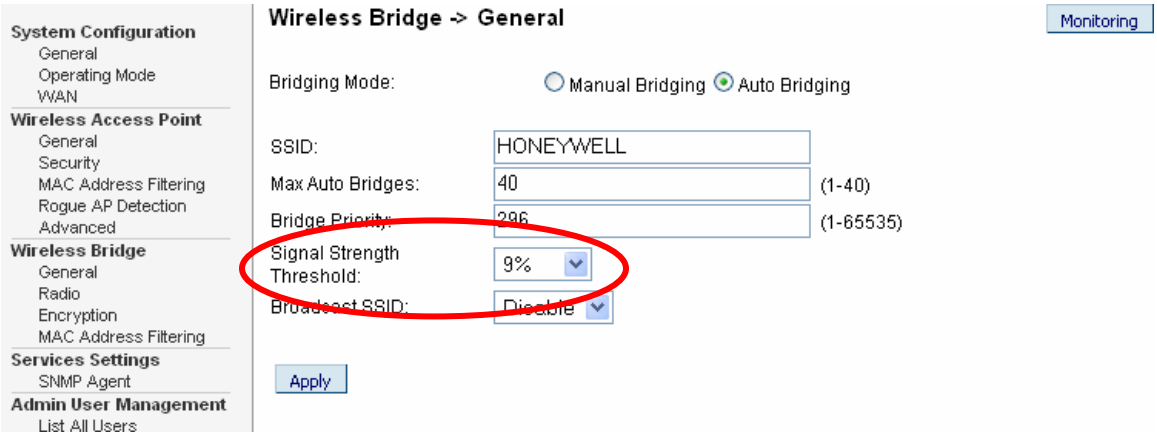


Figure 5, Tuning of the mesh RSSI threshold

Bridge Priority

Bridge priority sets the 802.1D/ RSTP (Rapid Spanning Tree) bridge priority. The latest revision of 802.1D requires the priority to be set to a multiple of 4096. Therefore, the value should be one of the following:

4096	8192	12288	16384	20480	24576	28672	32768
36864	40960	45056	49152	53248	57344	61440	

The device with the lowest bridge priority becomes the ROOT node. This device can be any RSTP compliant device, not necessarily a Mesh Node. Other than that, this number does not affect the general topology of the mesh networks.

MAC Address Filtering

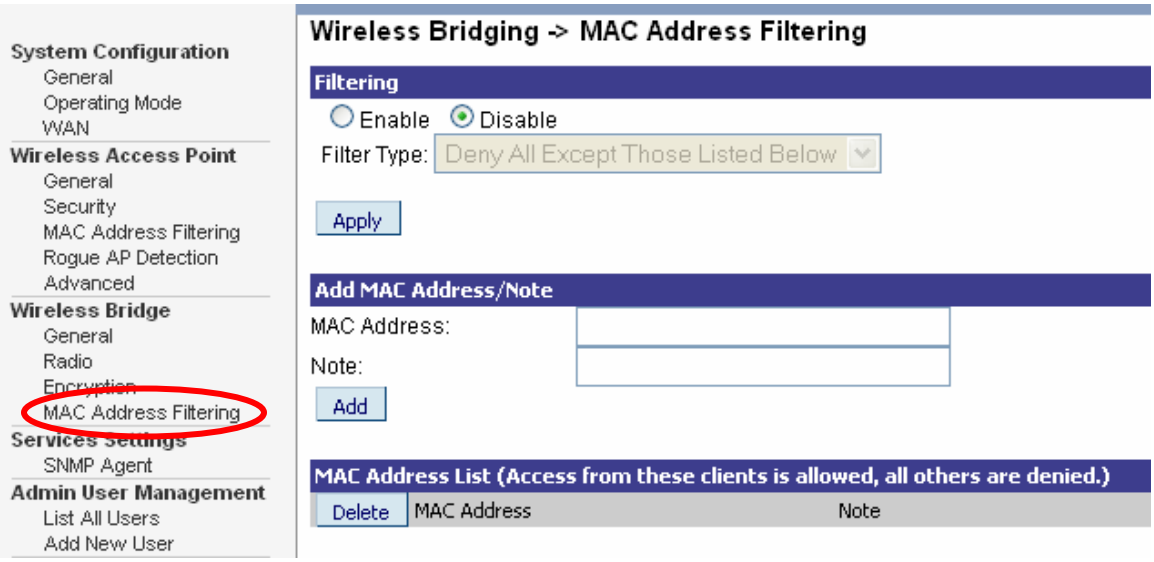


Figure 6, MAC Address Filtering can be used to further customize the mesh network (only available in auto-mesh mode)

In some cases, you may want to specifically link to one or a few nodes. You can use MAC Address Filtering to achieve this. For example, if one Mesh Node (A) is used to stream video to another Mesh Node (B) which is not the ROOT node, you can specify A to always connect to B and maybe another node for link backup. This way video is delivered using the shortest path to B.

You can also use MAC Address Filtering to specify that a set of nodes NOT to connect to.

Performance Estimation

Throughput and Signal Strength

The theoretical data rates and throughput values for corresponding signal strengths for wireless bridge connectivity are displayed in Table 1. These throughput values are based on a single point-to-point link between two Mesh Nodes.

Signal Strength (%)	Data Rate(Mbps)	Throughput(Mbps)
100	54	22
99	54	22
96	54	22
93	54	22
90	54	22
87	54	22
84	54	22
81	54	22
78	54	22
75	54	22
72	54	22
69	48	20
66	48	20
63	36	17
60	36	17
57	24	11
54	24	11
51	24	11
48	24	11
45	24	11
42	18	9
39	18	9
36	18	9
33	12	6
30	12	6
27	9	4.5
24	9	4.5
21	6	3
18	<6	<3
15	<6	<3
12	<6	<3
9	<6	<3

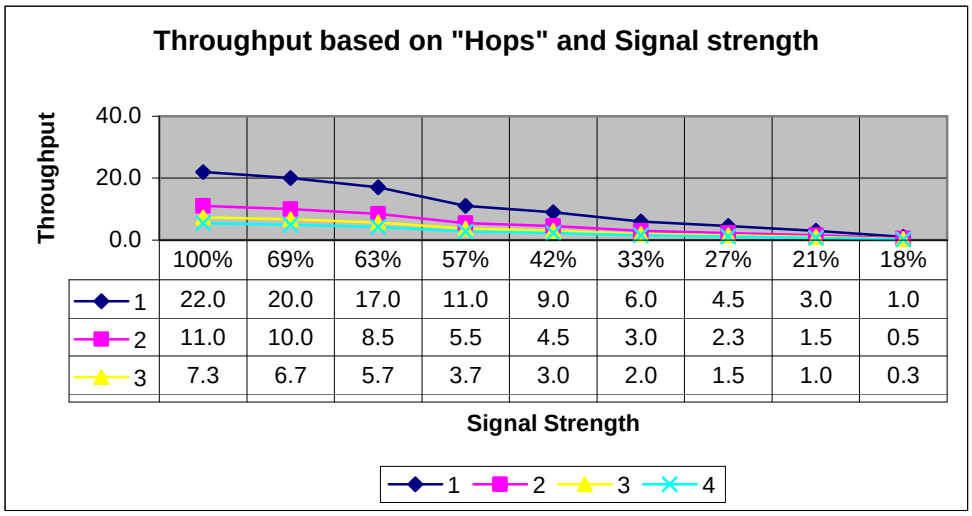
Table 1

The throughput values through a specified number of “hops” are shown in Table 2. Hops are defined as the number of devices through which the data must pass in order to reach its destination.

	1	2	3	4
100%	22.0	11.0	7.3	5.5
69%	20.0	10.0	6.7	5.0
63%	17.0	8.5	5.7	4.3
57%	11.0	5.5	3.7	2.8
42%	9.0	4.5	3.0	2.3
33%	6.0	3.0	2.0	1.5
27%	4.5	2.3	1.5	1.1
21%	3.0	1.5	1.0	0.8
18%	1.0	0.5	0.3	0.3

Table 2 Number of Hops, Signal Strength, and Throughput (Mbps)

The values from Table 1 and Table 2 are based on a best-case scenario, i.e. there is little to no 5.8GHz RF interference sources present while the data was passed. The values are also based on the bridge link radio only, which means it does not take into account the stability of the wireless client link to the access point radio of the Mesh Node.



Conclusion

Detailed site survey should always be conducted before the actual deployment of a mesh network. Mesh Node should be used along with other site survey tools for best results. When operating in Europe, special attention should be paid to find out possible radar signal existence in the deployment site, and if radar signal existence confirmed, channels without radar signals should be used for mesh operations. Meanwhile, Mesh Node provides configurable parameters so that the mesh networks can be tuned and customized to deliver optimal performance for each specific site. The actual throughput of the mesh network depends on many external factors, and good survey input, channel selection and antenna choice and installation will all contribute to better performance.