For
MESHDYNAMICS SYSTEM INTEGRATORS

CHANNEL ALLOCATION SCHEMES

5GHz Channels

- ## Difference in power between channels (52, 60) & (149, 157, 165)

  By MeshDynamics experimental results (as well as being due to regulation), channels 52 and 60 put out around 18-19dB of power as measured at the antenna port. Channels 149, 157, and 165 typically put out 22-23dB.

  In troubleshooting a weak (low signal, low connectivity) backhaul link, a sensible first step would be to check and see what channel the link using. Mouse over the parent node's icon to see the downlink channel. If the link is using a lower channel, manually set its downlink to an upper channel (or, just take the lower channels off of its DCA list). After rebooting the node, wait for the link to come back up and build confidence. See if a higher-quality link is achieved.

- ## When in doubt, change channels

  Since any *particular* channel is susceptible to interference on *that* frequency, and since its performance is dependent upon the characteristics of the antenna being used, and the surrounding environment in general, it is often beneficial to change the channel of a link when the link is not achieving optimal performance. This is done by going to the Interface Settings tab in the Configuration window of the parent node, and selecting the downlink radio. Under "Dynamic Channel Management", select "manual". Type in the desired channel to the left-hand-window, then click the "+" button. The channel should then appear in the right-hand window. Click "Update". Wait for the "Reboot Required" flag (RR) to show inside the node's icon. If this does not show, repeat the process, and again, see if the RR flag shows. Once the flag *does* show, reboot the node. The downlink radio will now beacon on the desired channel, and the child node will associate on the new channel.

- ## Necessary antennas for 5GHz (5.2-5.9GHz)

  Many "5GHz" antennas are only rated for the upper part of the spectrum (5.7-5.9GHz). The MeshDynamics backhaul uses both the lower part and the upper part of the 5GHz spectrum. Channels 52 and 60 are around 5.3GHz, while channels 149, 157, and 165 are around 5.8GHz. It is therefore necessary to select a 5GHz antenna capable of handling both parts of the spectrum.

5GHz Channels

- **Relationship between signal strength, receive sensitivity, and data rate**

  The quality of a link in a direction of data flow involves two main parameters: the output power at one end of the link, and the receive sensitivity at the other end of the link.

  By looking at the table below (for a Ubiquiti SR5 radio card), it can be seen how the data rate of the link relates to the two main parameters mentioned above.

  For example:
  According to the table below, a radio card can only put out 22dBm of power when transmitting 48Mbps. The receiving radio card must *see* this signal at –77dBm or higher in order to "keep up" with the 48Mbps. Otherwise, the receiving radio card will drop in data rate (and therefore, increase its sensitivity) to the point where it does see the incoming signal. If the signal at the receiving radio was –90dBm, the link would then drop to 18Mbps.

RADIO OPERATING FREQUENCY 5.20–5.825GHz

	TX SPECIFICATIONS			RX SPECIFICATIONS		
	DataRate	Avg.Power	Tolerance	DataRate	Sensitivity	Tolerance
802.11a OFDM	6Mbps	26 dBm	+/-1.5dB	6Mbps	-94 dBm	+/-1.5dB
	9Mbps	26 dBm	+/-1.5dB	9Mbps	-93 dBm	+/-1.5dB
	12Mbps	26 dBm	+/-1.5dB	12Mbps	-91 dBm	+/-1.5dB
	18Mbps	26 dBm	+/-1.5dB	18Mbps	-90 dBm	+/-1.5dB
	24Mbps	26 dBm	+/-1.5dB	24Mbps	-86 dBm	+/-1.5dB
	36Mbps	24 dBm	+/-1.5dB	36Mbps	-83 dBm	+/-1.5dB
	48Mbps	22 dBm	+/-1.5dB	48Mbps	-77 dBm	+/-1.5dB
	54Mbps	21 dBm	+/-1.5dB	54Mbps	-74 dBm	+/-1.5dB

Frequency Band	Channel ID	FCC (GHz)	ETSI (GHz)
Lower Band (36 = default)	34	—	—
	36	5.180	5.180
	38	—	—
	40	5.200	5.200
	42	—	—
	44	5.220	5.220
	46	—	—
	48	5.240	5.240
Middle Band (52 = default)	52	5.260	5.260
	56	5.280	5.280
	58	5.300	5.300
	60	5.320	5.320
H Band	100	—	5.500
	104	—	5.520
	108	—	5.540
	112	—	5.560
	116	—	5.580
	120	—	5.600
	124	—	5.620
	128	—	5.640
	132	—	5.660
	136	—	5.680
	140	—	5.700
Upper Band (149 = default)	149	5.745	—
	153	5.675	—
	157	5.785	—
	161	5.805	—
ISM Band	165	5.825	—

(Legend Next Page)

5GHz Channel Allocation Scheme

= **Meshdynamics default channels.**

Chans. 149, 157, and 165 and outdoor channels and have the highest Tx power. These channels are recommended for the "area" coverage for the vehicles.

Chans. 52 and 60 are typically indoor channels, and have about 3dB less Tx power than the upper channels. These channels are recommended for the backhaul, since high-gain directional antennas can be used; the high-gain antennas can compensate for the lower Tx power. Although these are indoor channels, they are commonly used in outdoor long distance links.

= **Non-default, indoor channels.**

Chans. 36 and 44 are also indoor channels, and have about 6dB less Tx power than the upper channels. These channels are also commonly used outside.

= **Non-default DFS channels.**

Chans. 100 to 140 are available to use if they have DFS activated. DFS is a radar-avoidance feature of the MD4000s.

***It is recommended that any non-default channels used be separated by 40MHz. This gives a maximum of 13 channels in the 5GHz spectrum.

Mobile-Node Antennas

Mobile nodes need the ability to transmit and receive in/from all directions, therefore, omni-directional antennas should be used on all scanner nodes.

There are two important issues to consider when selecting mobile-node antennas:

1)............The uplink and scanner antennas must be identical (same model number).
2)............The selected antennas must have a suitable *vertical radiation spread* to account for changes in the angle of the antennas as the vehicle moves over varying terrain.

The SuperPass model SPDJ60 (http://www.superpass.com/SPDJ6O.html) 8dBi omni-directional antenna is most suitable.

Stationary-Node-Backhaul Antennas

Stationary nodes that are placed more than ~300 meters apart can benefit from the use of directional antennas on the uplink radios. Directional antennas have a more focused beam which gives a higher gain to the backhaul link. Parent node downlink antennas must remain omni-directional in order to provide 360-degree coverage for the mobile nodes.

When using directional antennas, it is important to remember that the *uplink antenna of a child node* must be pointed at the *downlink antenna of its parent node*.

There is a "balance" achieved between **optimal gain of antenna** and **vertical + horizontal spread.** With a higher antenna gain comes narrower beam spread -which makes the antenna more difficult to aim. For a distance of 2km, the SuperPass model SPDN6F (http://www.superpass.com/SPDN6F.html#H_plane) is most suitable.
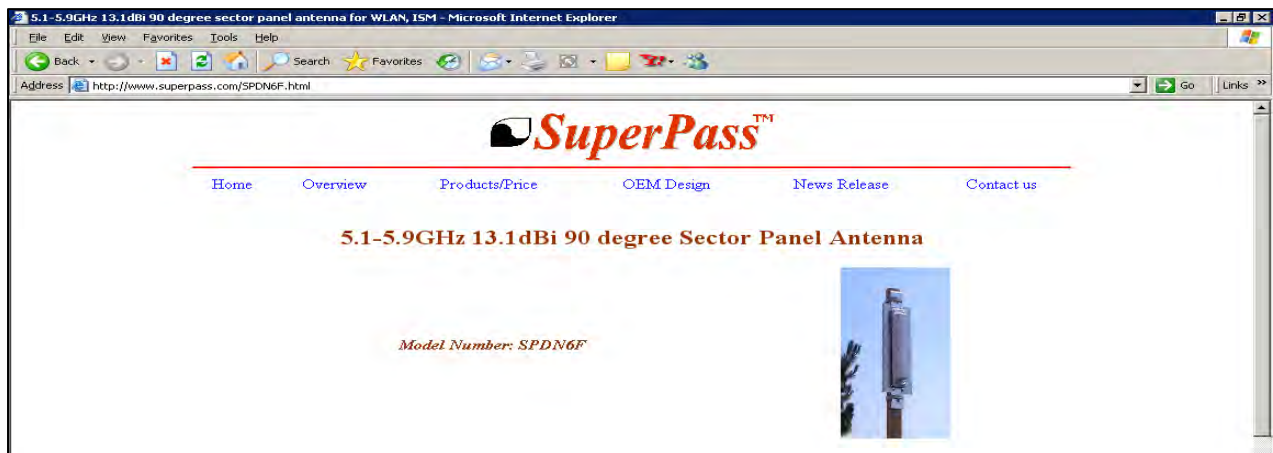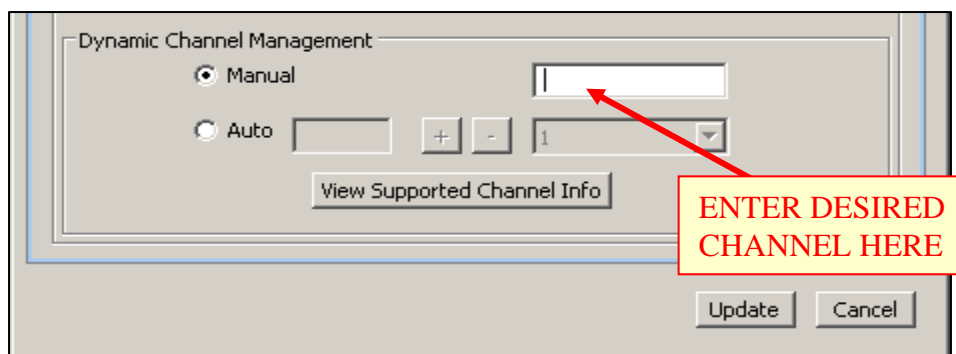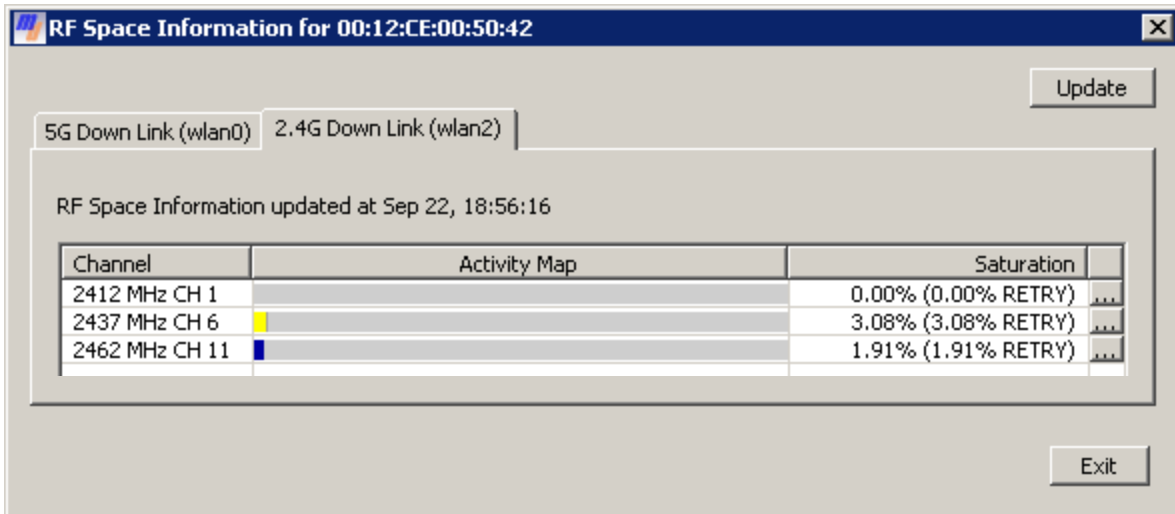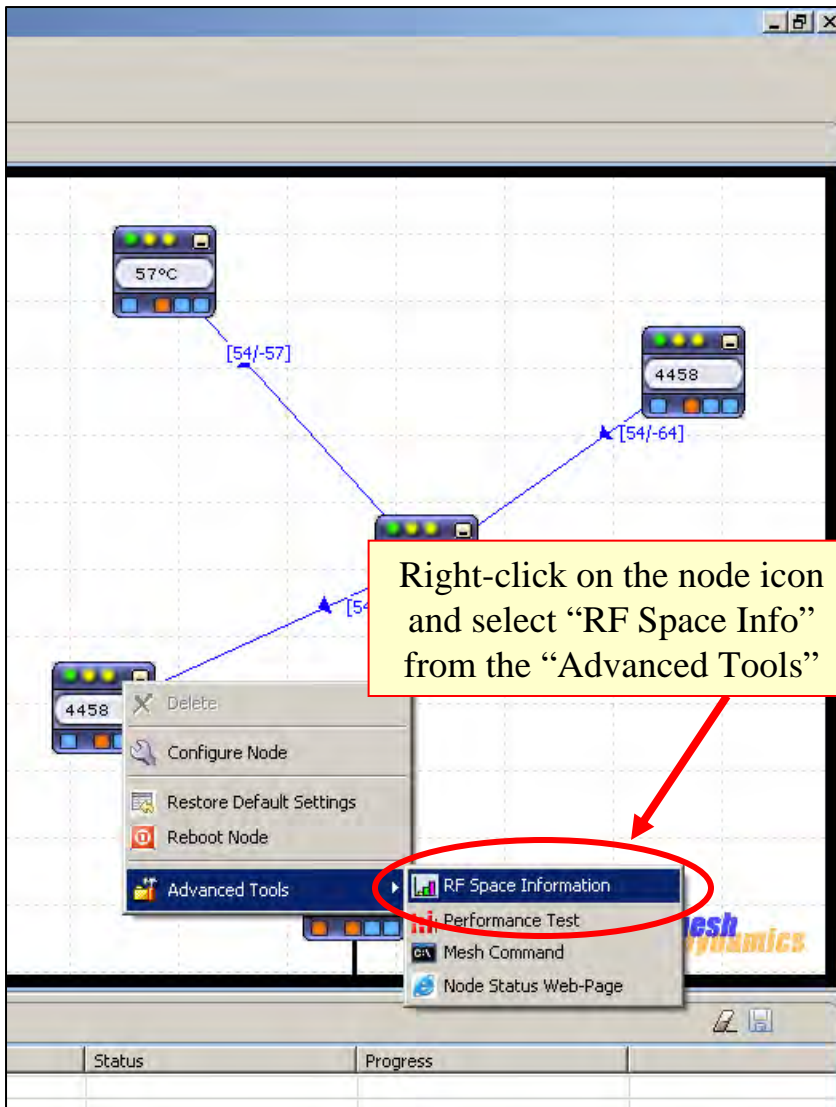
Poor Performance in 2.4GHz

Inconsistent throughput and/or latency issues are often the result of interference. This is especially prevalent in the 2.4GHz spectrum. If there are issues seen when using the 2.4GHz spectrum from node to node, or node to client, there are a few steps that can be taken to combat these negative effects:

1) Avoid testing in high-RF-traffic areas such as corporate parks or offices. Some buildings have a high density of access points. This can cause a very dirty RF environment that may result in high latency and bad throughput.

2) Change the channel that the AP is providing. The RF Space Information tool will provide an analysis of the 2.4GHz channels. With this information, it can be determined which channel has the cleanest RF space *in the vicinity* of the AP (of course this information is dependent upon the AP's antenna and what it is "seeing"). The channel of the AP is changed in the "Dynamic Channel Management" box under the "Interface Settings" tab.

Right-click on the node icon and select "RF Space Info" from the "Advanced Tools"

Poor Performance in 2.4GHz

Select the "2.4G Down Link" tab, then click "Update". Wait ~20 secs. For the node to scan the RF.

Poor Performance in 2.4GHz

RF Space Information for 00:12:ce:00:23:24

Update

Tabs: 5G Down Link | **2.4G Down Link** | 2.4G Down Link

RF Space Information updated at Oct 23, 17:07:07

Channel	Activity Map	Saturation
2412 MHz CH 1		0.00% (0.00% RETRY)
2437 MHz CH 6		4.92% (4.92% RETRY)
2462 MHz CH 11		8.33% (8.33% RETRY)

Cancel
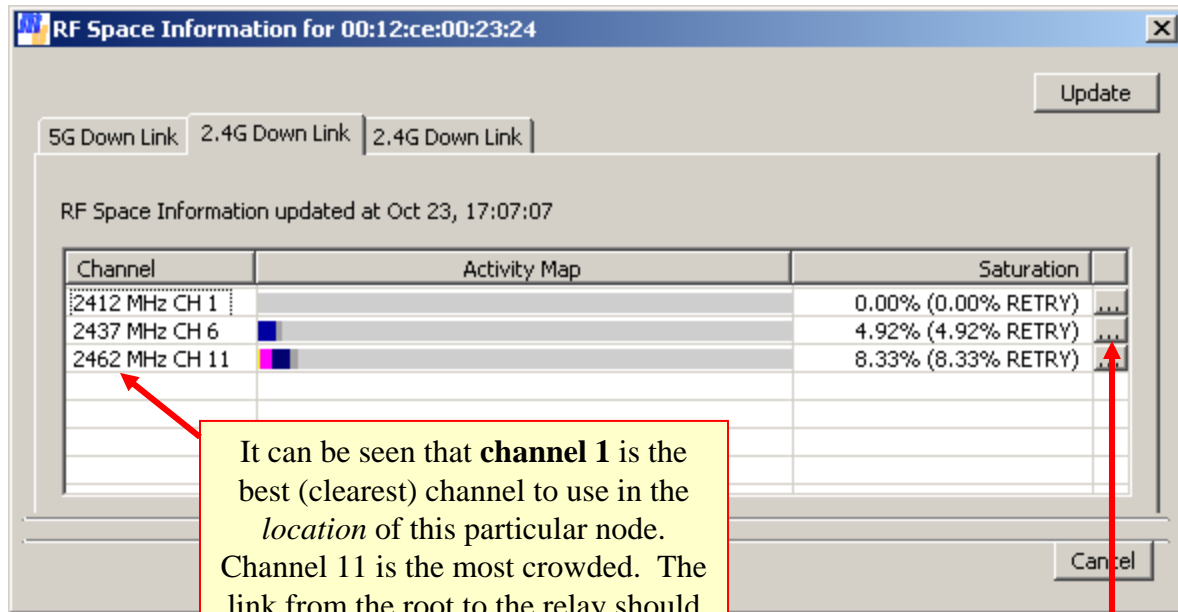
It can be seen that **channel 1** is the best (clearest) channel to use in the *location* of this particular node. Channel 11 is the most crowded. The link from the root to the relay should then be manually set to channel 1. This is detailed in the next page.

***It would be good practice to do this same process for the downlink radio of the relay node as well. This will give a more complete picture of the RF environment. Remember to attach an antenna to the downlink radio before performing the scan.

Click button here to see signal strengths of clients/APs

Activity Map

2462 MHz CH 11

	BSSID	ESSID	Signal	TX %	Retry %
	00:0b:85:51:6e:9d		-95 dBm	0.08%	0.08%
	00:0b:85:51:6e:9f	TELbeam	-95 dBm	0.40%	0.00%
	00:14:bf:ad:f4:78	linksys_SES_64483	-91 dBm	2.42%	0.42%
	00:14:6c:98:3b:00	BPNETGEAR1	-89 dBm	3.69%	1.92%
	-	Other (Not-categorized)	-	1.75%	0.00%

Cancel

Poor Performance in 2.4GHz

From the Node Configuration window, select the 2.4GHz downlink radio.

Make sure no 802.11b clients associate to the node.

Select "Manual" here and type in the desired channel.

Click "Save" and reboot the node.

Poor Performance in 2.4GHz

3) Avoid testing indoors. The MD4000 is an *outdoor* mesh node. Its high-powered radios are not intended for indoor use since there may be many reflections and multi-path. Using the radios indoors cannot guaranty reliable test results

4) Implement "Request to Send" (RTS) on the uplinks of child nodes. If testing involves having many clients or mesh nodes associating to *one downlink/AP radio* on a certain mesh node, this particular radio may be susceptible to the "hidden node effect". Implementing RTS on the uplinks of the child nodes and (if possible) client devices will help remedy this. RTS is a tunable feature, so each individual application may have its own optimal setting.

5) Set laptops involved in the testing to the highest performance wireless settings. Some laptops may be in "sleep mode" which is a power-saving option for wireless transmissions from the laptop to an AP. If a laptop is in sleep mode, it may **not** exhibit optimal throughput/performance to the mesh node's AP or downlink radio.

It is very common that a laptop will enter "sleep mode" when it is under battery power.   It is best practice to have the laptop plugged into the wall and to make sure it is set to the highest-performance settings. If the laptop is nowhere near an outlet, it is still possible to set it to high-performance.

6) Use different ESSIDs when using a dual-AP node. Some configurations of mesh node have two 2.4GHz beaconing radios (APs or downlinks). The MD4458-AAII is the most common. If the two radios have the same ESSID, and if a client sees both beaconing radios at nearly the same signal strength, the client will get "confused" and slosh between the two radios. In this case, throughput and performance will suffer. A troubleshooting step for this is to completely power down on of the radios and see if the client's performance changes. It is highly recommended that sector antennas be used on the radios to keep signal from overlapping. Most important is to make sure different ESSIDs are used on the radios.

2.4GHz Spectrum Usage (20 MHz separation)

Three channels in the 2.4GHz ISM band are referred to as "non-overlapping". These are channels 1, 6, and 11, and are the default 2.4GHz channels used by MeshDynamics. In the illustration below, it can be seen how the "tails" of the OFDM channel masks overlap, while the "plateaus" do not. Note that the separation between the center frequencies is less than 40 MHz. 2.4G is not a preferred backhaul spectrum due to its limited spectrum and adjacent channel interference resulting from the channel mask overlaps.
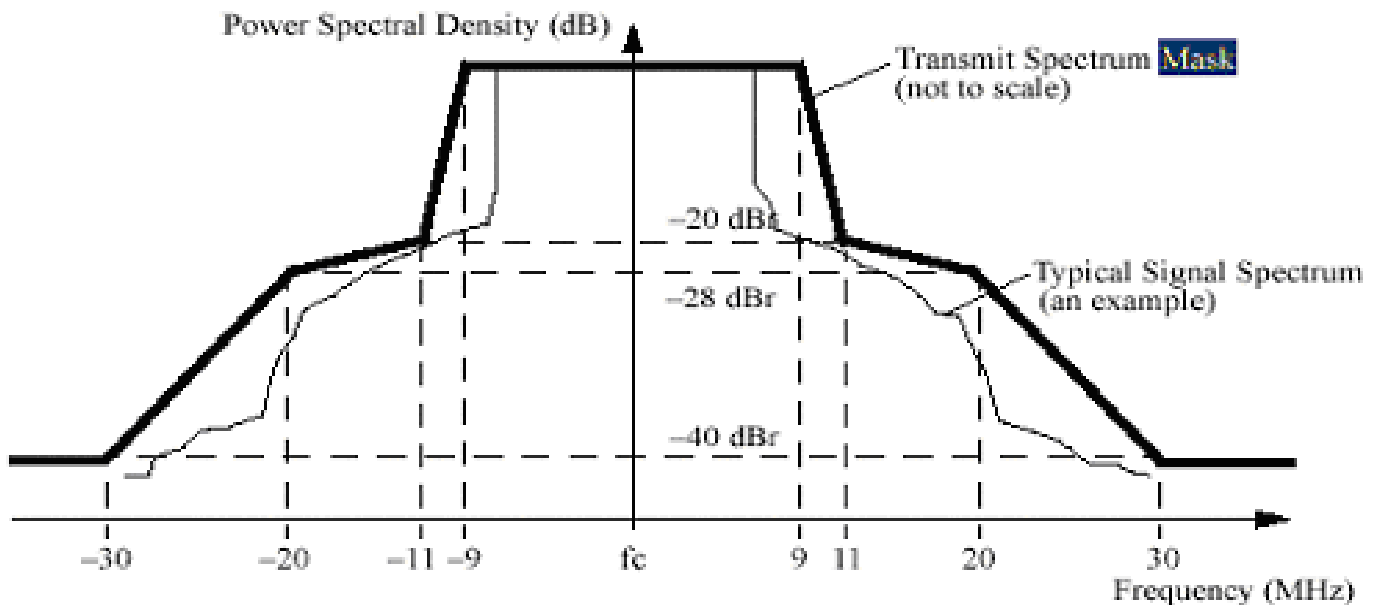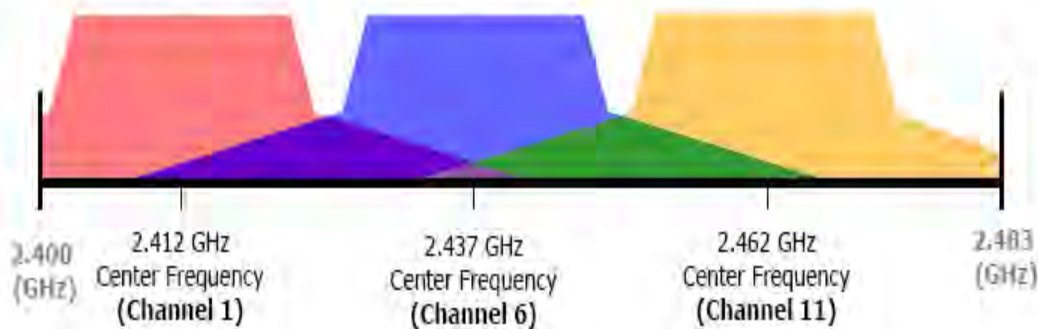
4.9GHz Channel Usage

The 4.9GHz channels on MD4000s are 10MHz wide by default. RF editor must be used to create 20MHz-wide channels, or 5MHz-wide channels. Below is a table of usable 4.9GHz channels and their corresponding center frequencies.
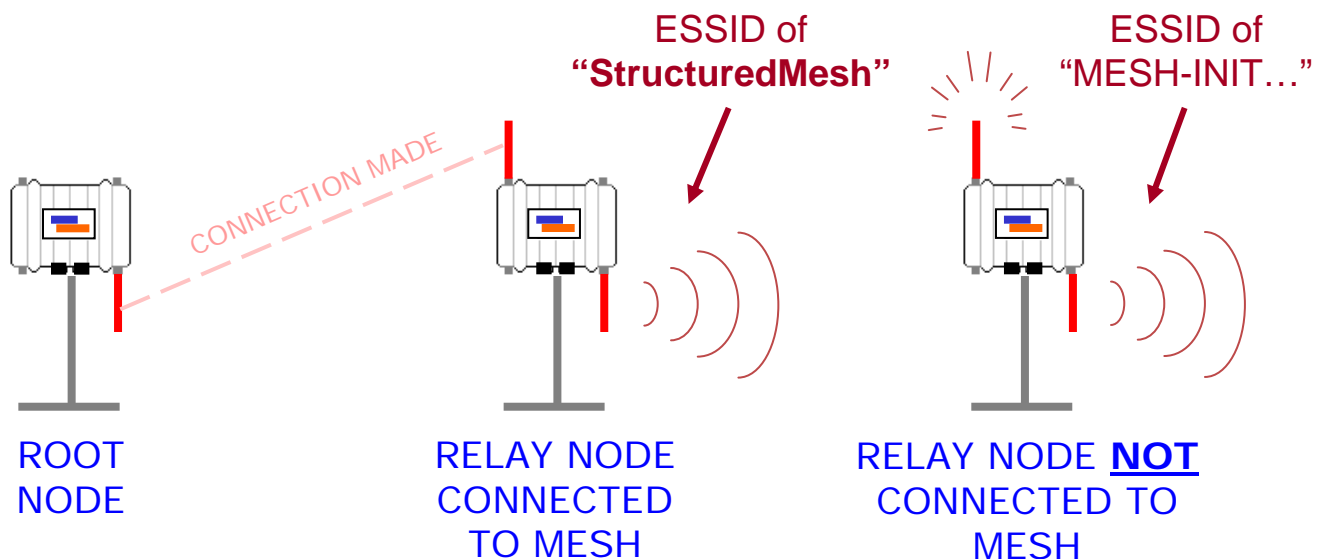
CHANNEL WIDTH	CHANNEL NUMBER	CENTER FREQUENCY (**MHz**)
20MHz	20	4950
	30	4955
	40	4960
	50	4965
	60	4970
	70	4975
	80	4980
10MHz	10	4945
	20	4950
	30	4955
	40	4960
	50	4965
	60	4970
	70	4975
	80	4980
	90	4985
5MHz	5	4942
	15	4947
	25	4952
	35	4957
	45	4962
	55	4967
	65	4972
	75	4977
	85	4982
	95	4987

Assuring Network Formation

Upon boot up, a root node will beacon a default ESSID of "StructuredMesh" on its downlink and AP radios. When a relay node boots up, it will scan on its *uplink* radio. When the uplink radio of a relay node hears the beacon from a root node, it will associate. This same relay node will then start to beacon on its downlink and AP radios. Any scanning relay nodes that hear *this* beacon will associate, thus growing the network.

Until a child node associates to a parent node, it will beacon an ESSID starting with the words "MESH-INIT" on its downlink and AP radios. This is to indicate that it has no association to the mesh network. If a *root* node continually beacons an ESSID of "MESH-INIT-… ", this indicates that it is not physically connected to the switch, and is therefore attempting to function as a relay node. ***A child node will not associate to a parent node if the parent node is in the "MESH-INIT" state.

Use a laptop to detect the ESSIDs and determine what state the node is in. To detect the ESSID from a 5GHz downlink, of course the laptop will need to be 5GHz-enabled. Keep in mind that the ability to detect the ESSID is dependent upon proximity to the node, and the antenna being used on the node's beaconing radio(s).
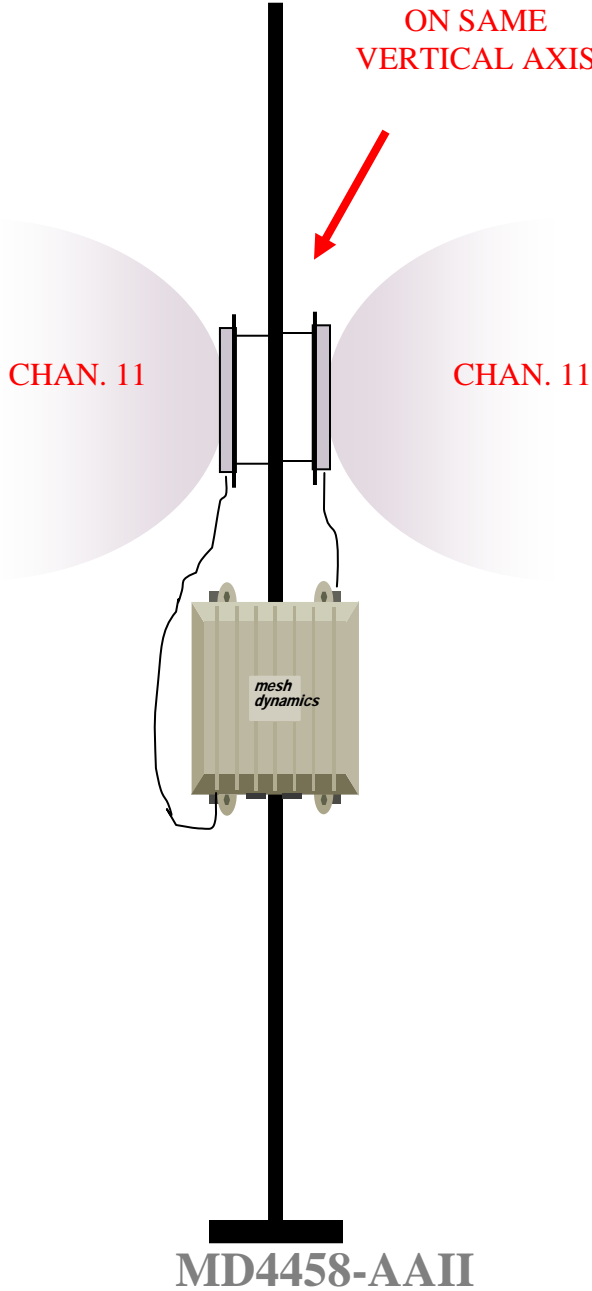

ESSID of **"StructuredMesh"**

ESSID of "MESH-INIT…"

CONNECTION MADE

ROOT NODE

RELAY NODE CONNECTED TO MESH

RELAY NODE **NOT** CONNECTED TO MESH

Managing Antennas

The physical separation of the antennas should be considered when deploying mesh nodes. Although "non-overlapping" channels are used for the backhaul, it is possible that the signals of two adjacent non-overlapping channels will interfere with each other *if* one of the signals is strong enough at the antenna that is operating on the other channel. Antennas should be installed with enough <u>vertical separation</u> such that this does not happen.

If it is not possible to give the antennas more vertical separation, use channels that are non-adjacent (for ex., chn. 52 and chn. 157).

UPLINK
ANTENNA
(DIRECTIONAL)
CHN. 52

DOWNLINK
ANTENNA
(OMNI-DIRECTIONAL)
CHN.60

UPLINK
ANTENNA
(DIRECTIONAL)
CHN. 52

DOWNLINK
ANTENNA
(OMNI-DIRECTIONAL)
CHN.60

Downlink antenna is **within** signal spread of uplink antenna

Downlink antenna is **below** signal spread of uplink antenna
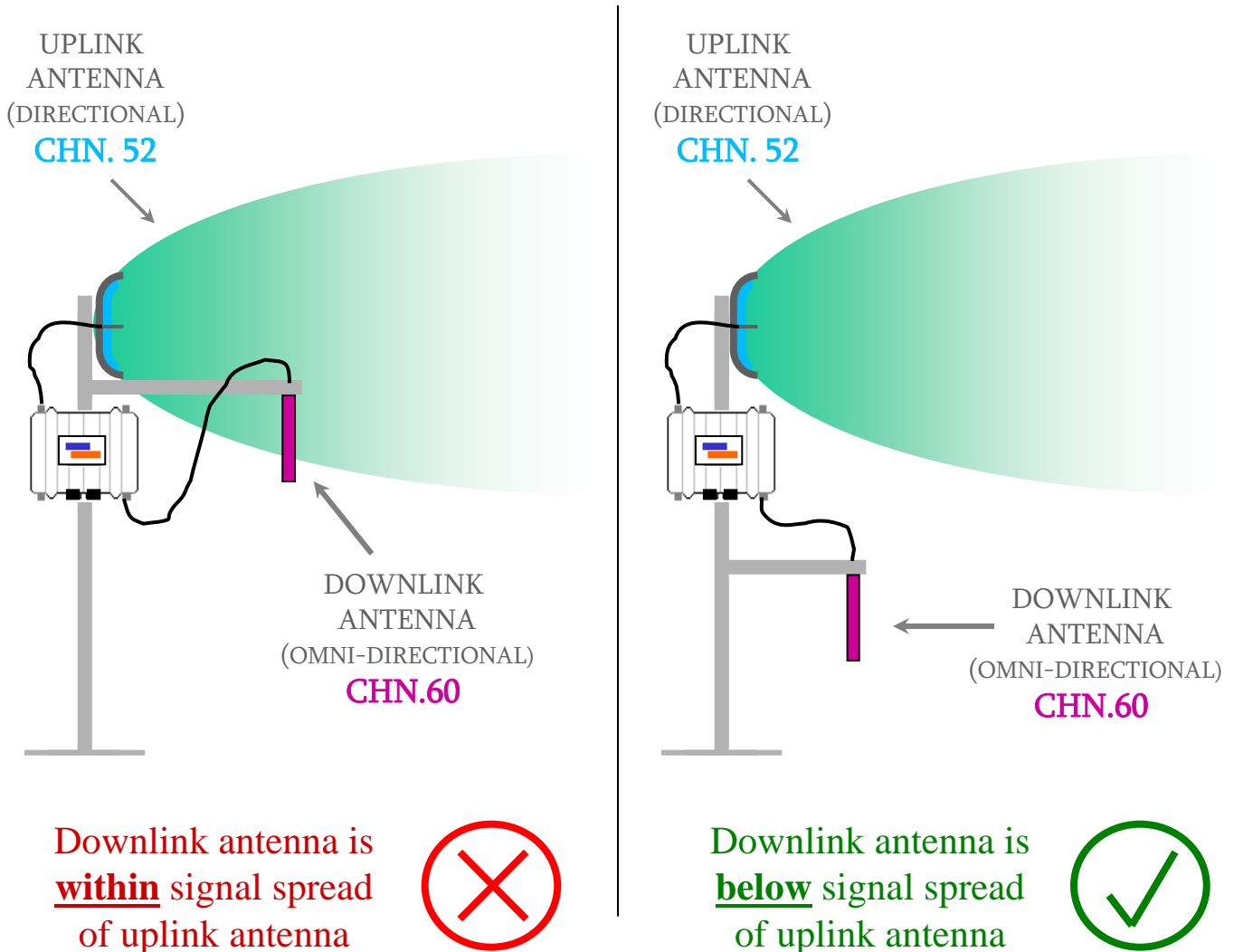
NO VERTICAL
SEPARATION,
ANTENNAS NOT
ON SAME
VERTICAL AXIS

ANTENNAS ON
SAME VERTICAL
AXIS

CHAN. 6

CHAN. 11   CHAN. 11

CHAN. 1

VERTICAL
SEPARATION
(>10cm)

*mesh
dynamics*

*mesh
dynamics*

MD4458-AAII

MD4458-AAII

1) No vertical separation between antennas
2) Antennas not on same vertical axis
3) AP radios on same channel
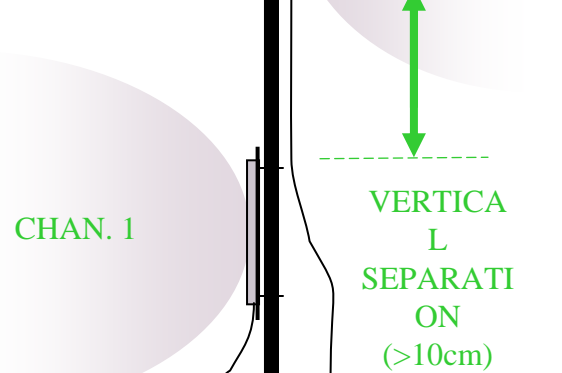
1) Sufficient vertical separation between antennas
2) Antennas on same vertical axis
3) AP radios on different channels

Managing Antennas

It is important that antennas be properly grounded to ensure solid performance. Be mindful of how the antennas are grounded, and if they are connected to a "dirty" ground (for ex., electrical machinery). Antennas can be mounted to the mesh node and still be properly grounded provided that the node itself is properly grounded.
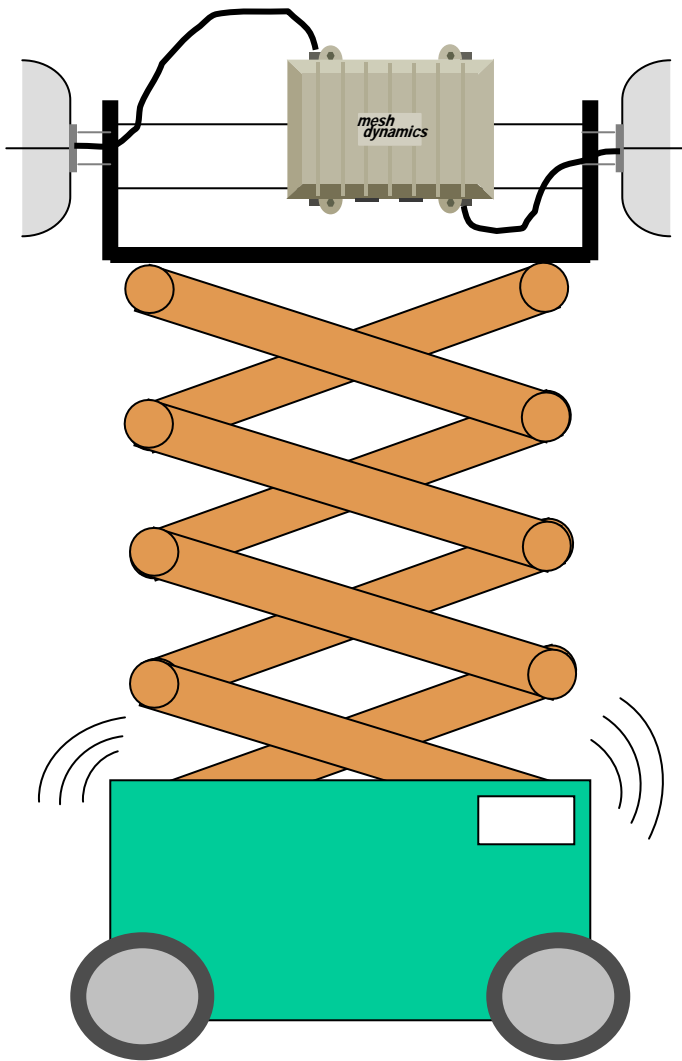
GROUNDED TO ELECTRICAL MACHINERY (!)
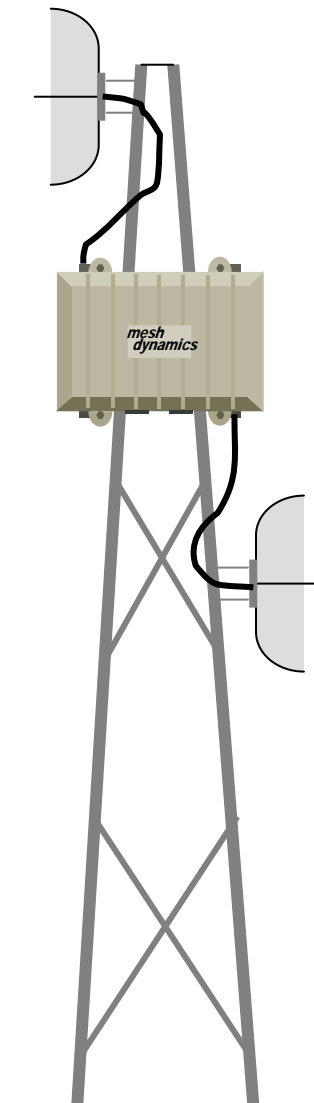
GROUNDED TO TOWER

Mobile Node Antenna Configurations

There are two different physical configurations of mobile node as seen below.

When using a splitter to combine the uplink and scanner radios into one antenna (right-hand illustration), it is important to consider the isolation rating for the splitter (which should be at least 20dB). This will determine the value of the attenuator needed. The combined value of the splitter isolation and the attenuator should be equal to 30dB.

When using an individual antenna for each radio (left-hand illustration), beware of the fact that it is possible for the scanner antenna to block the transmissions from the uplink antenna to the parent node if the mobile node is oriented in a certain way. This may happen when the vehicle with the mobile node is making a turn, for example. It is also possible for the uplink antenna to *shield* the scanner antenna from seeing potential parent nodes. This is a factor that should be considered.

SPLITTER

ATTENUATOR

mesh dynamics

mesh dynamics
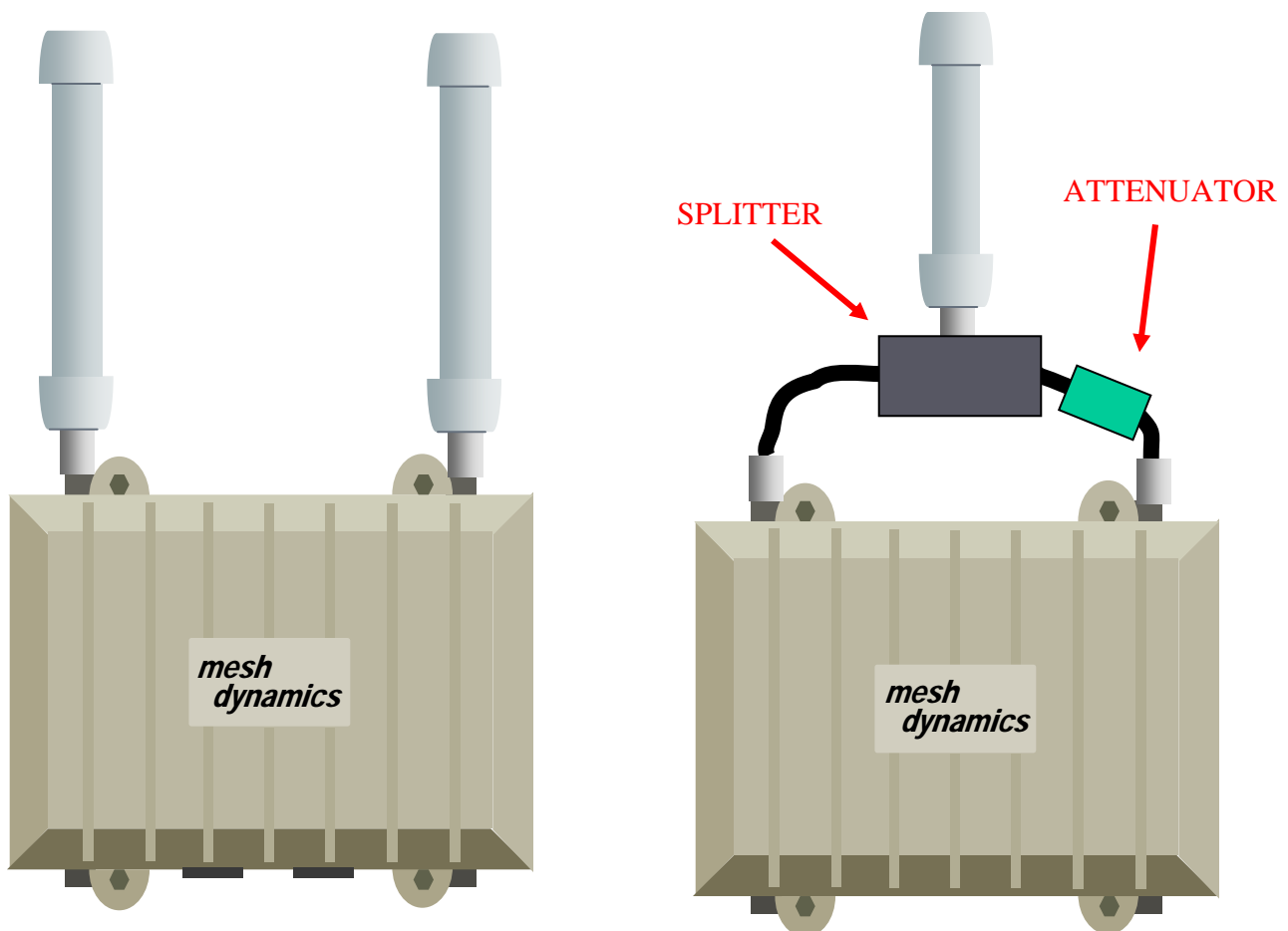
Backhaul Power Levels

In fine-tuning backhaul performance, it is recommended that the RSSI (signal strength) values be fairly balanced throughout the backhaul. Ideally, links should have Tx and Rx signal strengths between –55dBm and –65dBm. Adjusting the "Power Level Setting" on the downlinks of parent nodes, and the uplinks of child nodes will help bring signal strength values closer together. See pg. 12 of the MD4000 Network Viewer user manual for exact definitions pertaining to link values.

Rx Signal (dBm)	Rx Rate (Mbps)	Tx Signal (dBm)	Tx Rate (Mbps)
--	--	--	--
--	--	--	--
-43	54	-55	54
-60	54	-63	54
-71	54	-55	54
--	--	--	--
-54	54	-43	24
-71	54	-60	54

■ **Each Link Has _Four_ Associated Values: Parent Downlink <u>Signal</u> + <u>Rate</u> , Uplink <u>Signal</u> + <u>Rate</u>**

When booting up a mesh for the first time, it is good practice to boot up the root node(s) first, then the first (closest) relay, then the next closest relay, and so on. The NMS will display information about the links under the **Heartbeat tab** when the nodes boot up. This information can be used to troubleshoot the link (if necessary). The four values associated to each link are explained below.

A **Parent Downlink Signal**   This is the _signal strength that a particular child node sees from its parent node_. Keep in mind that this will vary from child-to-child, as child nodes are typically located at different distances from the parent node. This also depends on the antennas used in the link. A child node with a high-gain antenna on its uplink will "see" a stronger signal from the parent node than if a lower-gain antenna was used. This is because the higher gain antenna will have a higher receive sensitivity. Conversely, putting a higher gain antenna on the parent node's downlink will result in the child nodes "seeing" a stronger signal from the parent.

B **Parent Downlink Rate**   This is the _connectivity in the direction of parent-node-to-child-node_. Again, each child node will have its own value for "Parent Downlink Rate"

C **Uplink Signal**   This is the _signal strength of a node's uplink as seen by its parent node_. Keep in mind that this value depends on each antenna used in the link. A child node with a high-gain antenna on its uplink will transmit a stronger signal to the parent node than if a lower-gain antenna was used. Conversely, putting a higher gain antenna on the parent node's downlink will result in the parent node "seeing" a stronger signal from the parent since the higher gain antenna will have a higher receive sensitivity.

D **Uplink Rate**   This is the _connectivity in the direction of child-node-to-parent-node_.

***The two values displayed on the neighbor lines in between nodes are the "Uplink Rate", and the "Parent Downlink Signal"

For
MESHDYNAMICS
## *SYSTEM INTEGRATORS*

PERFORMANCE TESTING

Performance Test

The MeshDynamics Performance Test is a tool used to test data flow between two points. Its main purpose is to gauge the quality data flow between a parent node and a child node, **or** the path of data over multiple nodes.

- **Physical set-up**

  The Performance Test must be initiated through the NMS on a machine that is connected to the ixp1 (right-hand) Ethernet port of the starting point node. Data will flow between the laptop and the ending point node (EPN). It is good practice to have the laptop associate to the starting point node (SPN) over the wire as opposed to wirelessly. This will focus the results of the test on the wireless *mesh* links alone.

      ROOT   RELAY   RELAY
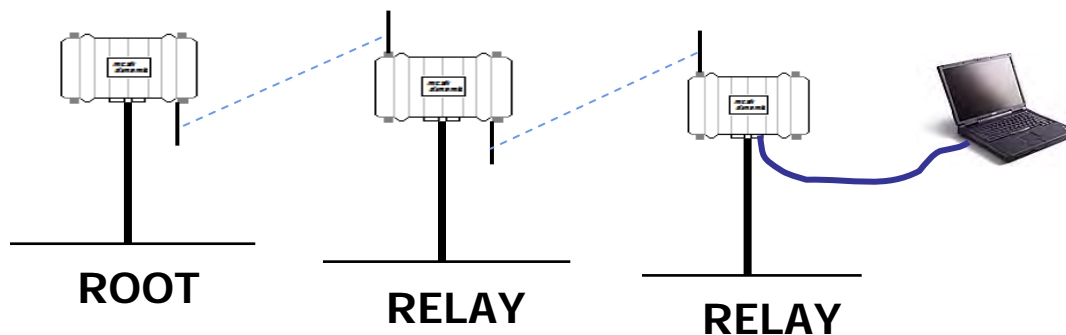
- **Enemies of throughput**

  Performance tests conducted indoors are susceptible to reflections that can effect throughput. Diminished throughput results may occur from indoor tests -especially with higher power outdoor radio cards.

  Uplink and downlink antennas on a node should have a vertical separation. Having a node flat on a table with both backhaul antennas angled upright will give zero vertical separation and therefore, effect throughput. This will happen *even* if the two radios are on separate channels.

Performance Test

To initiate the MeshDynamics Performance Test from the NMS, right-click on the EPN icon. Go to "Advanced Tools", then "Performance Test". This will introduce the Performance Test window as seen on the following page.
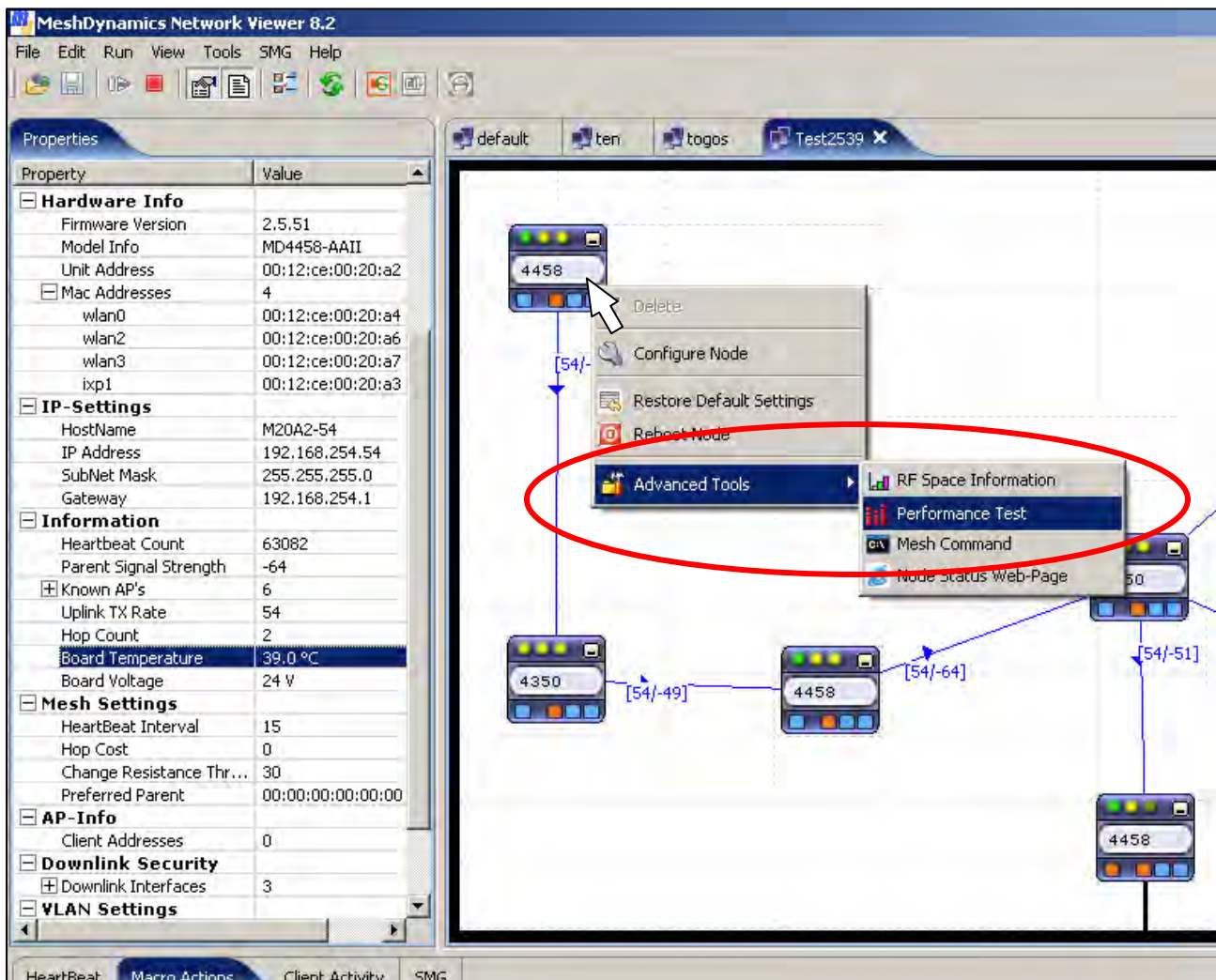
Performance Test

- **Running the Performance Test**

A   The EPN must be assigned an IP address (as well as the laptop's interface) in order to run the Performance Test.

B   For a test of longer duration, the "Record" can be increased from the default value of 15.

C   The "Single" type of test will send data **from** the laptop **to** the EPN. Selecting the "Dual" type of test provides the option of sending data in *both* directions along the assigned path/link. "Dual Individual" will send data from the SPN to the EPN for a duration, then vice versa. "Dual Simultaneous" will send data in both directions simultaneously.
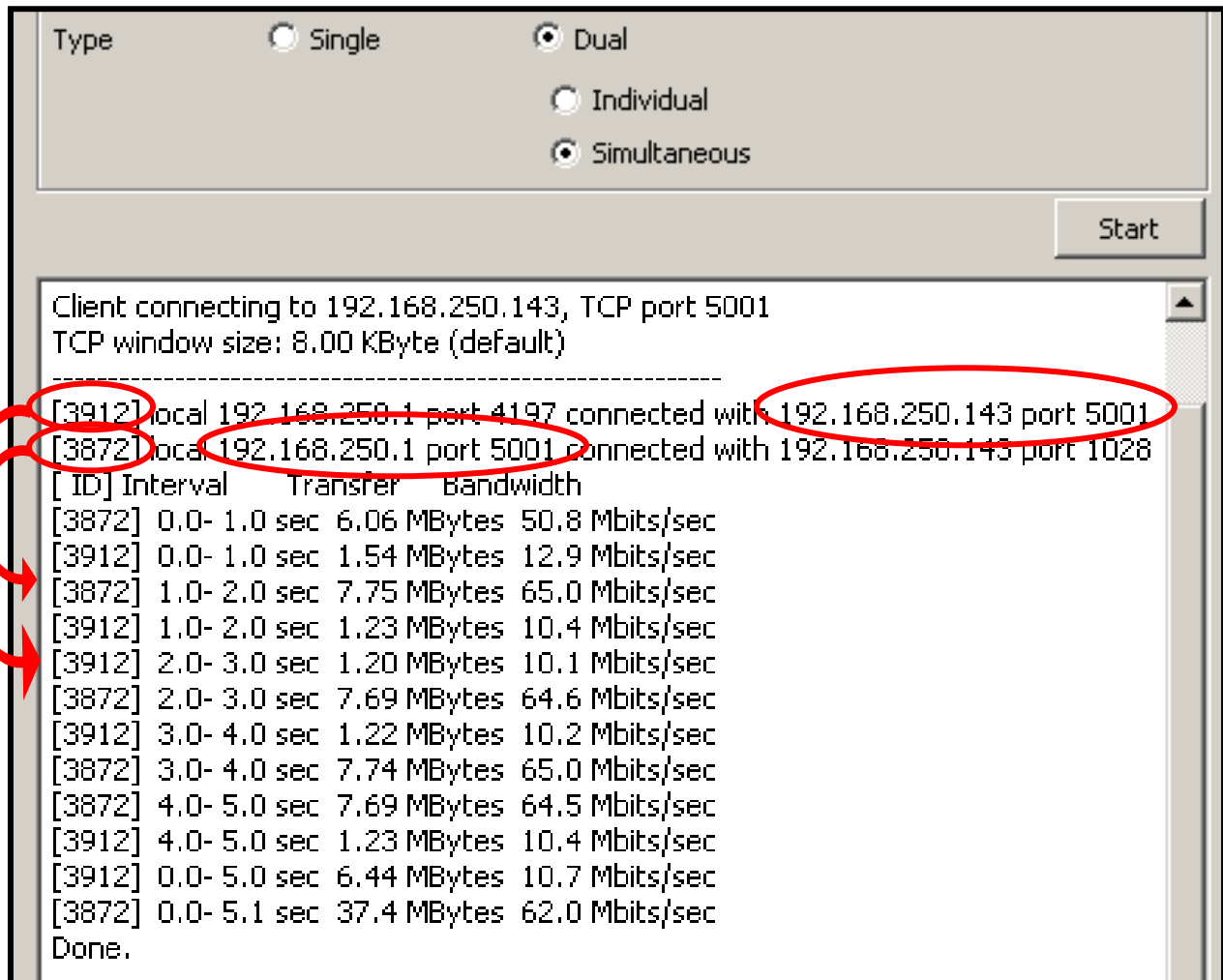
Performance Test

- **Interpreting results**

    Data will always flow *to* the TCP port 5001. This port therefore defines
    the endpoint of the data flow. In the sample output below, a "Dual
    Simultaneous" test was performed. Each direction of flow is labeled by
    the number to the left (in the below sample, the data flowing *to* the IP
    address of **192.168.250.143** is labeled by the number **3912**).

For
MESHDYNAMICS
SYSTEM INTEGRATORS

SELF-INTERFERENCE

Avoiding Self-interference

In certain situations, it is possible for a mesh to interfere with itself. Considering there are 5 default channels used by the backhaul, a mesh with 6 or more links will surely repeat one or more of these channels.

If an antenna that is operating on channel "A" is transmitting in the direction of an antenna involved with another link that is also operation on channel "A" , then, the two radios in the mesh network may interfere with each other. This can happen when sectored antennas are used

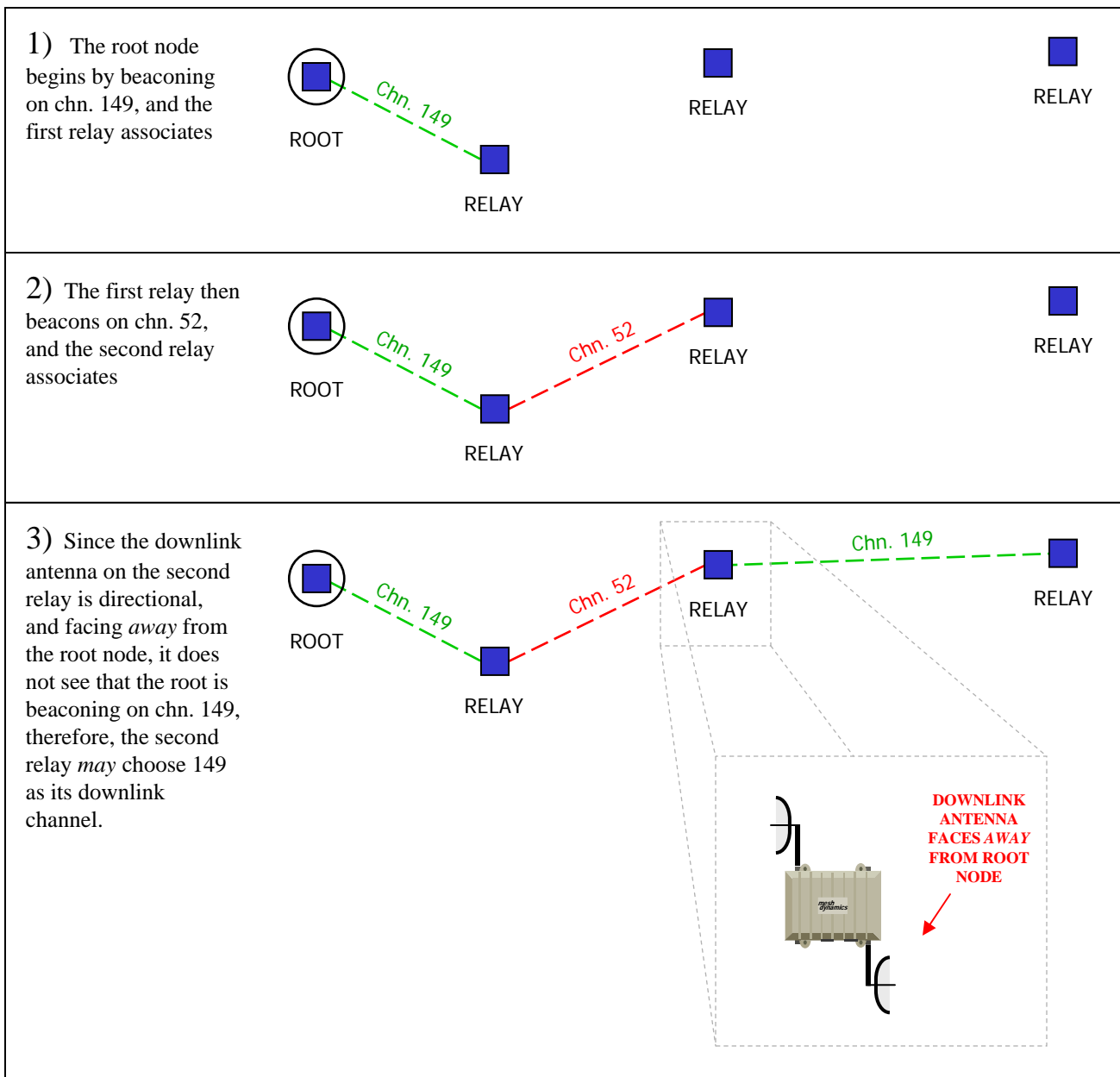Unlike Omni-directional antennas, Sectored antennas cannot see "behind" them.

This can result in Dynamic Channel Allocation based on incomplete knowledge.
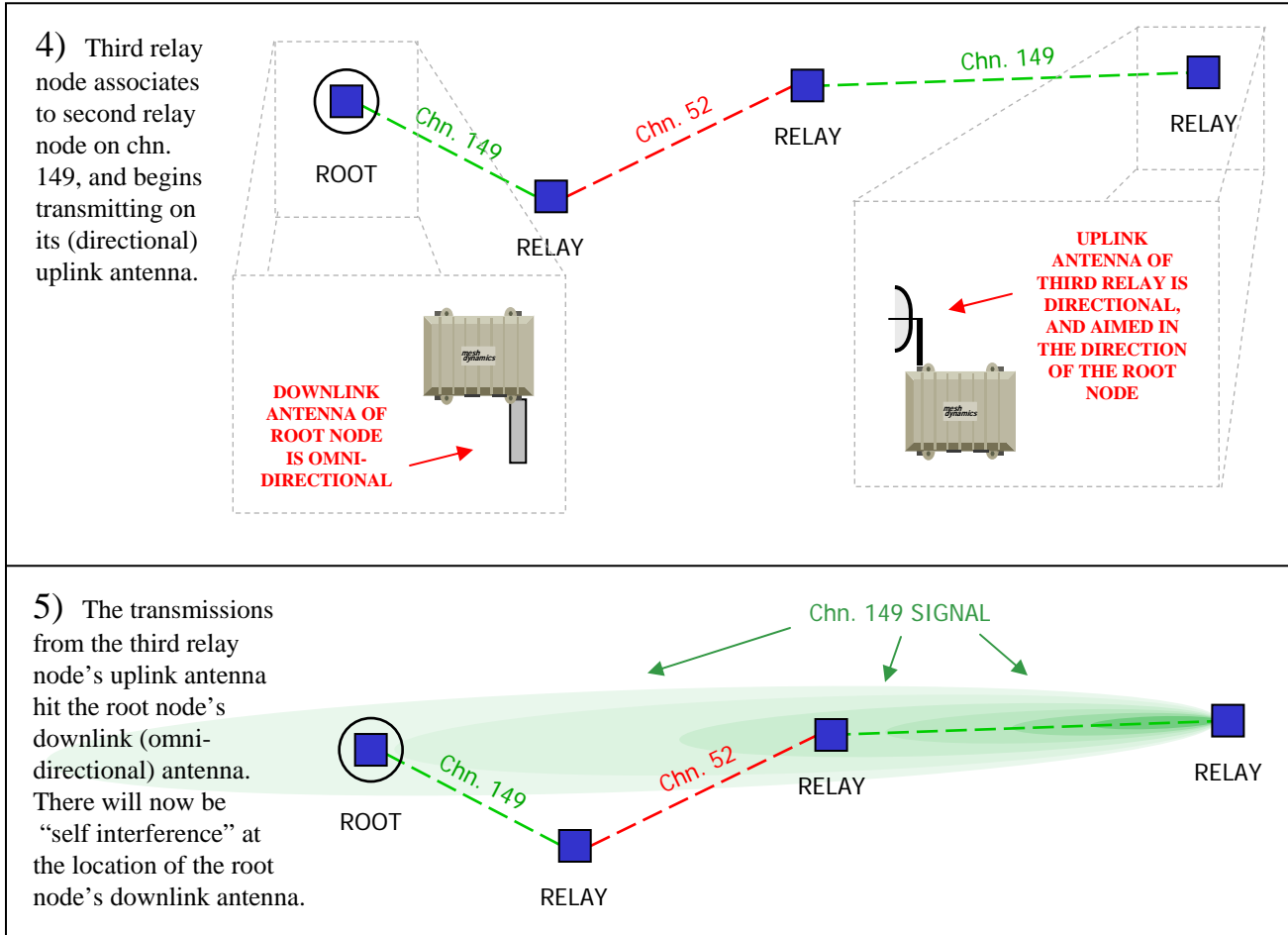
Steps to avoid this follow.

Avoiding Self-Interference

Although the MD4000 will choose the most optimal channels for each successive link in a mesh, it is still possible, in some situations, for a mesh to interfere with *itself*. This can cause drastic reductions in end-to-end throughput if not identified and corrected.

Consider the following situation:

1) The root node begins by beaconing on chn. 149, and the first relay associates	
2) The first relay then beacons on chn. 52, and the second relay associates	
3) Since the downlink antenna on the second relay is directional, and facing *away* from the root node, it does not see that the root is beaconing on chn. 149, therefore, the second relay *may* choose 149 as its downlink channel.	

Avoiding Self-Interference

4) Third relay node associates to second relay node on chn. 149, and begins transmitting on its (directional) uplink antenna.

Chn. 149

Chn. 149

Chn. 52

ROOT

RELAY

RELAY

RELAY

UPLINK ANTENNA OF THIRD RELAY IS DIRECTIONAL, AND AIMED IN THE DIRECTION OF THE ROOT NODE

DOWNLINK ANTENNA OF ROOT NODE IS OMNI-DIRECTIONAL

5) The transmissions from the third relay node's uplink antenna hit the root node's downlink (omni-directional) antenna. There will now be "self interference" at the location of the root node's downlink antenna.

Chn. 149 SIGNAL

Chn. 149

Chn. 52

ROOT

RELAY

RELAY

RELAY

Self interference can be identified by performing a series of successive throughput tests. This can be done using the MD Performance Test.

Measure the throughput of the *first* link (root to 1st relay). Next, measure the throughput of the first *two* links (root to 2nd relay). Next, measure the throughput of the first three links, and so on. If self interference is occurring, there will be a *drastic reduction in throughput* at some point in the test. When this happens, note the channel of the last link that was tested. See if this channel is being repeated elsewhere in the mesh. If so, change the channel of the one of the repeated links, and perform the throughput test again.

It is also important to note the **signal spread**, and the **aim** of the antennas involved in the mesh when conducting this test..

Optimizing Available Spectrum

In some deployments, there is a limitation on the available RF spectrum for the mesh (this is especially true for the 4.9GHz band). In these cases, it is often necessary to use techniques to make sure that there is *minimal self interference* in the mesh, and that each "chuck" of the available RF spectrum is put to maximum usage considering the bandwidth requirements of the network.

Minimizing self interference is best achieved by making sure *links of the same channel* are well separated in the deployment. Of course it is important to consider the **signal spread** of every antenna operating on the channel in question, as well as *where* these antennas are pointing in relation to each other. High-gain antennas are best in keeping signal from spreading to areas beyond where it is needed. Antennas with the smallest **horizontal** beam spread are recommended.

Since such antennas are high-gain, it is recommended to tune the power of each radio involved in the link (uplink of child node, and downlink of parent node) to appropriate levels, as indicated under the Heartbeat tab on the bottom section of the Network Viewer screen (see pg.12 of the Network Viewer user manual for information on tuning power of links).
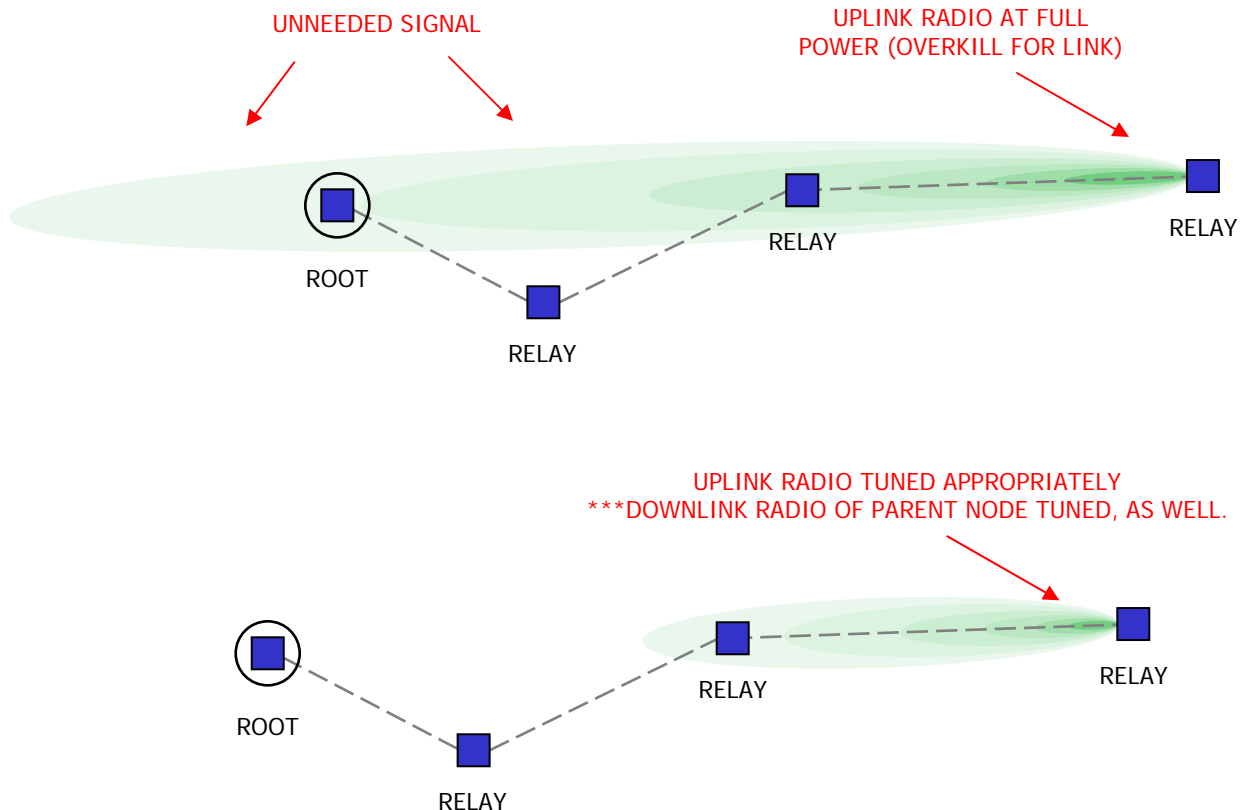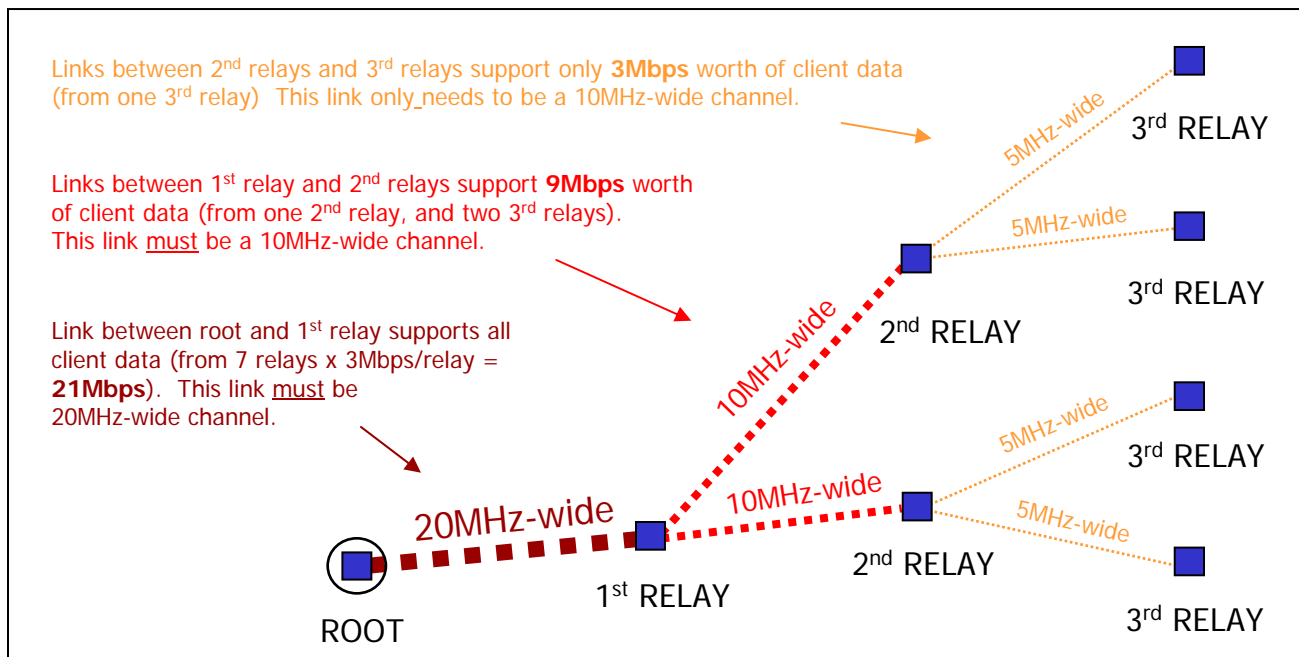
Optimizing Available Spectrum

In deployments with a high ratio of **node density** to **available channels**, it becomes increasingly difficult to avoid self interference. Using the RF Editor to create more channels *within the available spectrum* is beneficial in these situations. This requires that the existing, standard 20MHz-wide channels be cut in half (10MHz-wide), or in quarter (5MHz-wide).

The downside of cutting the *width* of a channel is that this also cuts the *throughput* of that channel proportionally:

20MHz-wide channel......~**22Mbps** of throughput
10MHz-wide channel......~**11Mbps** of throughput
5MHz-wide channel......~**5.5Mbps** of throughput

Given this effect, the required throughput of each link in the mesh needs to be taken into consideration. Generally speaking, the *closer* a link is to the root node, the more throughput is required for that link; the most distant link of a mesh only needs to support the throughput used by the *last* mesh node and its clients, however, the link *closest* to the root node needs to support the throughput used by not only the first relay node (and its clients), but **all relay nodes and clients beyond this link**.

The below diagram illustrates how to maximize the use of 60MHz of available spectrum (**1** x 20MHz channel, **2** x 10MHz channels, **4** x 5MHz channels), with no part of the spectrum being re-used. ***Let each relay node have **3Mbps** worth of client data.

Links between 2nd relays and 3rd relays support only **3Mbps** worth of client data (from one 3rd relay) This link only needs to be a 10MHz-wide channel.

Links between 1st relay and 2nd relays support **9Mbps** worth of client data (from one 2nd relay, and two 3rd relays). This link must be a 10MHz-wide channel.

Link between root and 1st relay supports all client data (from 7 relays x 3Mbps/relay = **21Mbps**). This link must be 20MHz-wide channel.

For
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MOBILITY SETTINGS

Mobile Node Optimization

- **Settings**
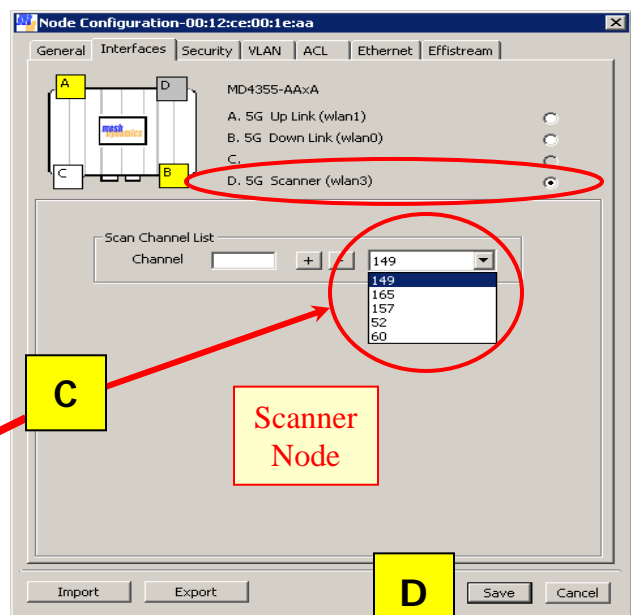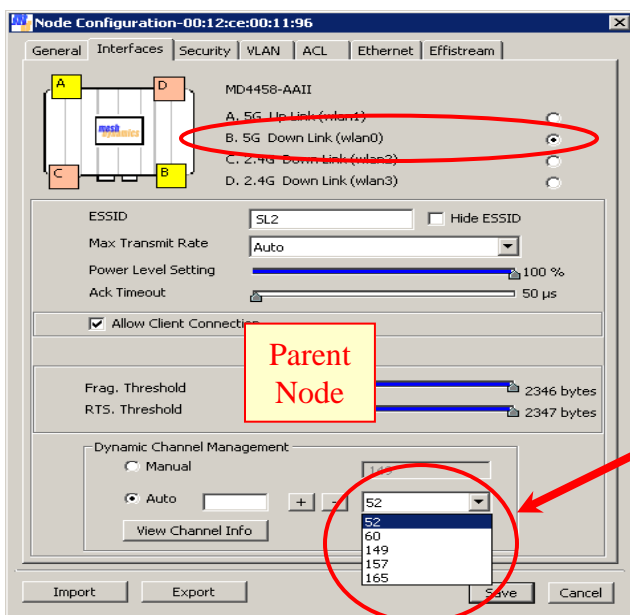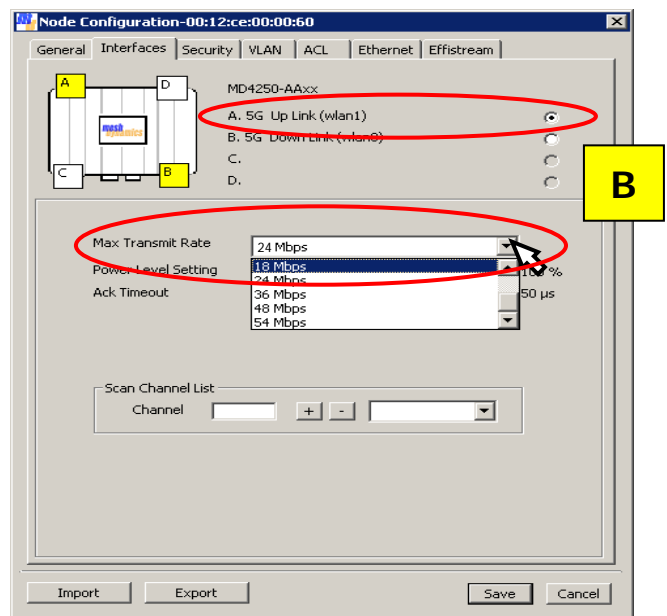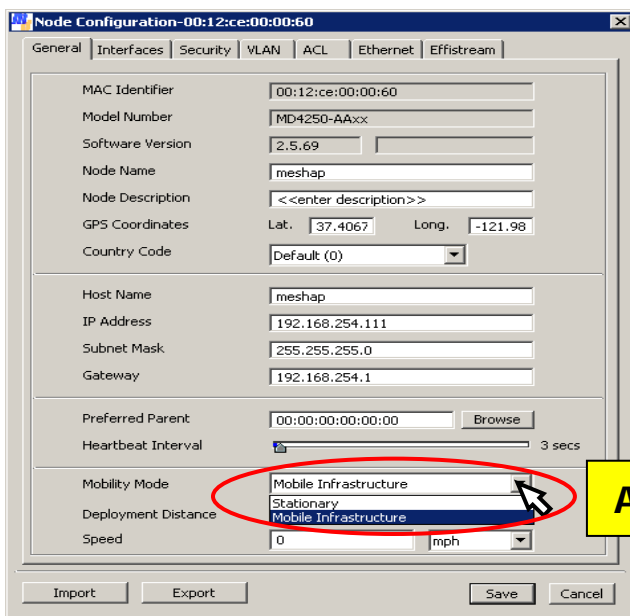
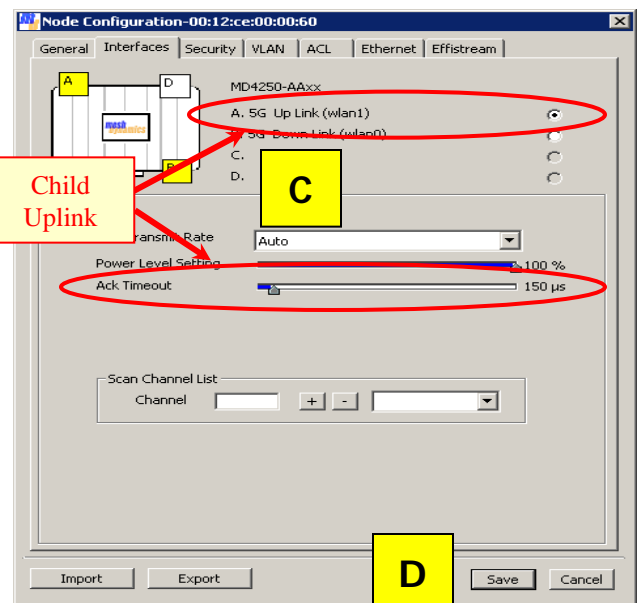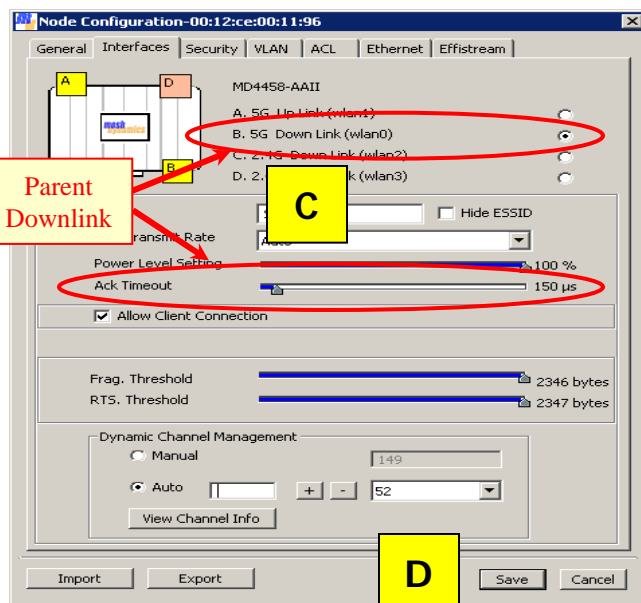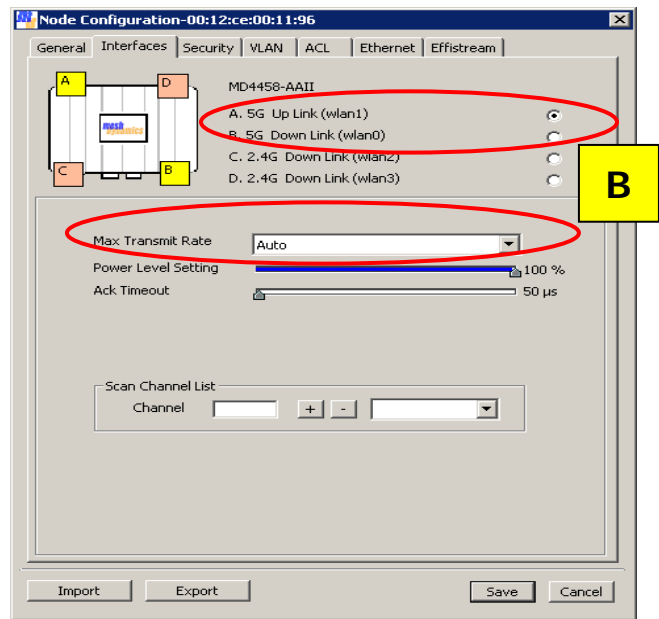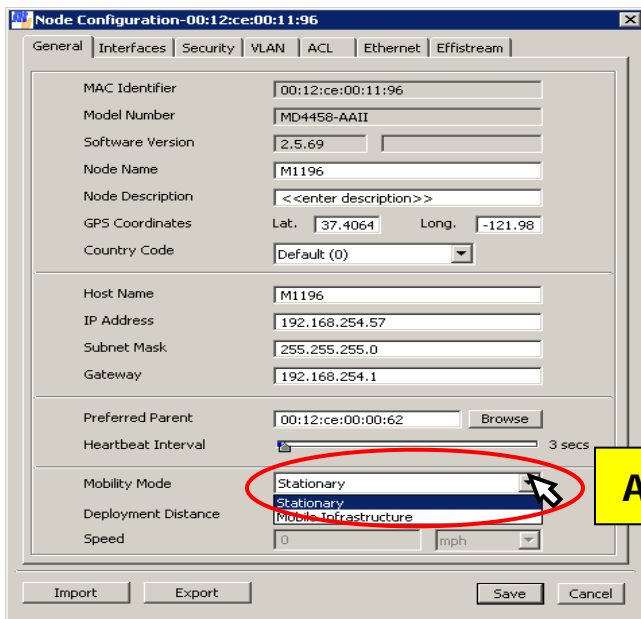The "Mobility Mode" should be set to "Mobile"

Configuring a Mobile Node

A From the "General" tab on the node configuration window, select the "Mobility Mode" setting to be **Mobile Infrastructure**. Set the "Distance" to be 234.6 feet (default). Set the "Speed" to be 30 mph.

B From the "Interfaces" tab on the node configuration window, set the "Max Transmit Rate" on the uplink radio to be **24Mbps.**

C Verify that the "Scan Channel List" on the Scanner radio is populated with every possible channel provided by the *parent-node downlinks* in the mesh (the default channels are 52, 60, 149, 157, 165). In other words, if a non-default channel is added to the *Dynamic Channel Management* section of a parent node's downlink radio (on the "Interfaces" tab), the same channel should be added to the Scanner radio's Scan Channel List.

D Click "**Save**" as the final step after making all changes in the Configuration window.

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mesh dynamics

Using an MD4455-AAII as a Static Node

An **MD4455-AAII** is, by default, a mobile node. When being used as a stationary (static) node, it should be *configured* as a stationary node. The following are the steps that should be taken to make this configuration. Only *after* all steps are taken, click "Save" at the bottom of the Node Configuration window.

A From the "General" tab on the node configuration window, select the "Mobility Mode" setting to be **Stationary**.

B From the "Interfaces" tab on the node configuration window, set the "Max Transmit Rate" to **Auto.** Do this for both backhaul radios.

C When deploying stationary nodes at larger distances, the ACK Timeout setting should be increased above the default (50 microsecond) setting. For a 2km distance between nodes, increase the ACK to 150 microseconds. Do this for *both radios that are involved in the link between stationary nodes* (**uplink of child node**, and **downlink of parent node**).

D Click "**Save**" as the final step after making all changes in the Configuration window.

Using an MD4455-AAII as a Mobile Node

Using the **MD4455-AAII** as a mobile node requires a different set of settings. The following are the steps that should be taken to make this configuration. Only *after* all steps are taken, click "Save" at the bottom of the Node Configuration window.

A   From the "General" tab on the node configuration window, select the "Mobility Mode" setting to be **Mobile Infrastructure**. Set the "Distance" to be 234.6 feet. Set the "Speed" to be 30 mph.

B   From the "Interfaces" tab on the node configuration window, set the "Max Transmit Rate" on the uplink radio to be **18Mbps.**

C   Verify that the "Scan Channel List" on the Scanner radio is populated with every possible channel provided by the *parent-node downlinks* in the mesh (the default channels are 52, 60, 149, 157, 165). In other words, if a non-default channel is added to the *Dynamic Channel Management* section of a parent node's downlink radio (on the "Interfaces" tab), the same channel should be added to the Scanner radio's Scan Channel List.

D   Click "**Save**" as the final step after making all changes in the Configuration window.

37
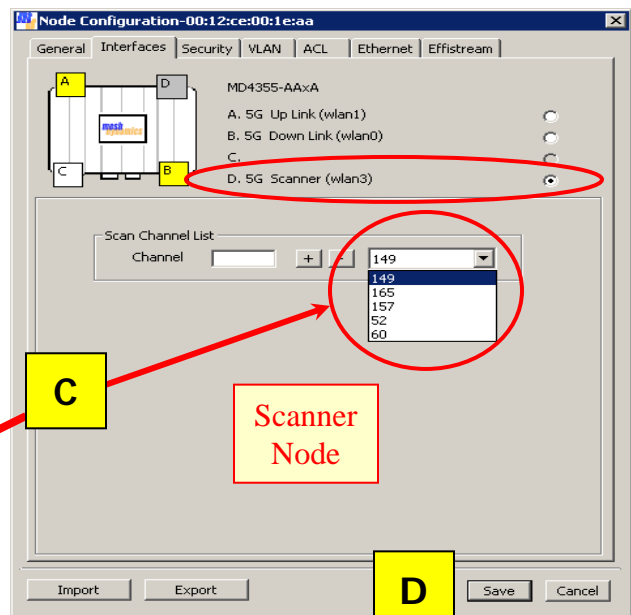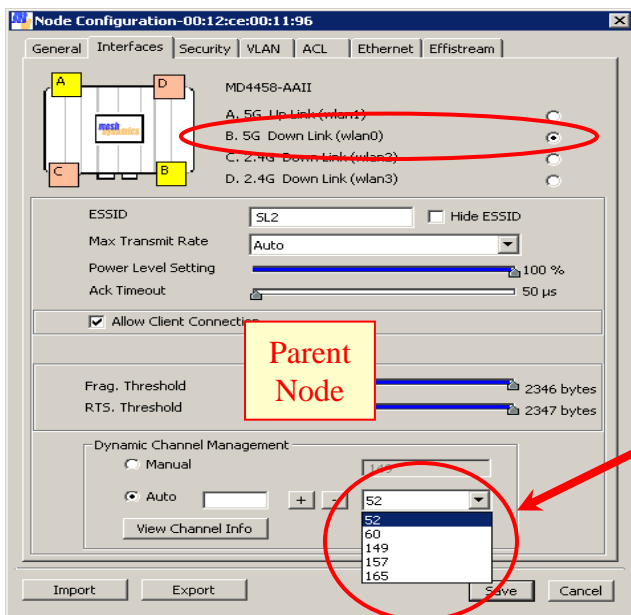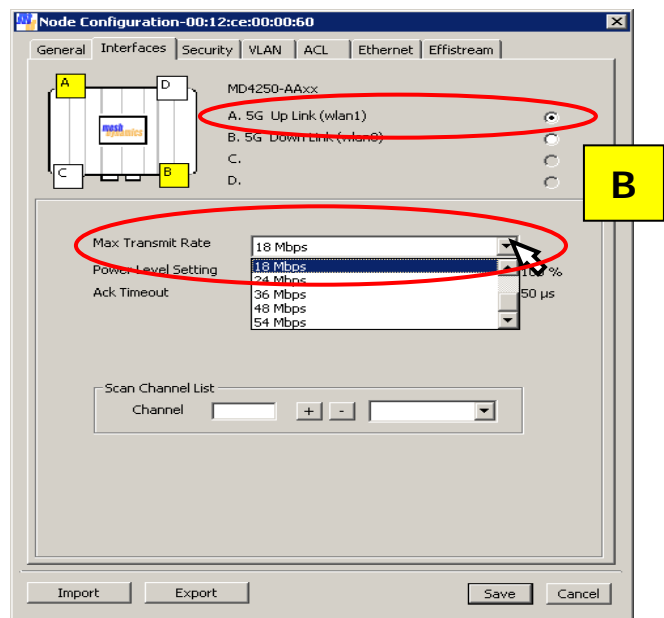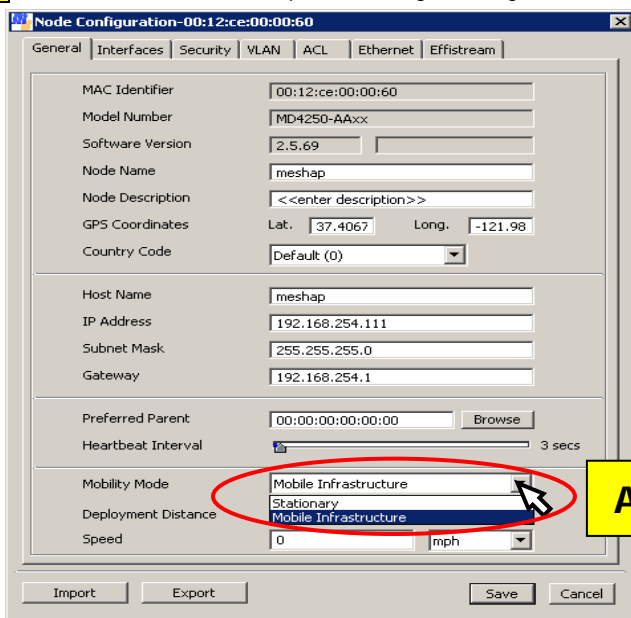
Tune Scanner Node's Downlink Power to 0% When Not Using Scanner Node's Downlink

The downlink radio should be shut off if not in use. This is done by the slider bar in the Node Configuration window of the scanner node's icon.

A   Select the downlink radio.

B   Move the slider bar to **0%**.

C   Click "Save"
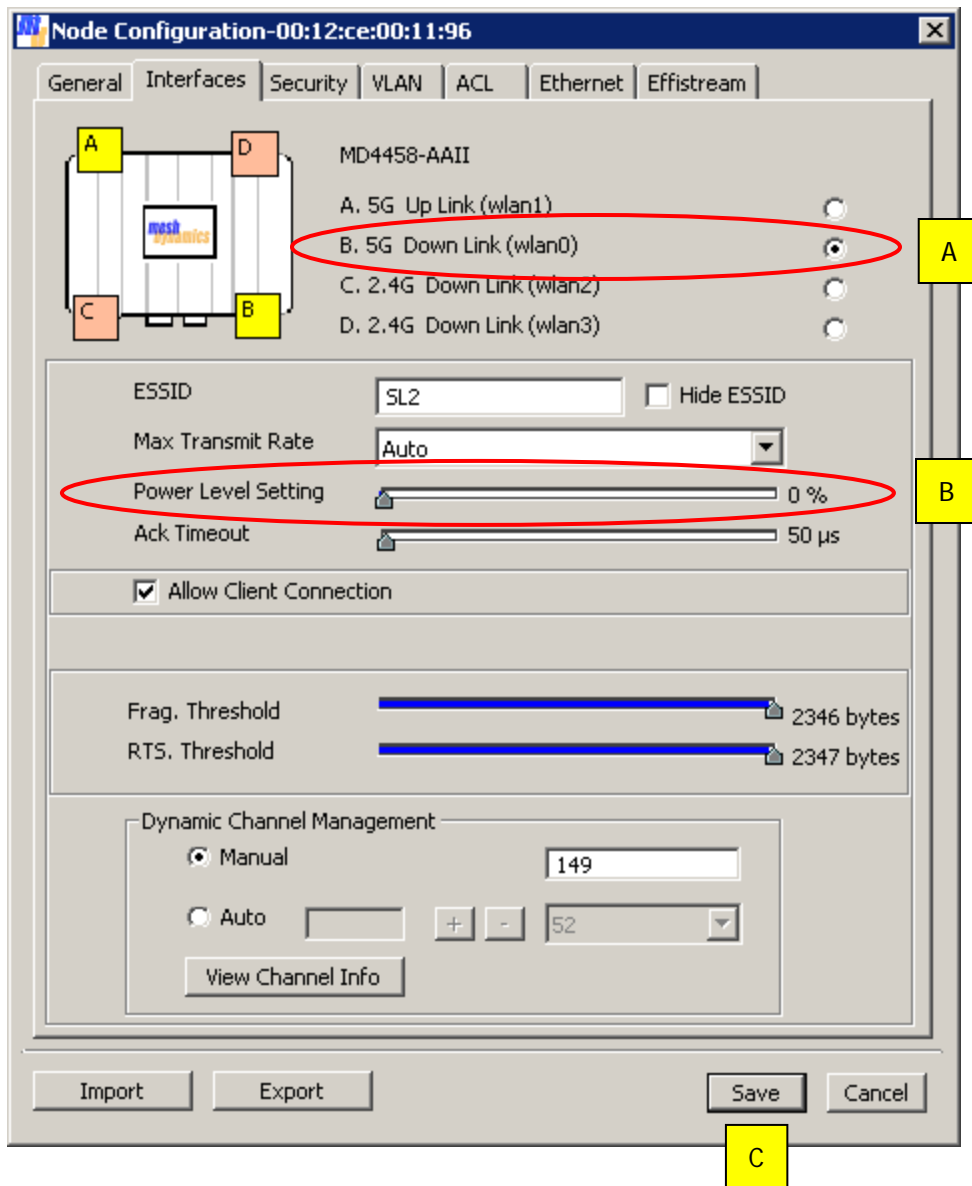
Mobile Node Optimization

- **Settings**

Make sure the *Scan Channel List* of the mobile node's *Scanner Radio* is populated with the same channels as the *Dynamic Channel Management* list of the *parent node's radio* (this will be the parent node's AP radio, <u>or</u> downlink radio, depending on the frequency used by the mobile node's uplink).

The mobile node will only scan on channels in its Scan Channel List. If there are channels in the Dynamic Channel Management list of the parents nodes that the mobile node does <u>not</u> have in its Scan Channel List, the mobile node will not see these channels, and therefore, not associate.

For optimal switching behavior, populate the Scan Channel List with only the channels that are being provided by the parent nodes. For example, in a three-node mesh with a root and two relays, a *maximum* of three channels would be used. In this case, only three channels should be entered into the Scan Channel List of the Scanner Radio.
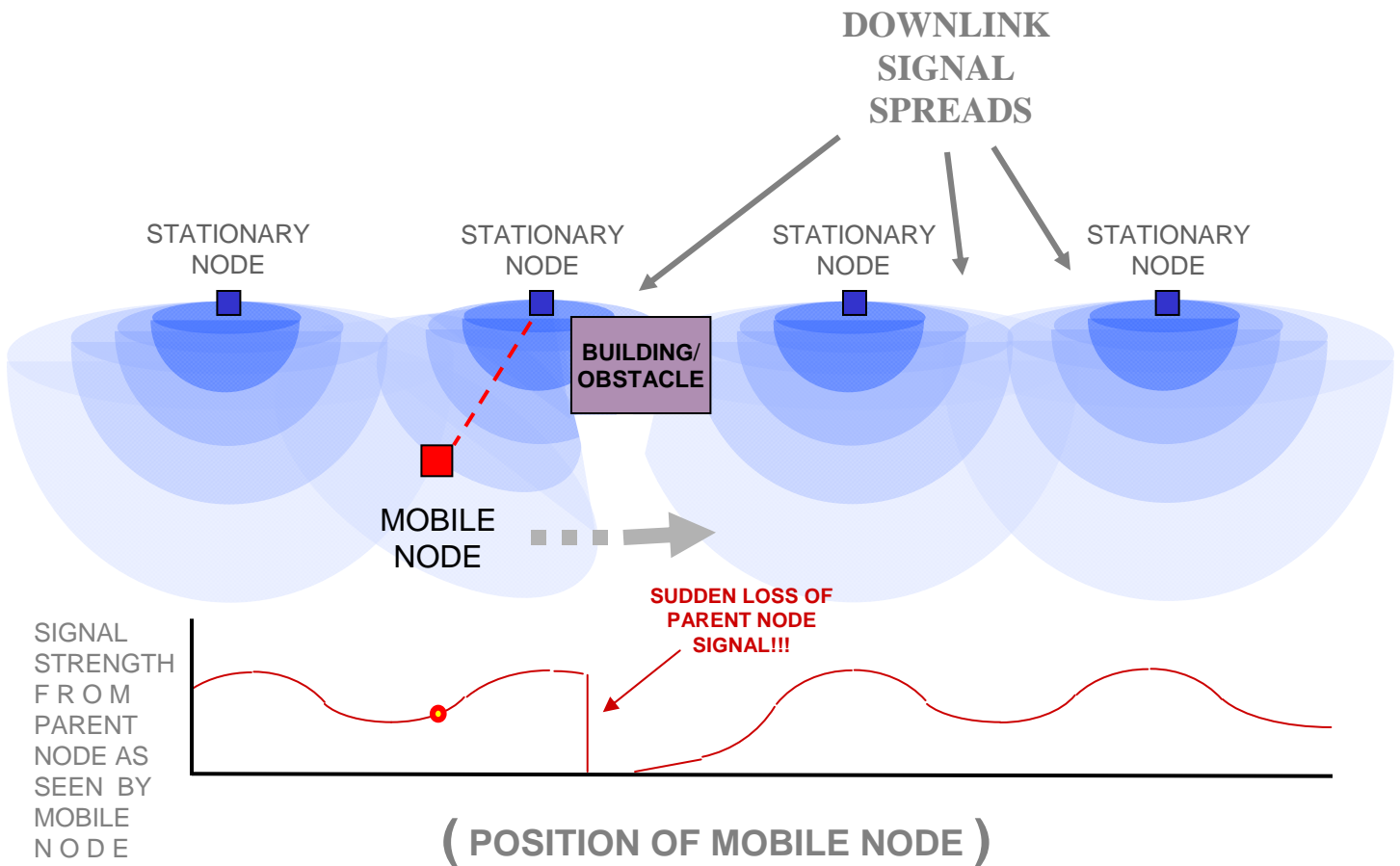

39
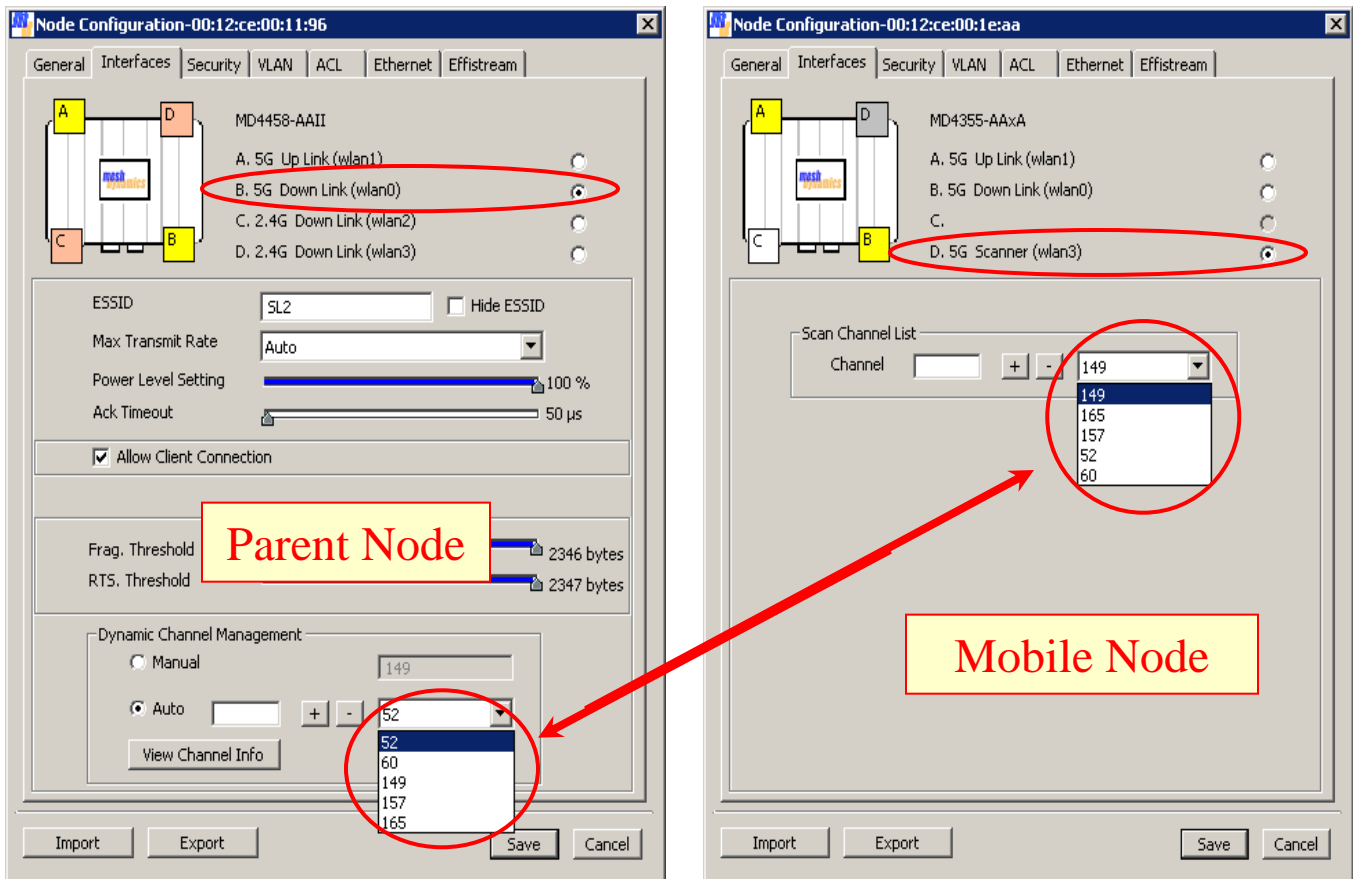
Mobile Node Optimization

- **Deployment**

For optimal mobile-node switching, the RF coverage of the mobile node's environment must contain smooth signal transitions from parent node to parent node. A parent node's signal that *suddenly* drops off may result in brief packet loss before the mobile node associates to another parent node.
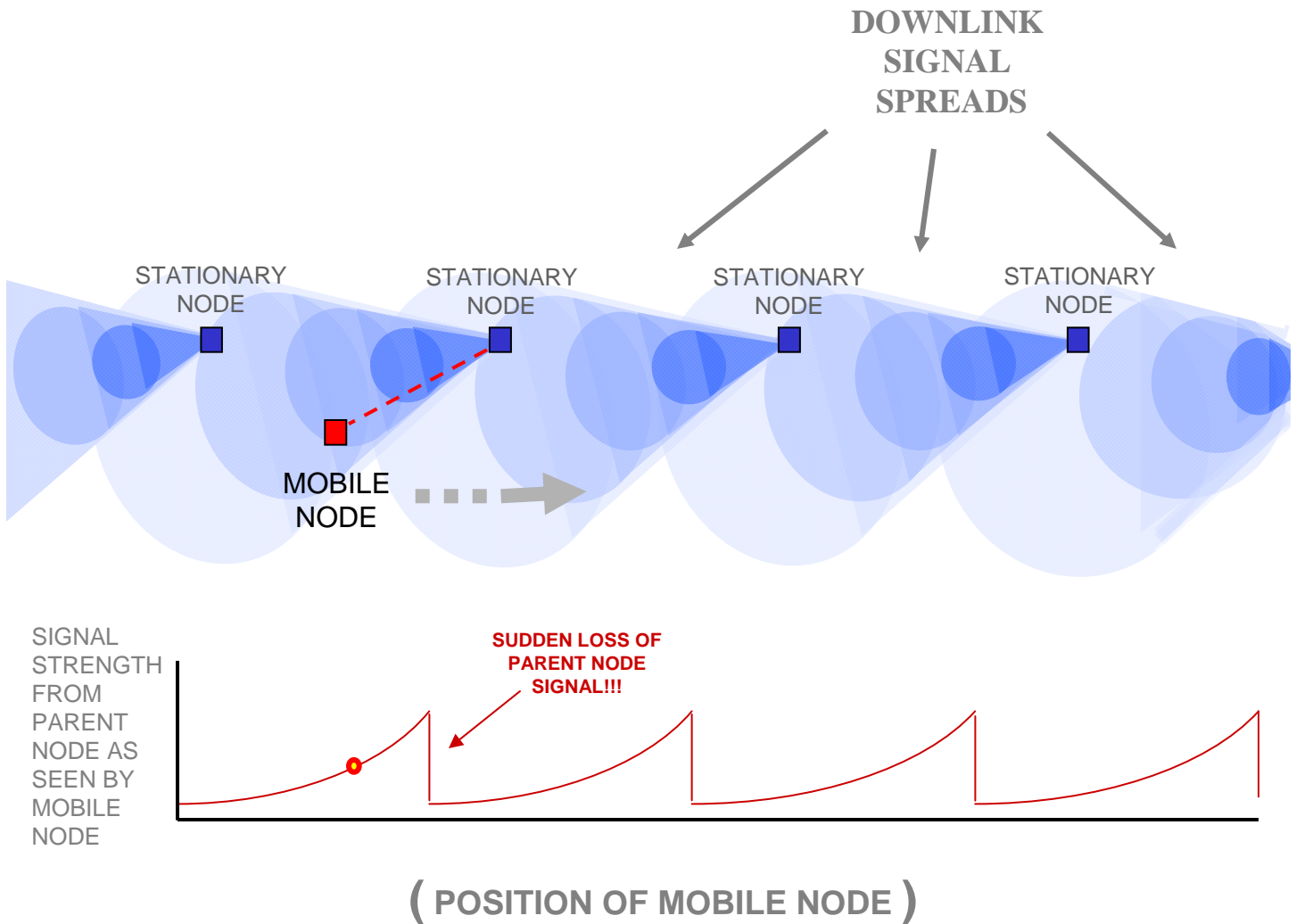
Here, we have a situation where an obstacle causes a sudden signal drop-off in the coverage to the mobile node. Although the mobile node will recover automatically, the abrupt vanishing of the parent node's signal will halt the transfer of data for a brief period of time.

DOWNLINK
SIGNAL
SPREADS

STATIONARY
NODE

STATIONARY
NODE

STATIONARY
NODE

STATIONARY
NODE

BUILDING/
OBSTACLE

MOBILE
NODE

SUDDEN LOSS OF
PARENT NODE
SIGNAL!!!

SIGNAL
STRENGTH
F R O M
PARENT
NODE AS
SEEN BY
MOBILE
N O D E

(**POSITION OF MOBILE NODE**)
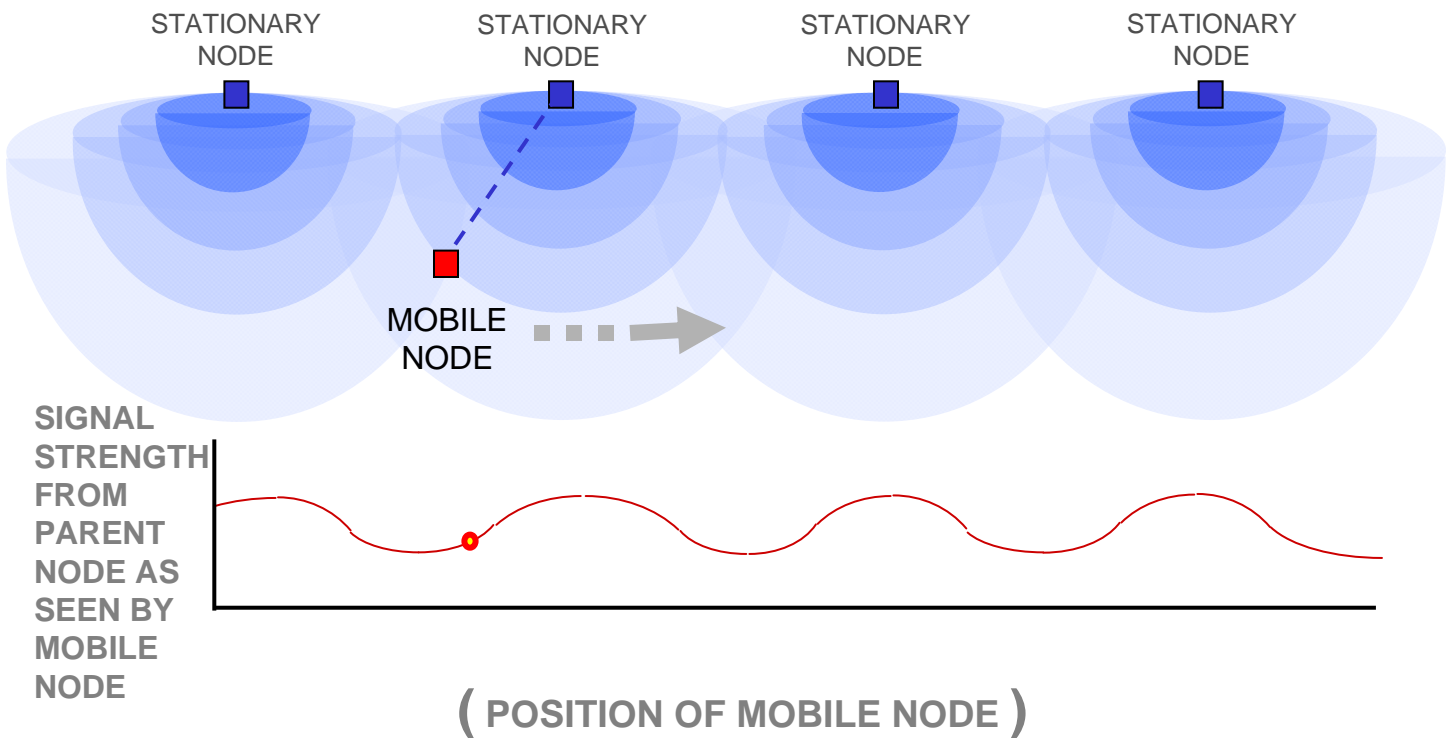
Mobile Node Optimization

- **Deployment**

It is possible to have ***sudden signal drop-offs*** even if no obstacles are present. Using sector or directional antennas to provide the coverage area for mobile nodes can present such a scenario. In the example below, the mobile node moves from left to right. Even though the mobile node remains within the RF coverage of the stationary nodes, it is seen how its parent node's signal is *suddenly* lost due to the characteristics of the sector antennas used.

DOWNLINK SIGNAL SPREADS

STATIONARY NODE   STATIONARY NODE   STATIONARY NODE   STATIONARY NODE

MOBILE NODE

SIGNAL STRENGTH FROM PARENT NODE AS SEEN BY MOBILE NODE

SUDDEN LOSS OF PARENT NODE SIGNAL!!!

(POSITION OF MOBILE NODE)
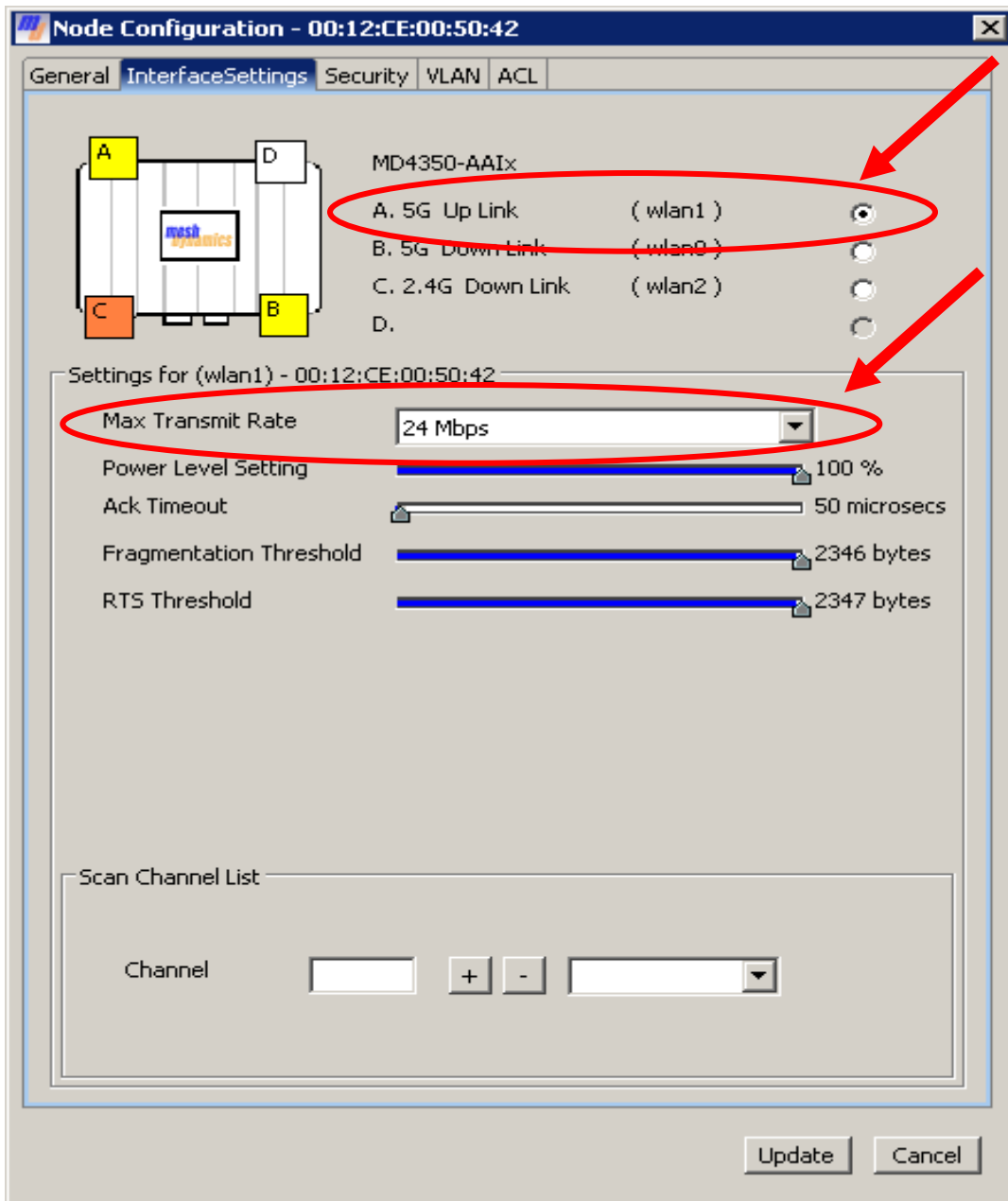
Mobile Node Optimization

- **Deployment**

The illustration below shows no sudden signal drop-offs from parent nodes. This is the ideal deployment where the mobile node can make smooth transitions from parent node to parent node.
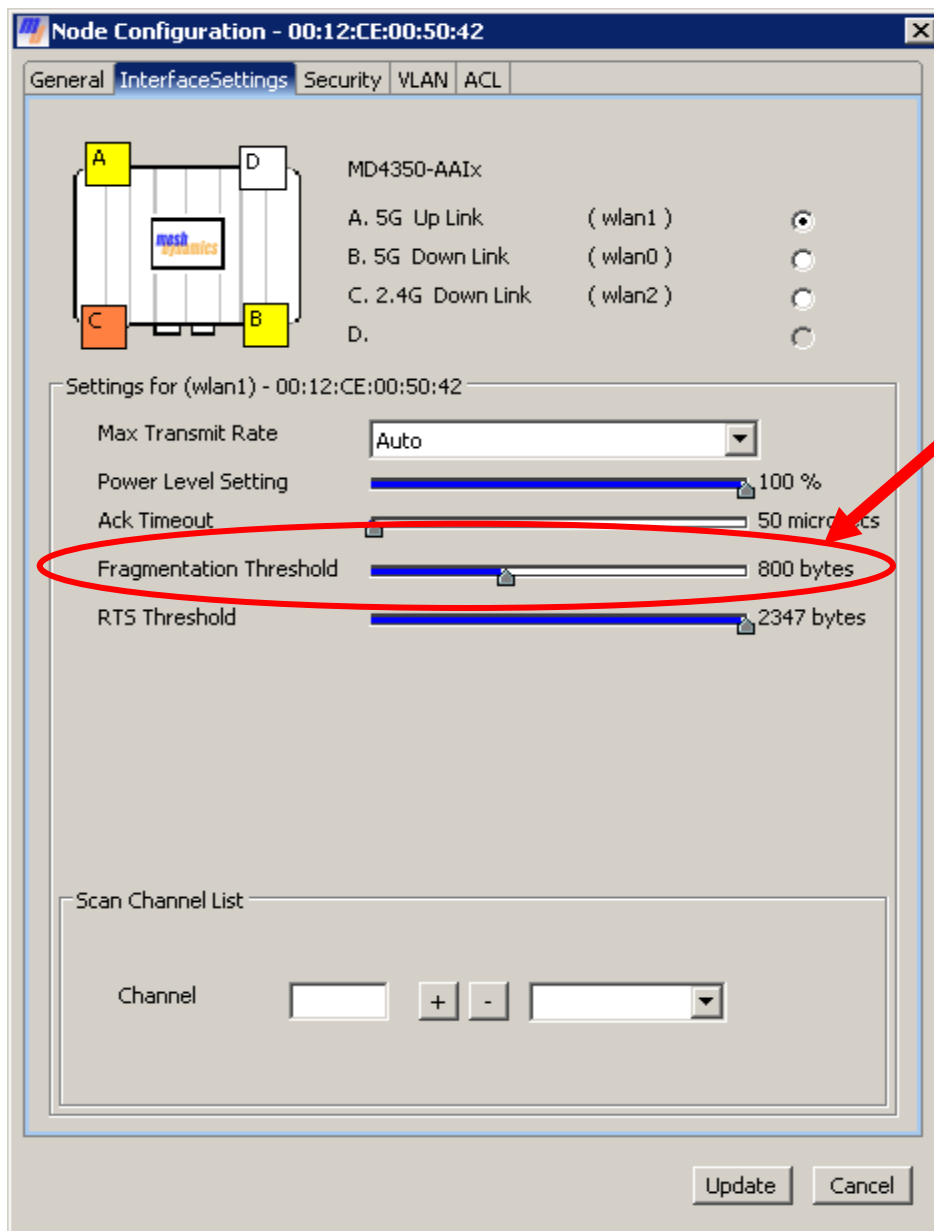
Mobile Video Optimization

- **Settings**

In mobile video applications, it is recommended that the 16QAM modulation scheme be used in order to better handle the dynamic RF environment. This is done by setting the Max Transmit Rate of the uplink radio of the mobile node to 24Mbps.

Mobile Video Optimization

- **Settings**

Jittery video from a mobile node can often be remedied by the use of fragmentation. Fragmentation will make transmitted packets smaller, and therefore, less likely to be corrupted. Implementing fragmentation will reduce the overall bandwidth, but may very well increase video quality .
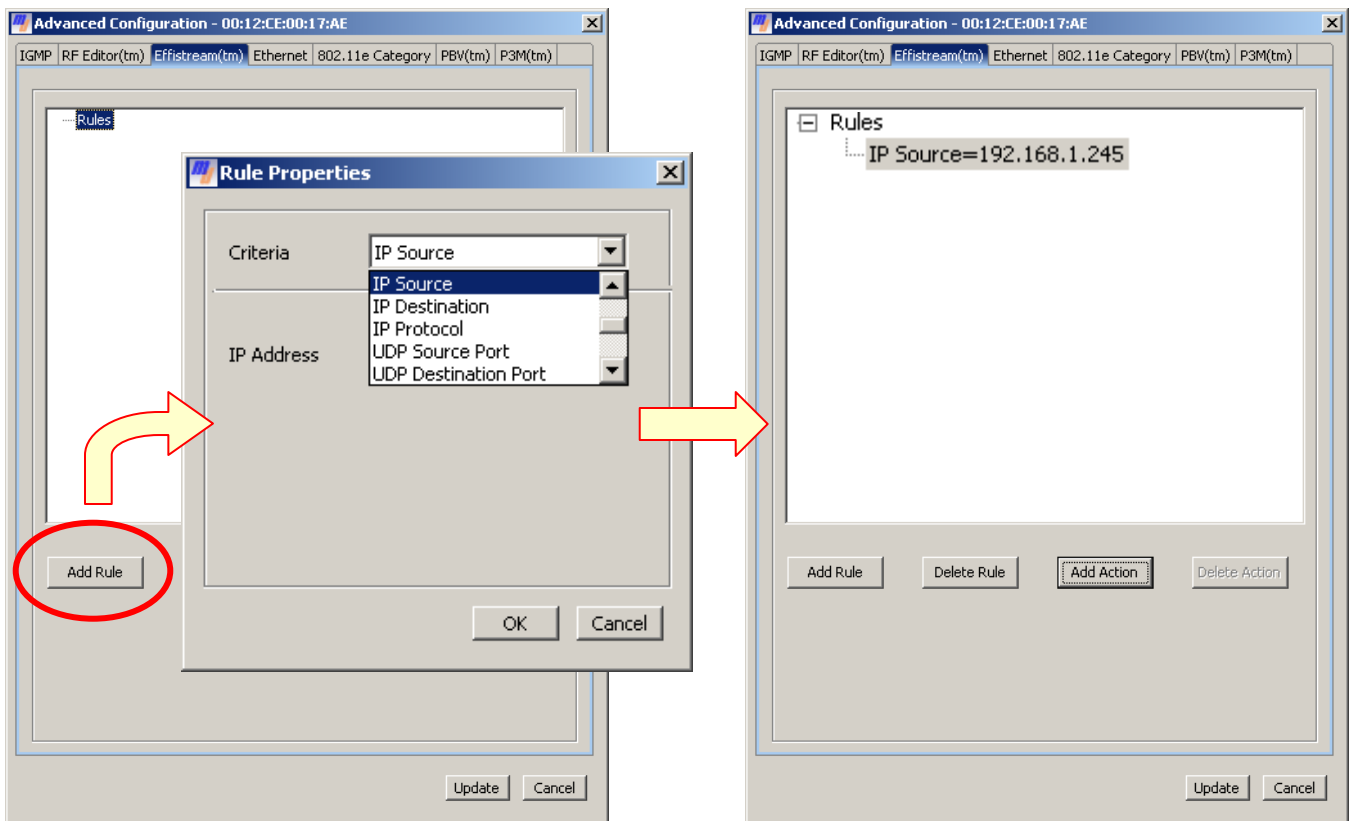
Mobile Video Optimization

- **Settings**

Broadcast and multicast video is transmitted, by default, at the lowest rate of the medium (6Mbps for 802.11a/g). Broadcast and multicast video transmissions can be *forced* to be sent at a higher transmit rate. This will, in effect, increase the bandwidth available for the transmissions.

This is done using EFFISTREAM in the Advanced Configuration window. EFFISTREAM "rules" can be specified to treat data based on several different parameters such as Ethernet type, IP source, and UDP length, to name a few.

Mobile Video Optimization

After a rule is selected, an "action" can be applied to the rule. The Action Properties window is where the **transmit rate** and other actions can be selected to apply to the rule.
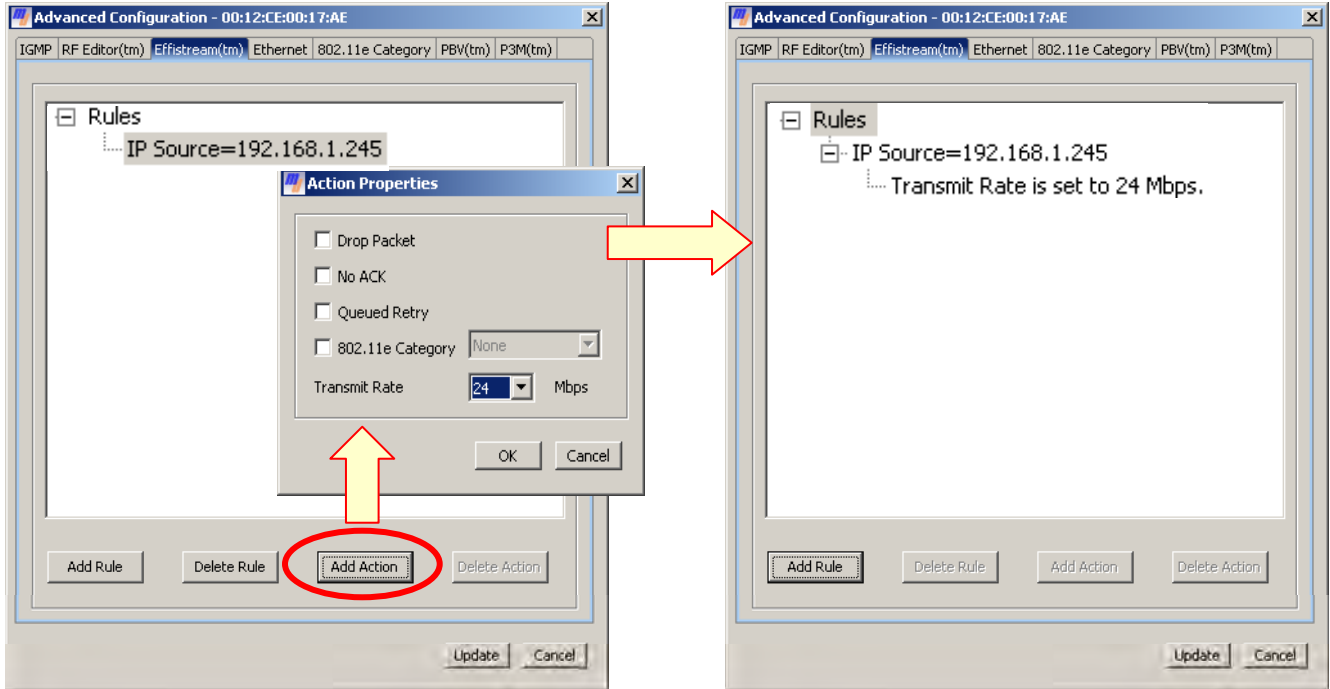
It is possible for multiple rules and associated actions to be applied on a single node. ***When using EFFISTREAM, it is good practice to implement it on all nodes used in the deployment.
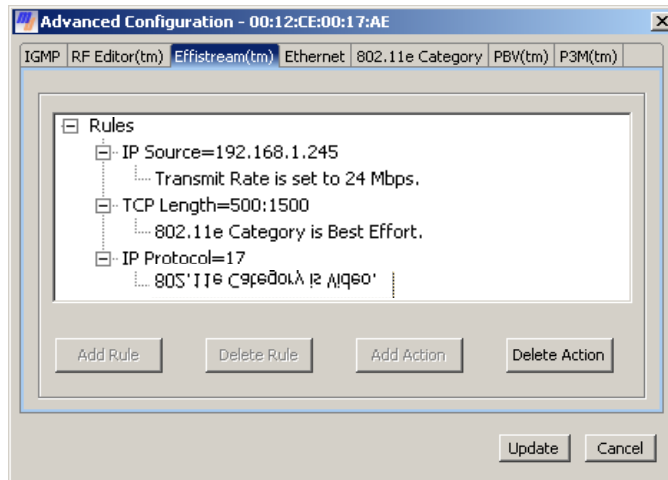
For
MESHDYNAMICS
SYSTEM INTEGRATORS

WISTRON RADIO SPECS

WLAN 802.11a/b/g High Power mini-PCI Module

DCMA-82

- **Two kinds of RD connector models for choice_ MMCX & UFL type**
- **Single-Chip 802.11a/b/g mini-PCI Design for Embedded Application**
- **High Power Design, average power up to 25dBm**
- **Hear sink design provide reliable high power RD performance**
- **Screw hole reserved for assembly with AP main board**
- **Integrated 802.11i/WPA2 Supplicant**
- **802.11e Compatible Bursting**
- **Internal Low Frequency Oscillator for Low Power Sleep Mode**
- **Host Interface PCI 2.3 Compatible**
- **WHQL Certified**
- **RoHS Compliant**
- **Operating Temp. Range can reach fm -40°C to 80°C, Industrial Spec. (optional)**

WLAN 802.11a/b/g High Power mini-PCI Module

DCMA-82

SPECIFICATION

Frequency Band	➢ **A Mode:** 5.15~5.35 & 5.725~ 5.85 GHz for US 5.15~5.35 GHz for Japan 5.15~5.35 & 5.47~5.725 GHz for ETSI 5.725~5.85 GHz for China 4.94~4.989Ghz for US safety band ➢ **B/G Mode:** 2400~2483.5 MHz (for US, Canada, EU, China and Japan)
Modulation technique	➢ **802.11 a/b/g** DSSS (DBPSK, DQPSK, CCK) OFDM (BPSK,QPSK, 16-QAM, 64-QAM)
Host interface	➢ Mini-PCI type 3A
Channels support	➢ **802.11b/g** US/Canada: 11 (1 ~ 11) Major European country: 13 (1 ~ 13) France: 4 (10 ~ 13) Japan: 11b: 14 (1~13 or 14th), 11g: 13 (1 ~ 13) ➢ **802.11a** US/Canada: 12 non-overlapping channels Europe: 19 non-overlapping channel Japan: 8 non-overlapping channels US(safety band) : 4940~4990Mhz
Operation voltage	➢ 3.3V +/- 10%
Power consumption	➢ **A Mode:** Cont. Tx: 1100mA (typical)~1300mA (max) Cont. Rx: 250mA (typical)~270mA (max) Stand by: 280mA (typical)~290mA (max) ➢ **B Mode:** Cont. Tx: 730mA (typical)~780mA (max) Cont. Rx: 200mA (typical)~220mA (max) Stand by: 230mA (typical)~240mA (max) ➢ **G Mode:** Cont. Tx: 730mA (typical)~780mA (max) Cont. Rx: 240mA (typical)~260mA (max) Stand by: 280mA (typical)~290mA (max) ➢ **Power saving:** 35mA (typical)~55mA (max) ➢ **Radio off:** 40mA (typical)~50mA (max)
Output power	➢ **A Mode:** +22.5dBm at 6, 9, 12, 18Mbps +21.5dBm at 36Mbps +19dBm at 48Mbps +18dBm at 54Mbps ➢ **B Mode:** +24.5dBm at 1,2, 5.5, and 11Mbps ➢ **G Mode:** +24.5dBm at 6, 9, 12, 18Mbps +23.5dBm at 36Mbps +22dBm at 48Mbps +21dBm at 54Mbps

WLAN 802.11a/b/g High Power mini-PCI Module

DCMA-82

SPECIFICATION

Operation System supported	➢ Windows® 2K, XP
Dimension	➢ 59.6mm(L) * 50.8mm (W) * 7.5mm (H)
Security	➢ 64-bit,128-bit, 152-bit WEP Encryption ➢ 802.1x Authentication ➢ AES-CCM & TKIP Encryption
Operation temperature	➢ 0°C ~ 70°C
Storage temperature	➢ -20°C ~ 80°C
Wi-Fi® Alliance	➢ WECA Compliant
WHQL	➢ Microsoft® 2K, XP Complaint
FAA	➢ S/W radio On/Off support
EMC certificate	➢ FCC part 15 (USA) ➢ ETSI, EN301893, EN60950 (Europe)
Media access protocol	➢ CSMA/CA with ACK architecture 32-bit MAC
Advance Function	➢ Super AG ➢ Extended Range ➢ Support JumpStart V1.0 on Microsoft® 2K, XP
Antenna connector	➢ 2 x SMT Ultra-miniature coaxial connectors (2*U.FL or 2*MCX)

The 4.9GHz products will have separate ordering codes and will be available only to customers who have applied and received authorization by the FCC to use the public safety band.

Specifications are preliminary and information only.
Subject to change without notices.

WNC

Wistron NeWeb Corporation

No. 10-1, Li-hsin Road I, Hsinchu Science Park,
Hsinchu 300, Taiwan, R.O.C.
TEL: +886 3 666 7799
FAX: +886 3 611 6821