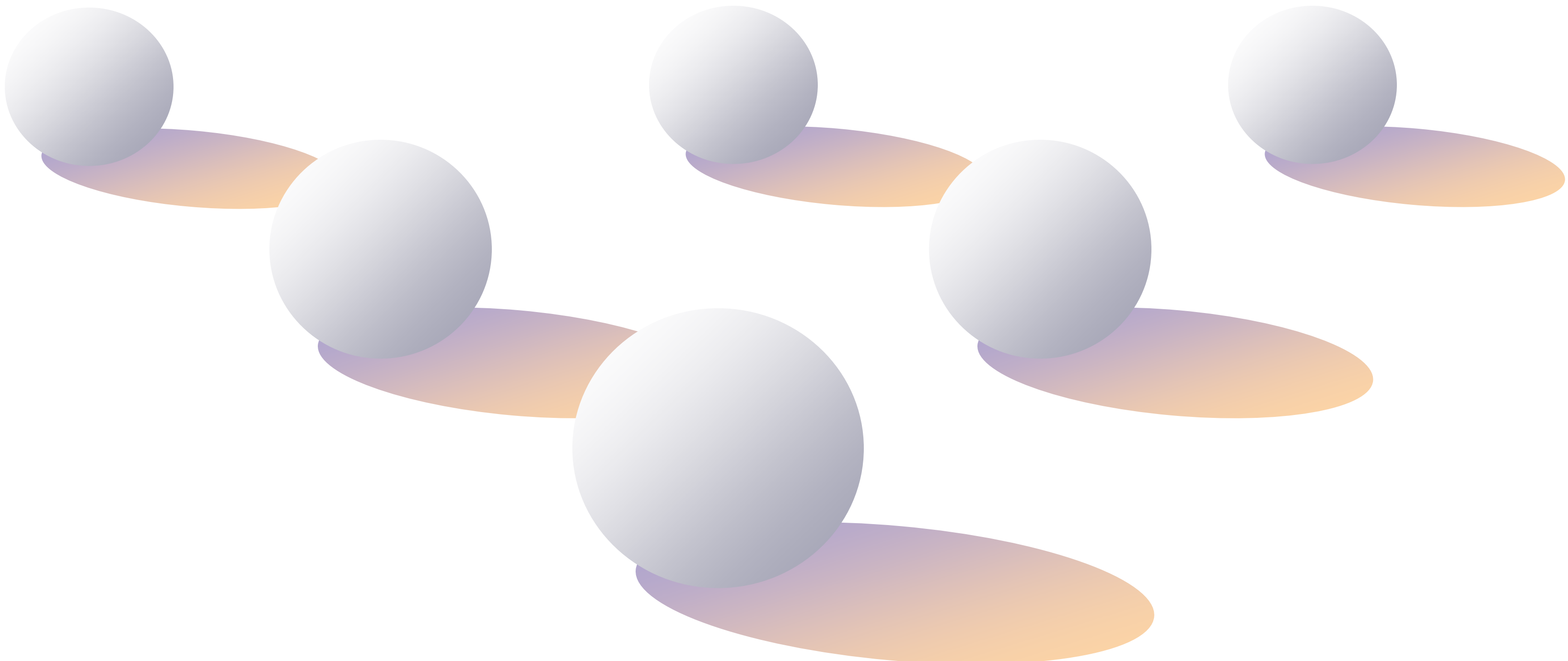
MD4000

PRODUCT TRAINING



H a n k O t t e y

December 1, 2009

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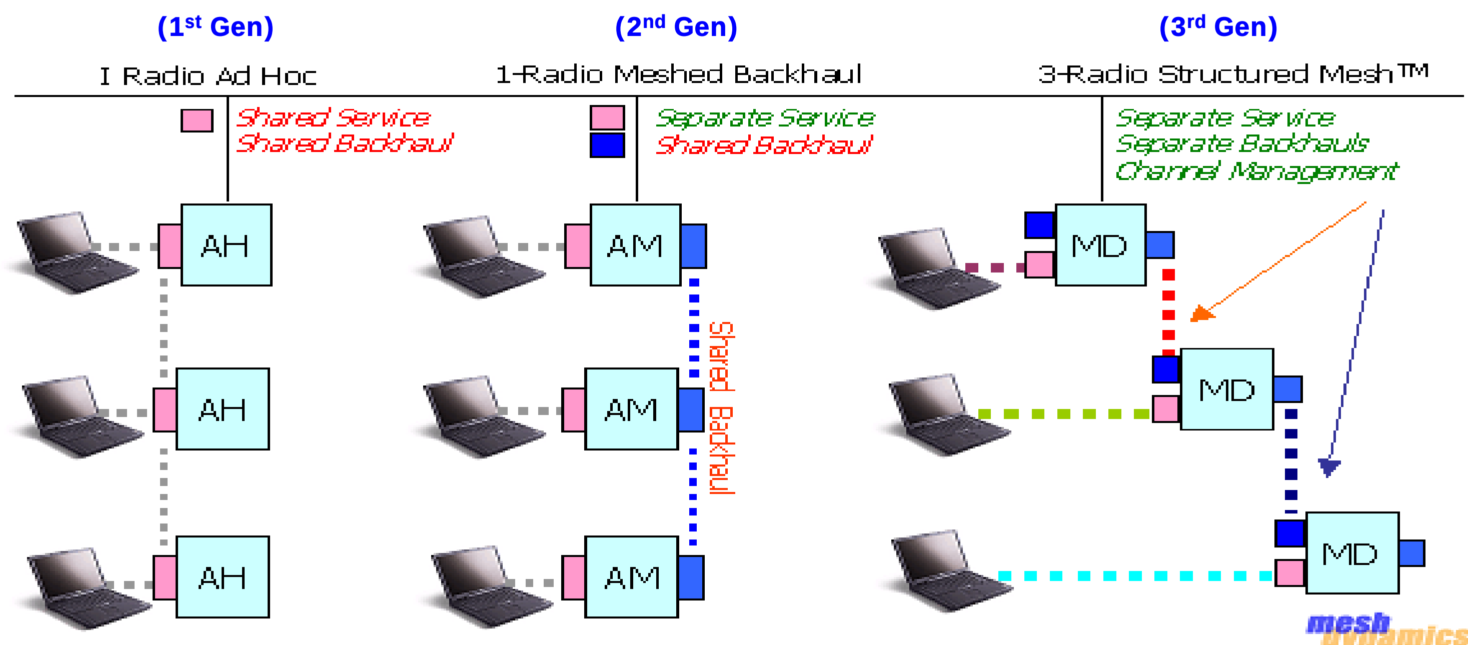
WHY USE MESHDYNAMICS?

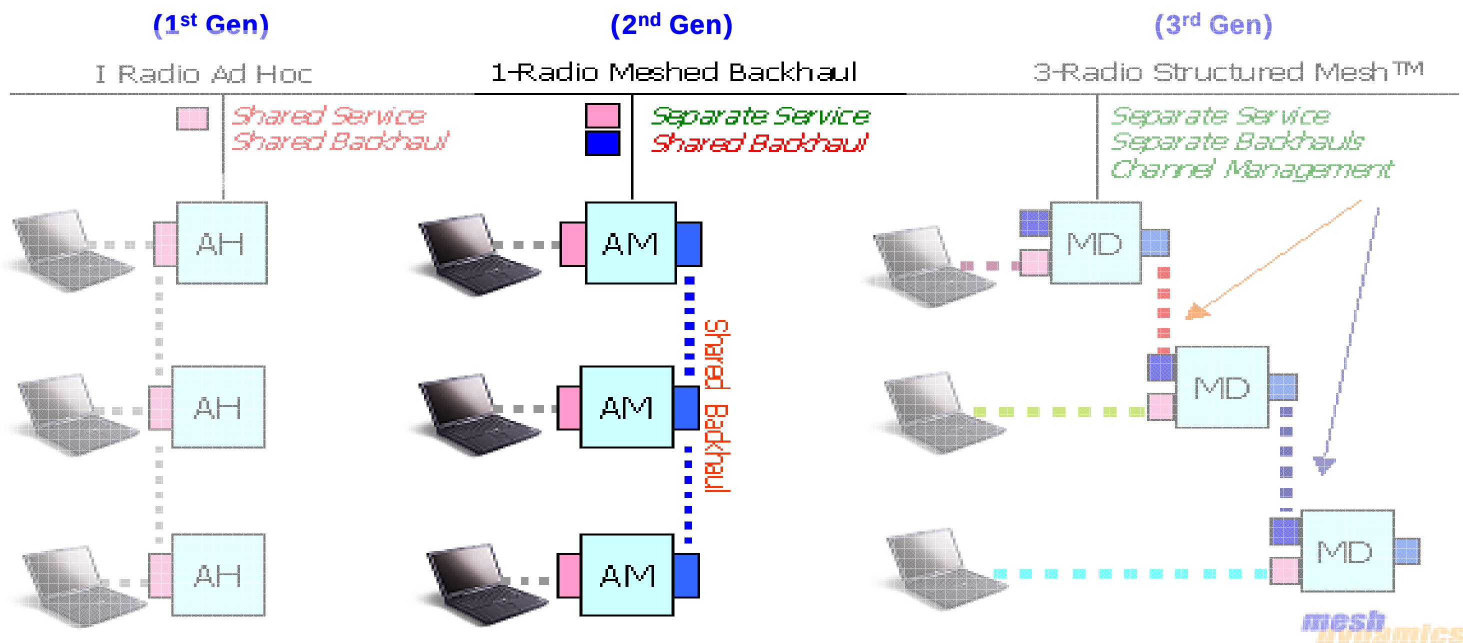
- The MeshDynamics **3rd generation** mesh technology far surpasses the 1st and 2nd generation mesh technology currently available on the market. In addition, MeshDynamics offers the *smallest*, *most configurable* **3rd generation** mesh node.

First Generation: Uses 1-radio ad-hoc mesh (left). This network uses one radio channel to handle the backhaul, and to provide service to wireless clients. This architecture provides the worst services of all the options since both backhaul and wireless clients compete for bandwidth.



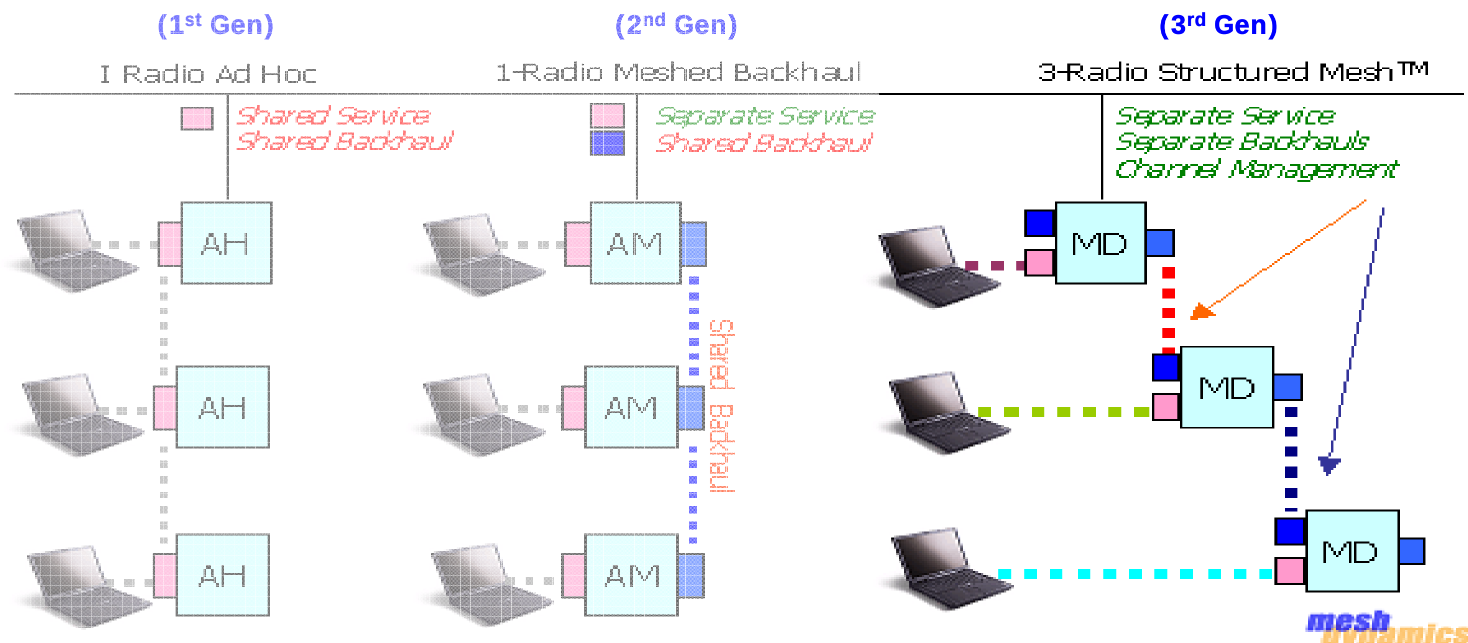
WHY USE MESHDYNAMICS?

Second Generation: Is a dual-radio system with a single radio ad-hoc meshed backhaul (center). A second radio is dedicated for client access, which allows the backhaul to operate on a separate frequency band. Client activity does not interfere with backhaul activity.



WHY USE MESHDYNAMICS?

Third Generation: The 3-radio Structured Mesh uses *two* radios for the backhaul, and a third radio for client access (right). In addition to providing separate backhaul and service functionality, the 3rd generation mesh technology dynamically manages channels of all of the radios so that all node-to-node links are on non-interfering channels. Performance analysis indicates that this provides the best performance of any of the methods considered here.

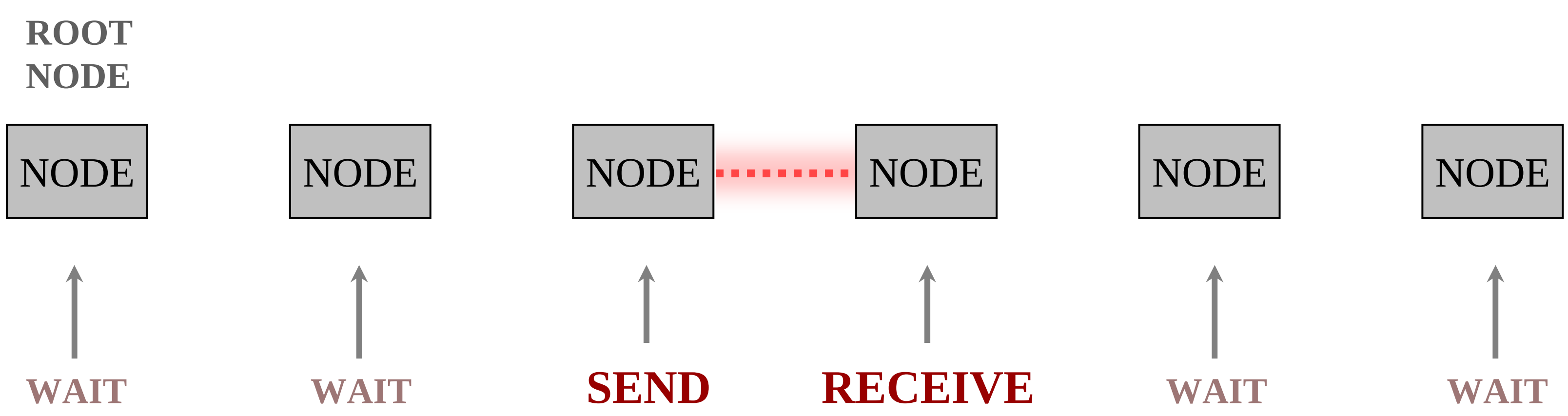


1ST & 2ND GENERATION BACKHAUL

First and second generation mesh nodes use only one channel of a frequency spectrum across all links of a backhaul during operation.

A node in the mesh cannot send and receive at the same time since the same frequency is used for both functions. This makes for a very inefficient process that severely effects bandwidth as the number of hops increases.

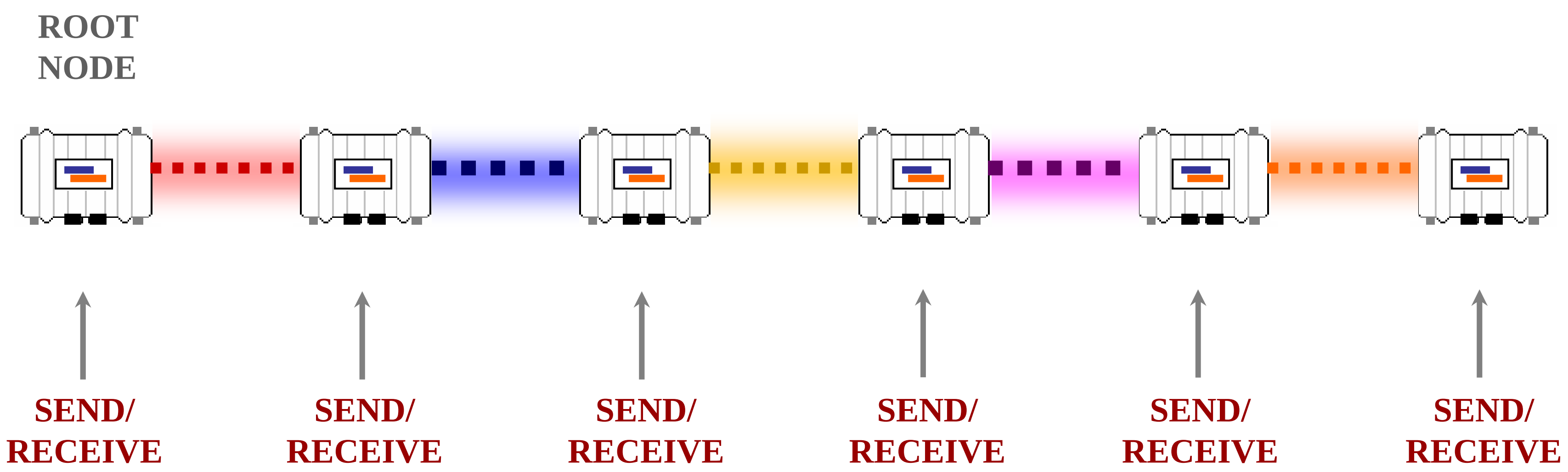
High-bandwidth applications can start to encounter issues after only a few hops in first and second generation meshes.



THIRD GENERATION BACKHAUL

The third generation backhaul of the MD4000 uses multiple channels simultaneously *within* the utilized spectrum in order to ensure minimal bandwidth loss as the number of hops increases.

Typically, the 5GHz spectrum is used for the backhaul. Since different 5GHz channels are used by adjacent links in the mesh, there is no interference along the backhaul. This allows each node to send and receive at the same time, therefore, conserving bandwidth over *many* hops.



THIRD GENERATION BACKHAUL FREQUENCIES

Although MeshDynamics third generation mesh nodes typically use the 5GHz spectrum for the multi-channel backhaul, the 2.4GHz spectrum and the 4.9GHz Public Safety band can also be used.

The 5GHz spectrum is used mainly for two reasons: there is more available channel space in this spectrum allowing for the most number of channels to be used, and because it is a relatively clean RF space which caters to smooth, consistent bandwidth.

The 2.4GHz spectrum is usually used for the backhaul in rural areas where great distances are needed, and the RF pollution is much lighter than in civilized areas.

The 4.9GHz Public Safety band is a licensed spectrum reserved for police and emergency services.

MESHDYNAMICS APPLICATIONS

- The small form factor and 3rd generation mesh technology of the MeshDynamics MD4000 mesh node allows for applications that are simply not possible with other mesh nodes. 3rd generation meshes allow for *numerous* hops without sacrificing bandwidth, and the 1ms delay per hop in the MD4000 module gives very low latency.

VOIP

Meshdynamics currently has an underground (mine) installation that uses VOIP phones over 14 hops with multiple simultaneous users. Communications over this system are crystal clear. Space inside the mine is extremely limited, and the small size of the MD4000 is very attractive for such an application.

VIDEO

Many applications require surveillance a relatively long distance from the "root" node. This intern demands many hops be used to communicate the bandwidth over such distances. The combination of the two-radio backhaul with the five 802.11a channels used *within* the backhaul provides ample throughput for video as well as other 802.11b/g clients that may also be using the mesh. Red River, NM (seen to the right) takes advantage of this technology. Surveillance of a national border also currently benefits from being able to carry video bandwidth to and from great distances.

EASE OF INSTALLATION / SCALING NETWORKS

The MD4000 is self-configuring. Once the 3lb. node is mounted in place and powered up, the work is done. Should there be a need to grow the network, more MD4000s can be installed near the existing network and they will automatically join up and become part of the mesh.

The MeshDynamics mesh nodes are currently used in sporting events where it is necessary that the network be set up and taken down in a very short period of time. It is simply a matter of elevating the node and plugging it in.

QUICK START

- After loading the MeshDynamics software (see bottom of page 6 in the Network Viewer User Guide), connect the MD4000 mesh module as seen in the figure. It is necessary that the CAT5 cable coming from the POE goes into the *left hand* Ethernet port on the module. Of all the connections shown in the diagram, make sure this is the last connection made.

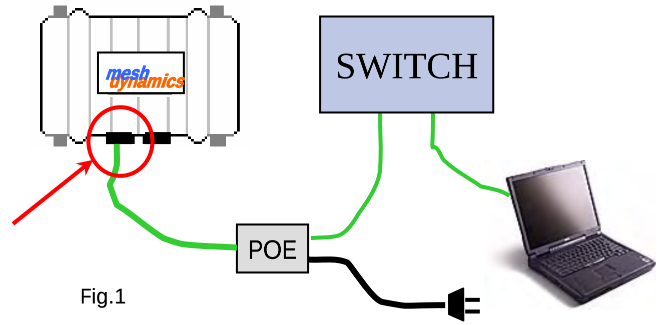


Fig.1

- Disable any firewalls on the machine running the Network Viewer. Click the “Play” button (Fig.2) and after 1-2 minutes, the node’s icon will appear on the mesh viewer screen (Fig.3).

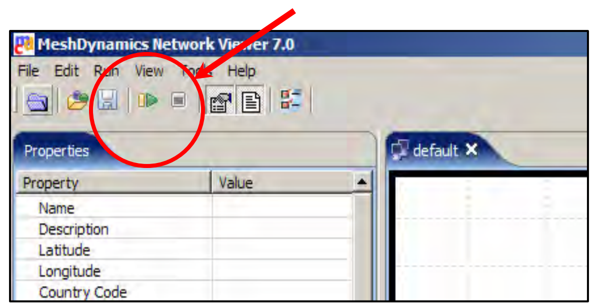


Fig.2

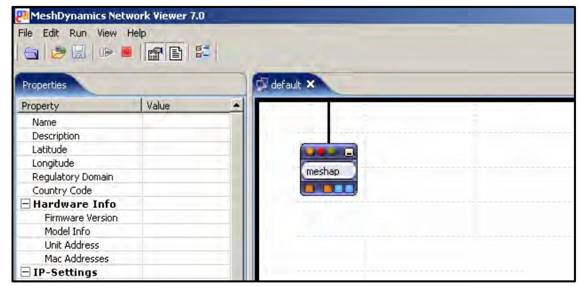


Fig.3

- Right-click on the node icon and select “Configure Node” (Fig.4). This will introduce the Configuration window (Fig.5). From the Configuration window, the ESSIDs and encryption of the mesh module can be immediately set.

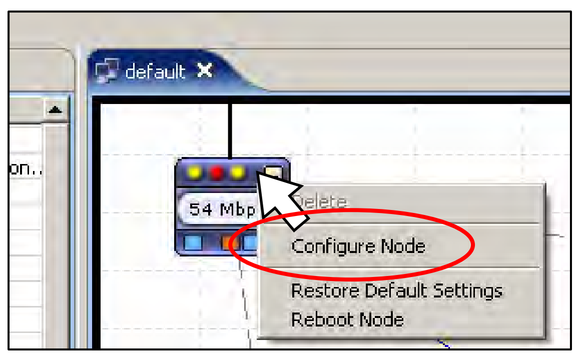


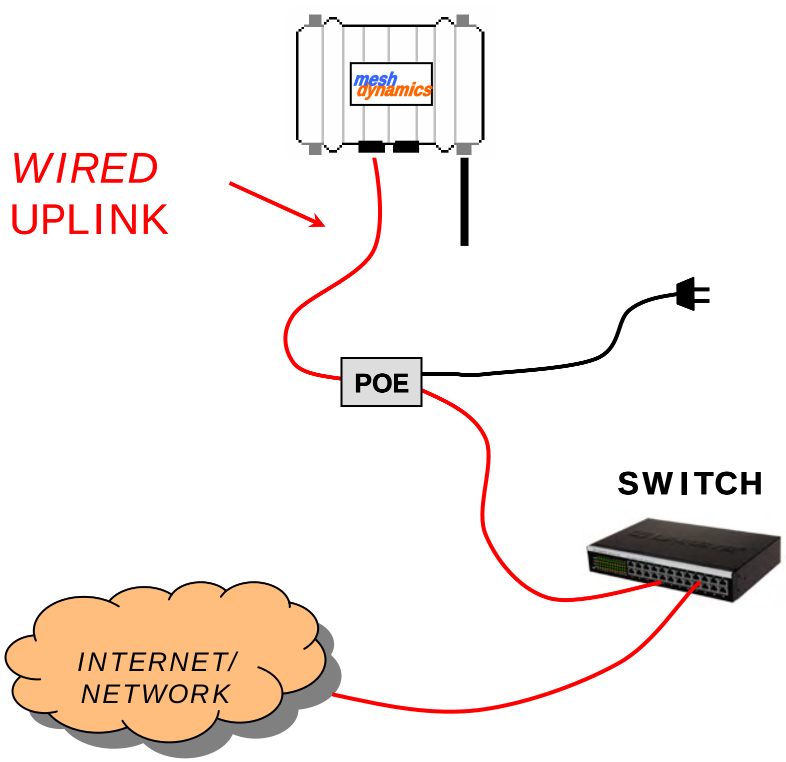
Fig.4


Fig.5

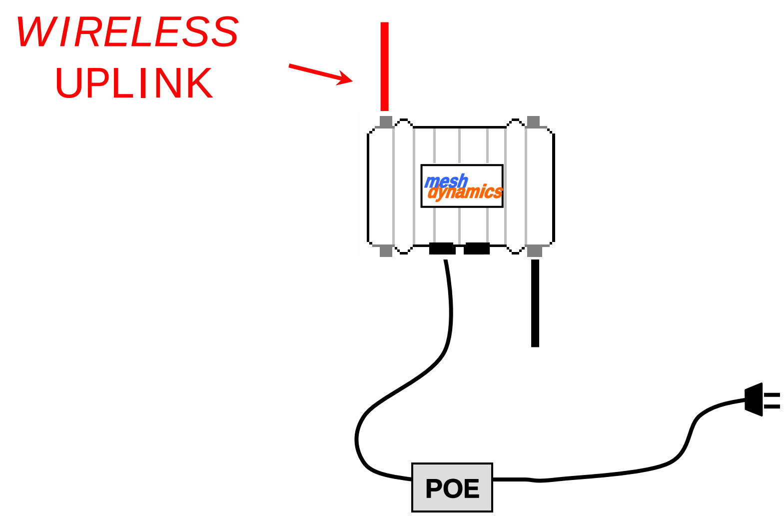
TERMINOLOGY

The difference in the physical setup of root nodes and relay nodes is the connection from a root node's POE to a switch. This connection acts as the uplink for root nodes, whereas relay nodes have a wireless uplink. Whenever either of the the physical setups are altered, the nodes must be rebooted in order to assume their new role.

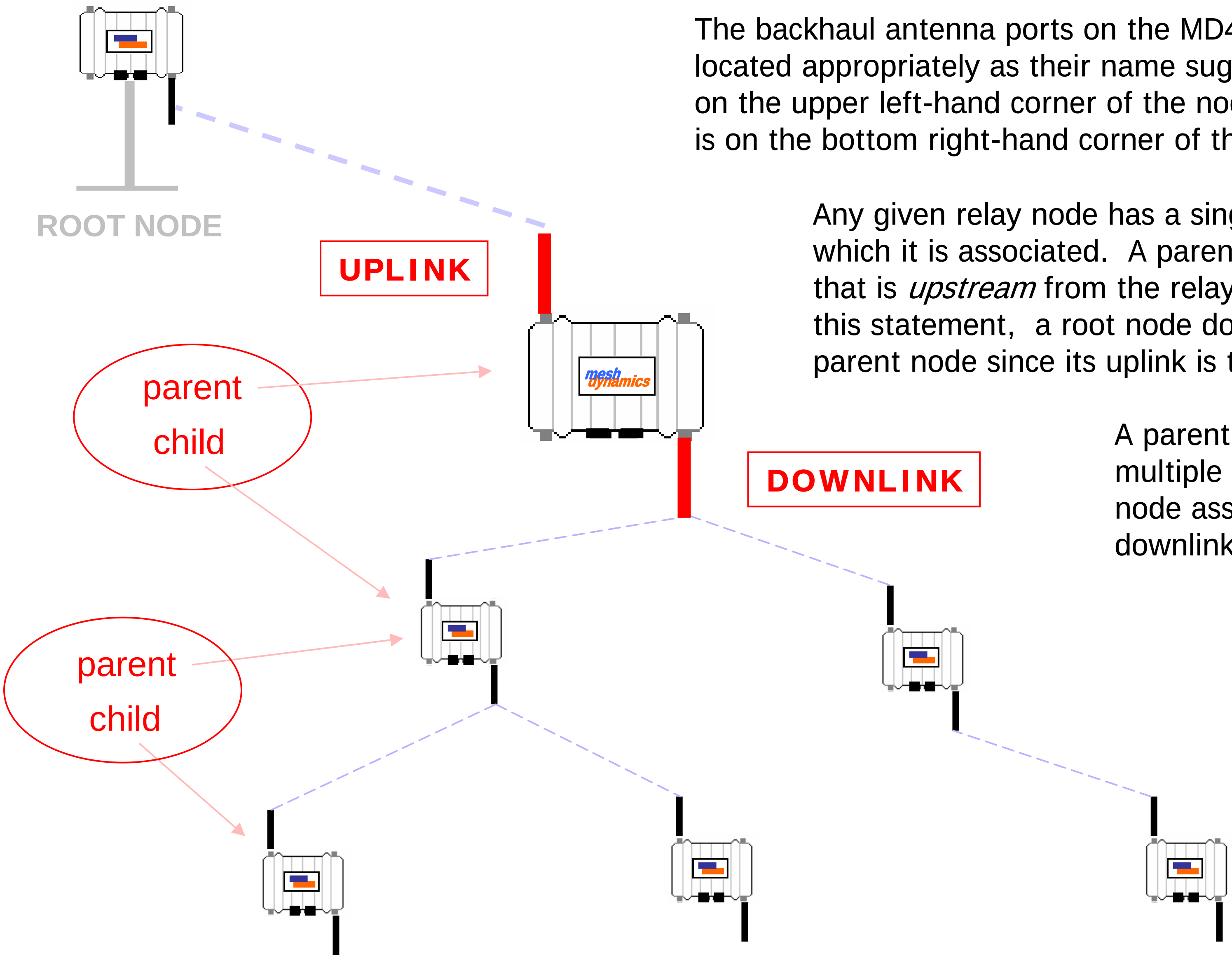
ROOT NODE



RELAY NODE



PATH OF INFORMATION AND TERMINOLOGY



The backhaul antenna ports on the MD4000 are physically located appropriately as their name suggests; the uplink is on the upper left-hand corner of the node, the downlink is on the bottom right-hand corner of the node.

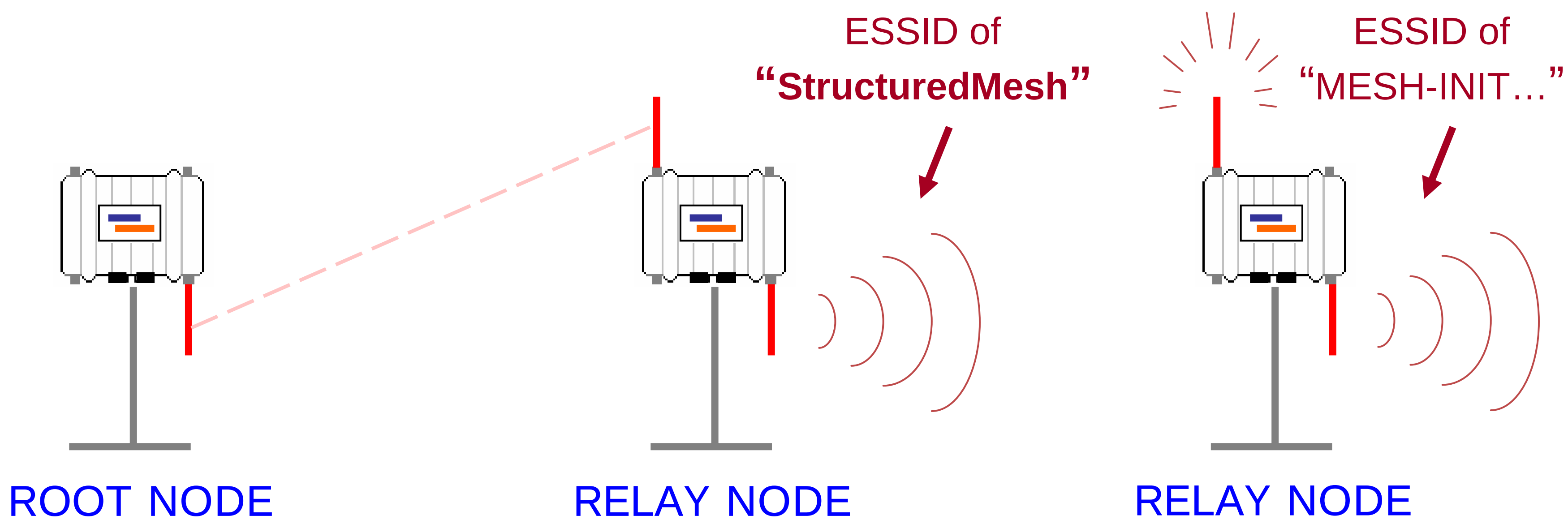
Any given relay node has a single parent node to which it is associated. A parent node is the node that is *upstream* from the relay node. Considering this statement, a root node does not have a parent node since its uplink is the wired network.

A parent node can have multiple child nodes; each node associated to its downlink is its child node.

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 the default ESSID of “StructuredMesh” on its downlink and AP radios. Any scanning relay nodes that hear *this* beacon will associate, thus growing the network.

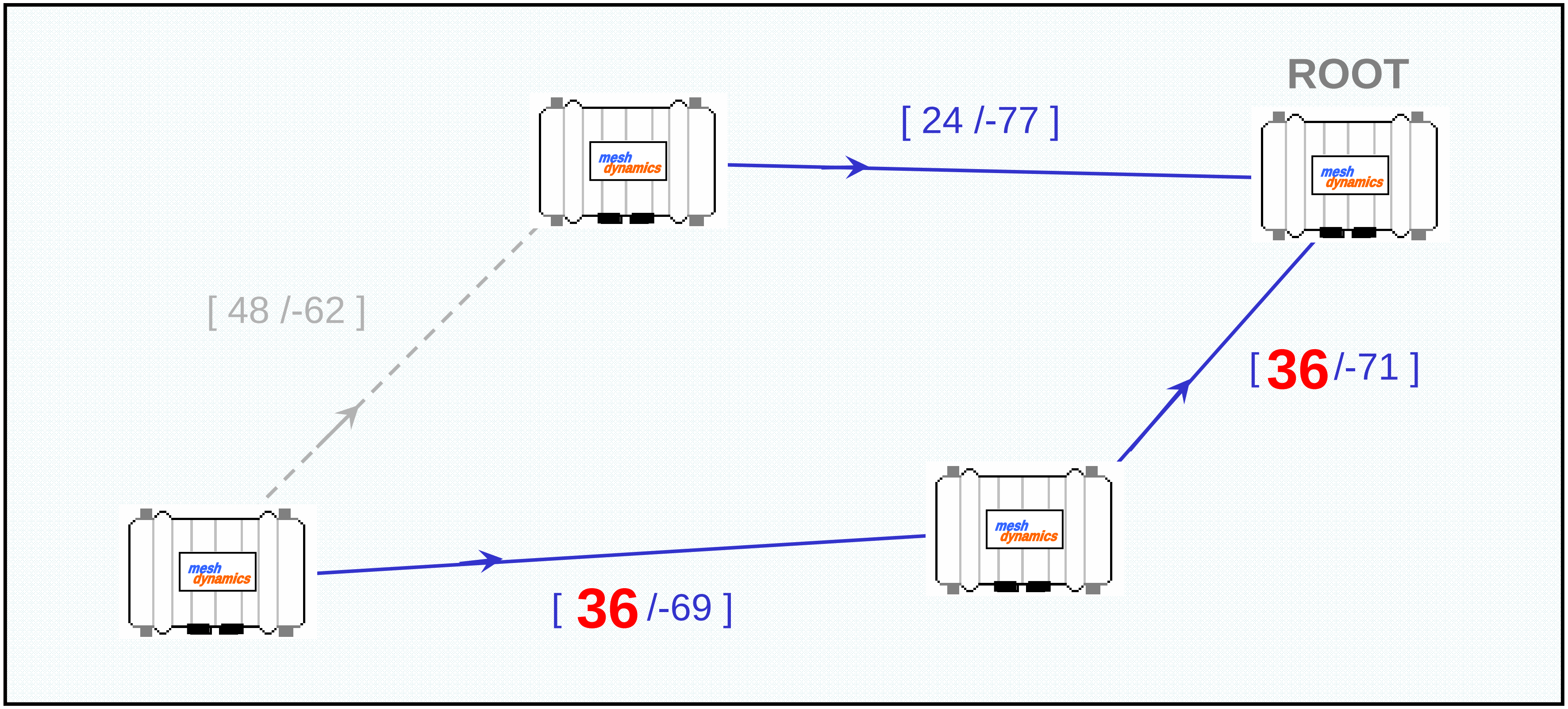
Until a relay node associates to a parent node, it will beacon an ESSID starting with the words “MESH-INIT” on its downlink and AP radios. This is to indicate that it has no association to the mesh network. If a *root* node continually beacons an ESSID of “MESH-INIT-... ”, this indicates that it is not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



JOINING CRITERIA AND SWITCHING

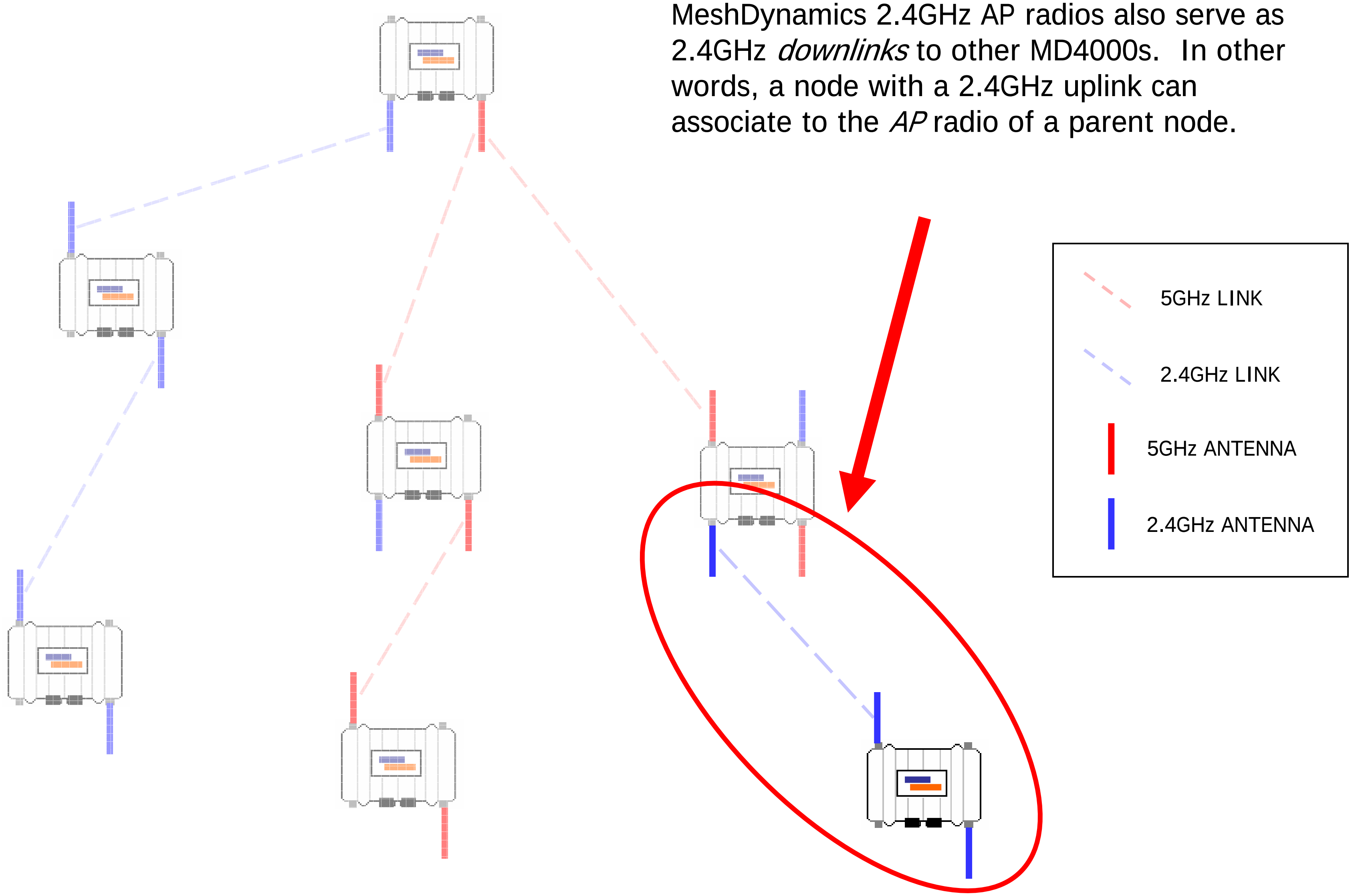
The initial child-to-parent link is formed based on the signal strength the child sees from the parent. After joining, the child node pro-actively samples neighbor links. The connectivity rate then becomes the main criteria, and the “global” connectivity rate is given the higher priority.

Link switching decisions for stationary nodes are made every heartbeat interval. Mobile nodes make switching decisions much more quickly. For a child node to switch parent nodes, the new ‘best’ parent must provide the best link qualities for 3 consecutive heartbeats.



OPTIONS OF NODE CONNECTIONS

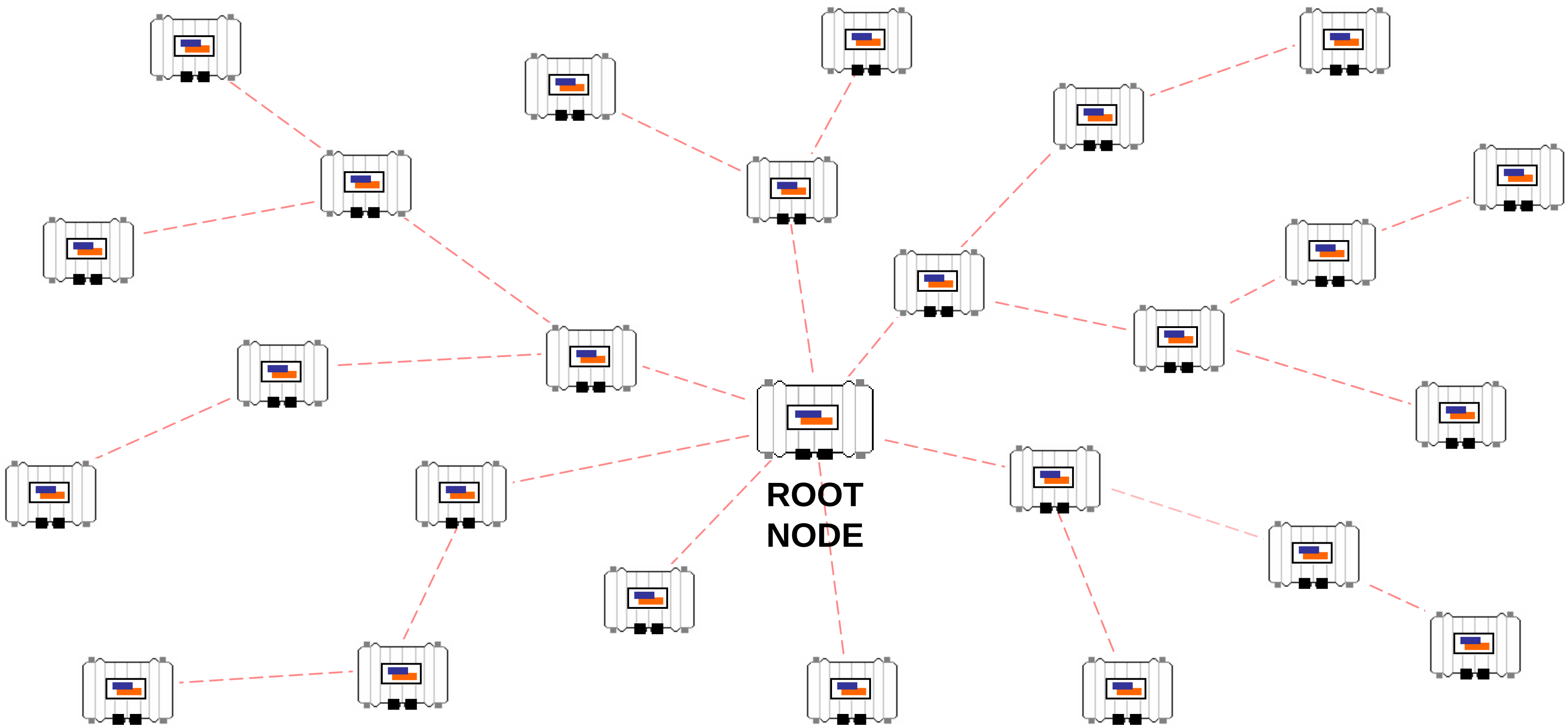
MeshDynamics 2.4GHz AP radios also serve as 2.4GHz *downlinks* to other MD4000s. In other words, a node with a 2.4GHz uplink can associate to the *AP* radio of a parent node.



ANTENNAS

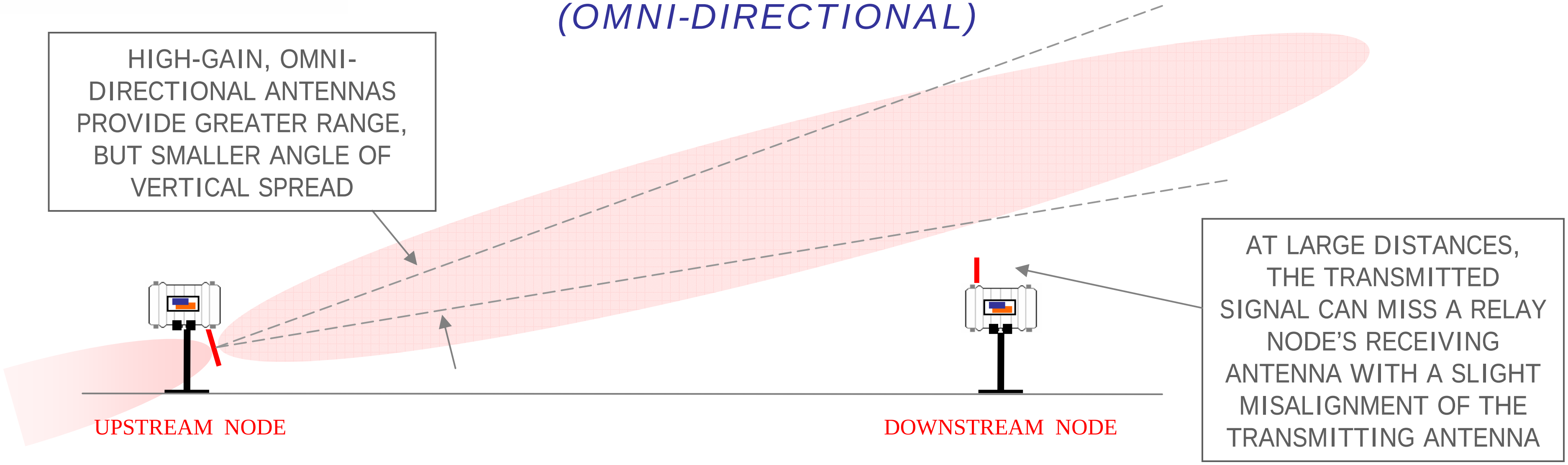
(OMNI-DIRECTIONAL)

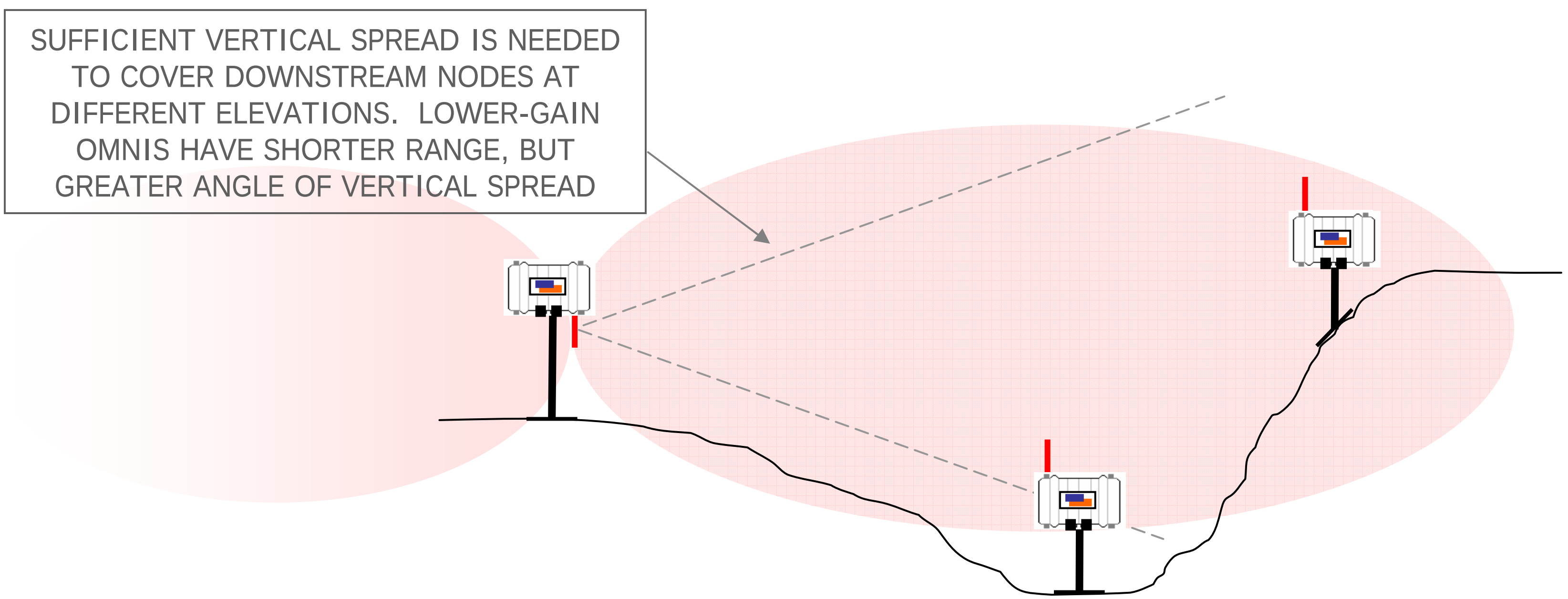
Omni-directional antennas are very easy to implement and require no aiming. When using 8dBi omni-directional antennas on both radios involved in the link, typical node-to-node distances are 1000-1500ft (300-450m). Omni-directional antennas are useful when nodes are evenly distributed throughout the mesh, and minimal effort is to be spent installing nodes.



ANTENNAS

(OMNI-DIRECTIONAL)

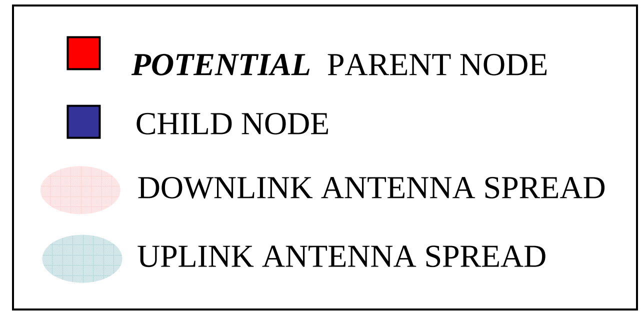


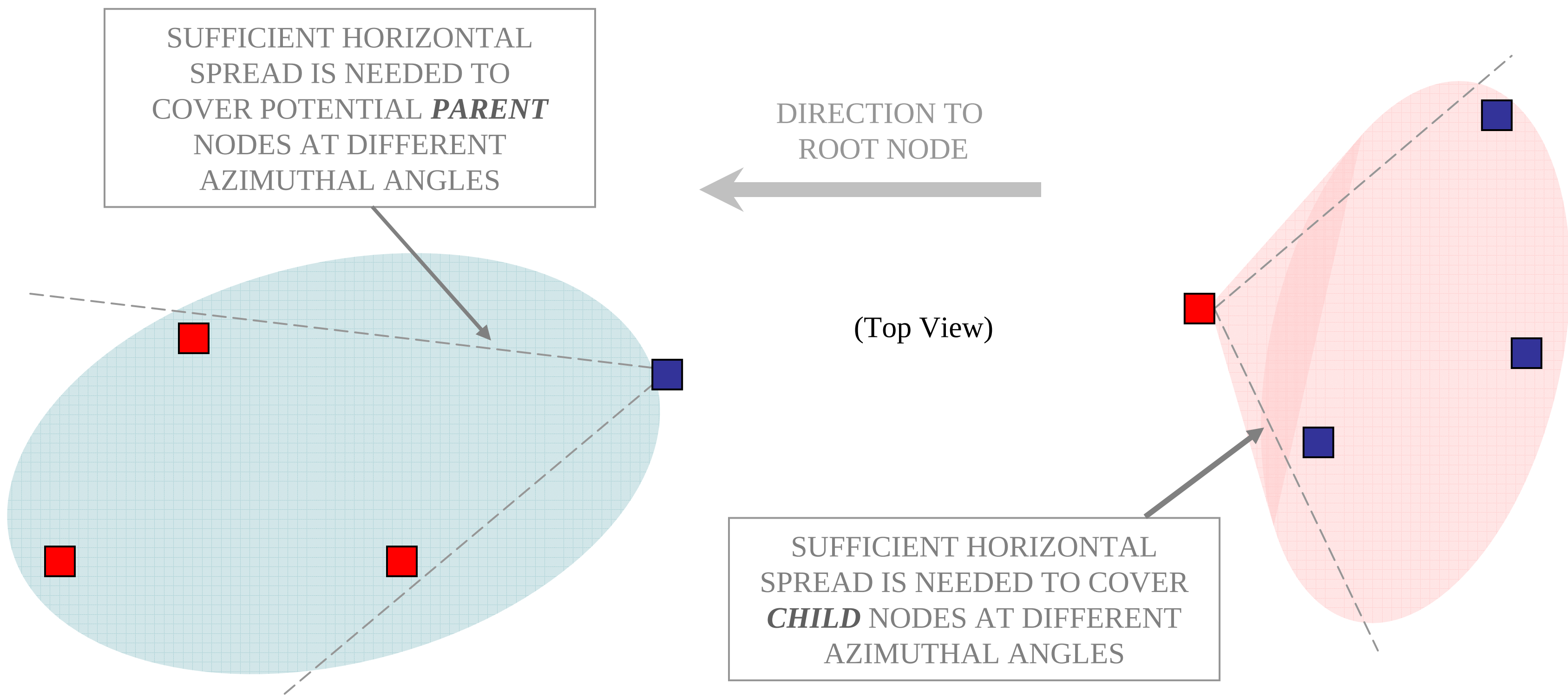


ANTENNAS

(SECTORS AND DIRECTIONALS)

Since the MD4000 has two separate radios on each node for the backhaul, this allows for the use of sector and directional antennas to increase range and functionality. Oftentimes, omni-directional antennas will spread signal where it is not needed. Sectors and directionals make better use of the transmitted power.

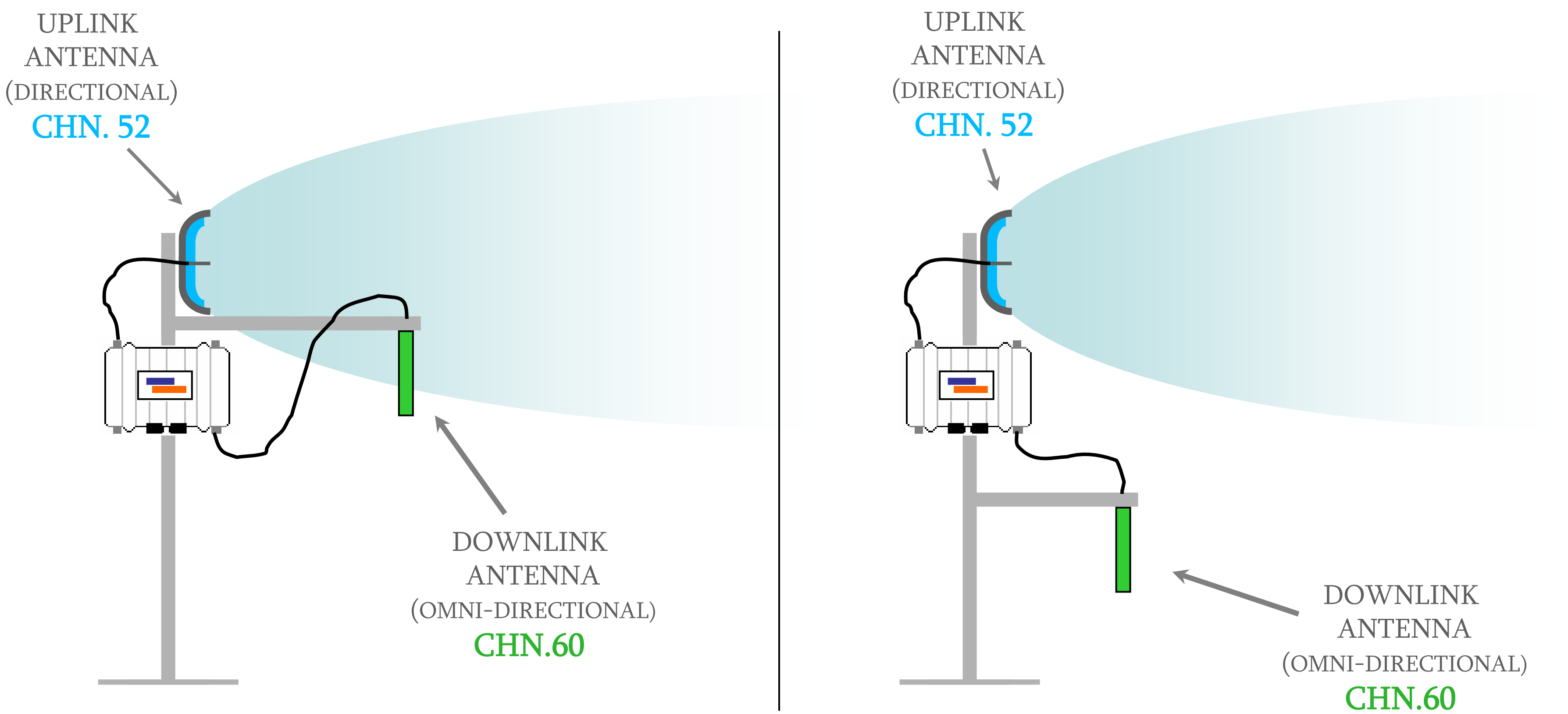




ANTENNAS

(OVERLAPPING SIGNALS)

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 vertical separation such that this does not happen. This is especially important when using a 2.4GHz backhaul as the standard 2.4GHz channels are separated by only 25MHz, whereas the standard 5GHz channels are separated by 40MHz.

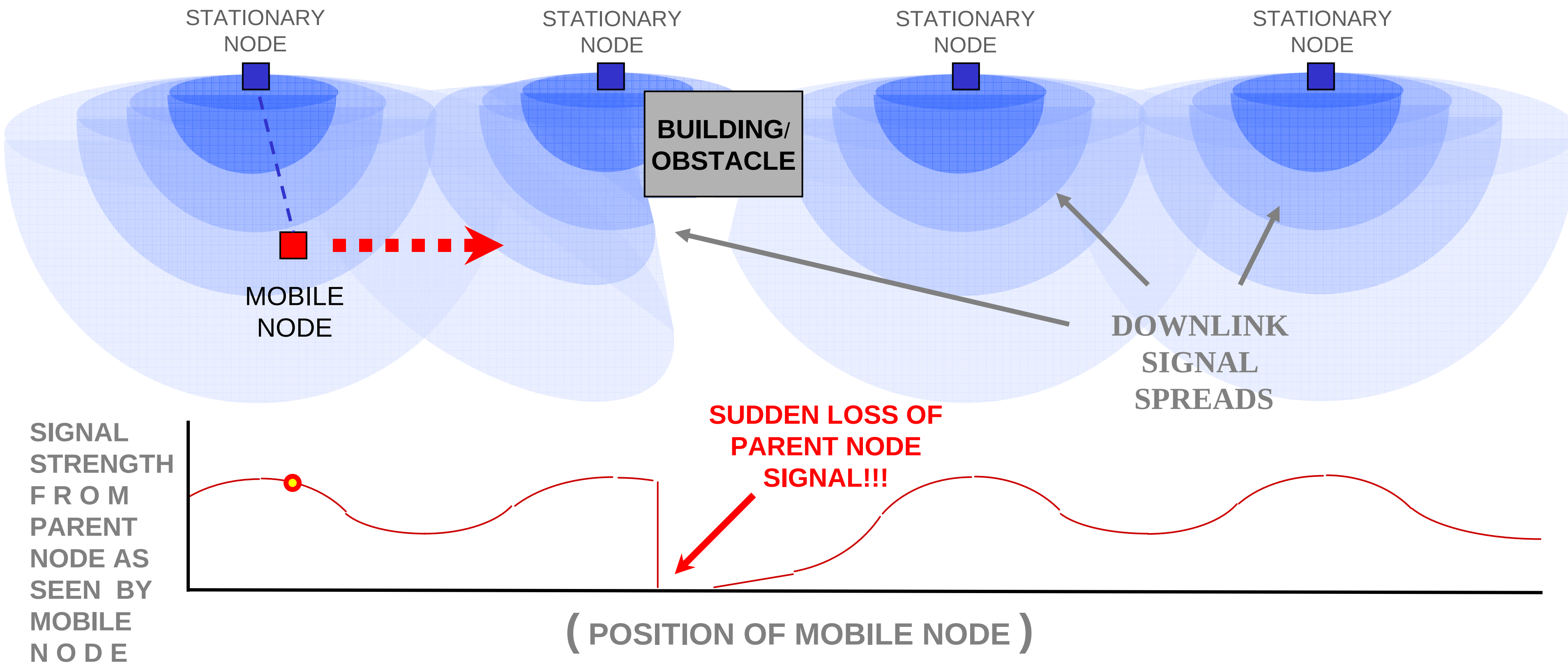


ANTENNAS

(MOBILE-NODE COVERAGE)

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.

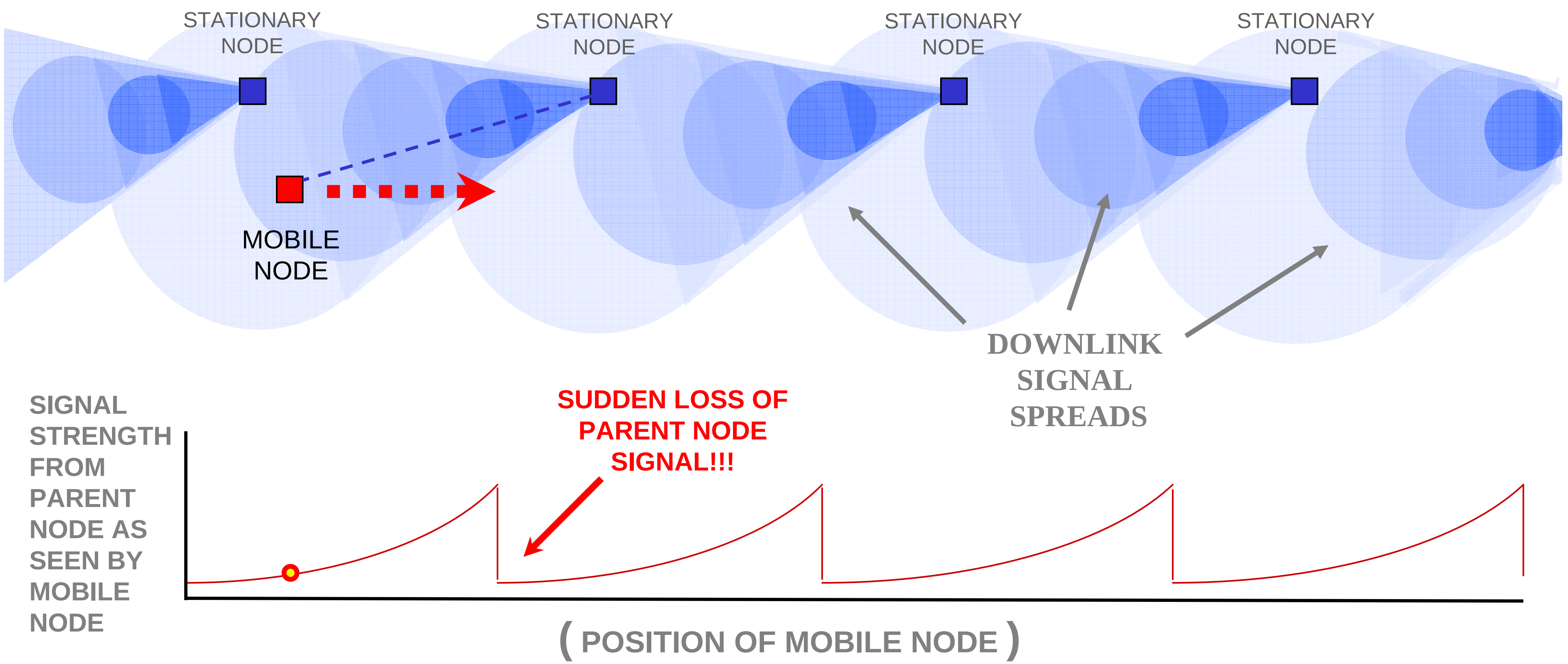
Here, we have a situation where an obstacle causes a sudden signal drop-off in the coverage to the mobile node. Although the mobile node will recover automatically, the abrupt vanishing of the parent node's signal will halt the transfer of data for a brief period of time.



ANTENNAS

(MOBILE-NODE COVERAGE)

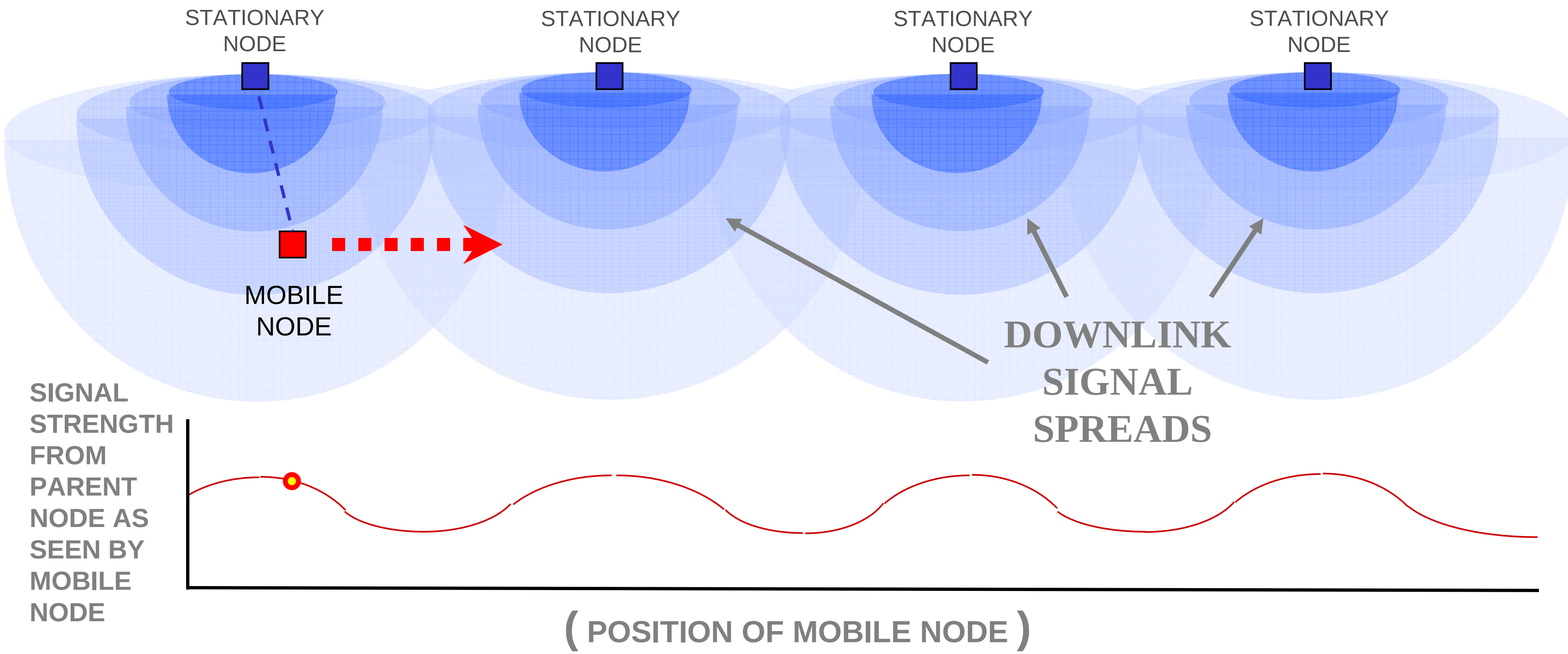
It is possible to have sudden signal drop-offs even if no obstacles are present. Using sector or directional antennas to provide the coverage area for mobile nodes can present such a scenario. In the example below, the mobile node moves from left to right. Even though the mobile node remains within the 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.



ANTENNAS

(MOBILE-NODE COVERAGE)

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.



DETERMINING CONFIGURATIONS FROM MODEL NUMBERS

MeshDynamics model numbers use eight characters to convey the full configuration of the MD4000 mesh node. The first four characters after "MD" convey the number and functionality of the radios used in the mesh node. The second set of four characters convey the protocol used by these radios.

MD

4.....4 *available* radio slots

3.....Number of radio cards used for this particular configuration (can be 1, 2, 3, or 4)

5.....Type of backhaul ("5" for 5.8GHz backhaul, "2" for 2.4GHz backhaul, "4" for 4.9GHz backhaul)

0.....This represents an *additional function* of the node. 0 is no additional function, 5 for scanner, 2 for extra downlink, 8 for extra service radio, 4 means that all radios are downlinks (only possible with root nodes).

A.....Bottom-right antenna port (downlink).....can be A (802.11a), 4 (4.9GHz) or I (802.11b/g)

A.....Top-left antenna port (uplink)..... can be A (802.11a), 4 (4.9GHz) or I (802.11b/g)

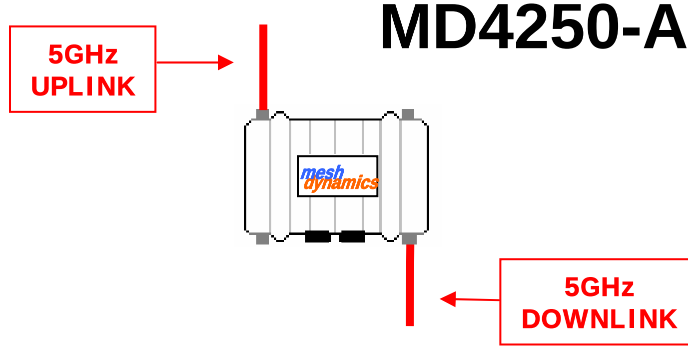
I......Bottom-left antenna port....can be A, I, 4 or X ("x" means *empty*).

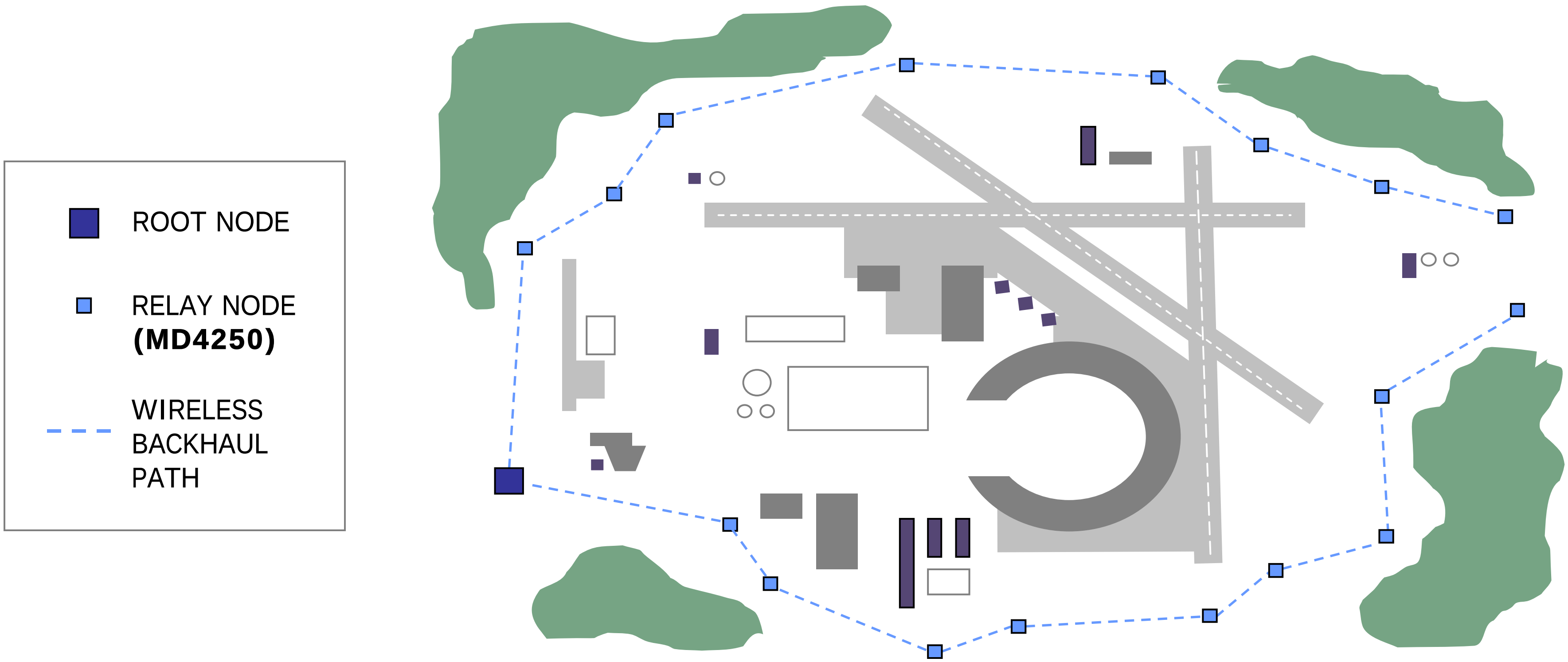
X.....Top-right antenna port....can be A, I, 4 or X ("x" means *empty*).

FUNCTIONALITY AND MODEL NUMBERS

The **MD4250-AAxx** has one 5GHz uplink and one 5GHz downlink. It can be referred to as a “backhaul only” mesh node. Typical uses included perimeter surveillance (such as in the airport diagram below) with each node having an IP camera connected, or linking two separate meshes together along a backhaul path.

MD4250-AAxx

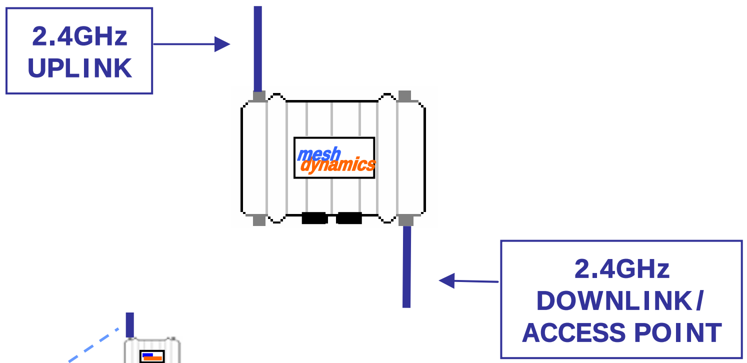


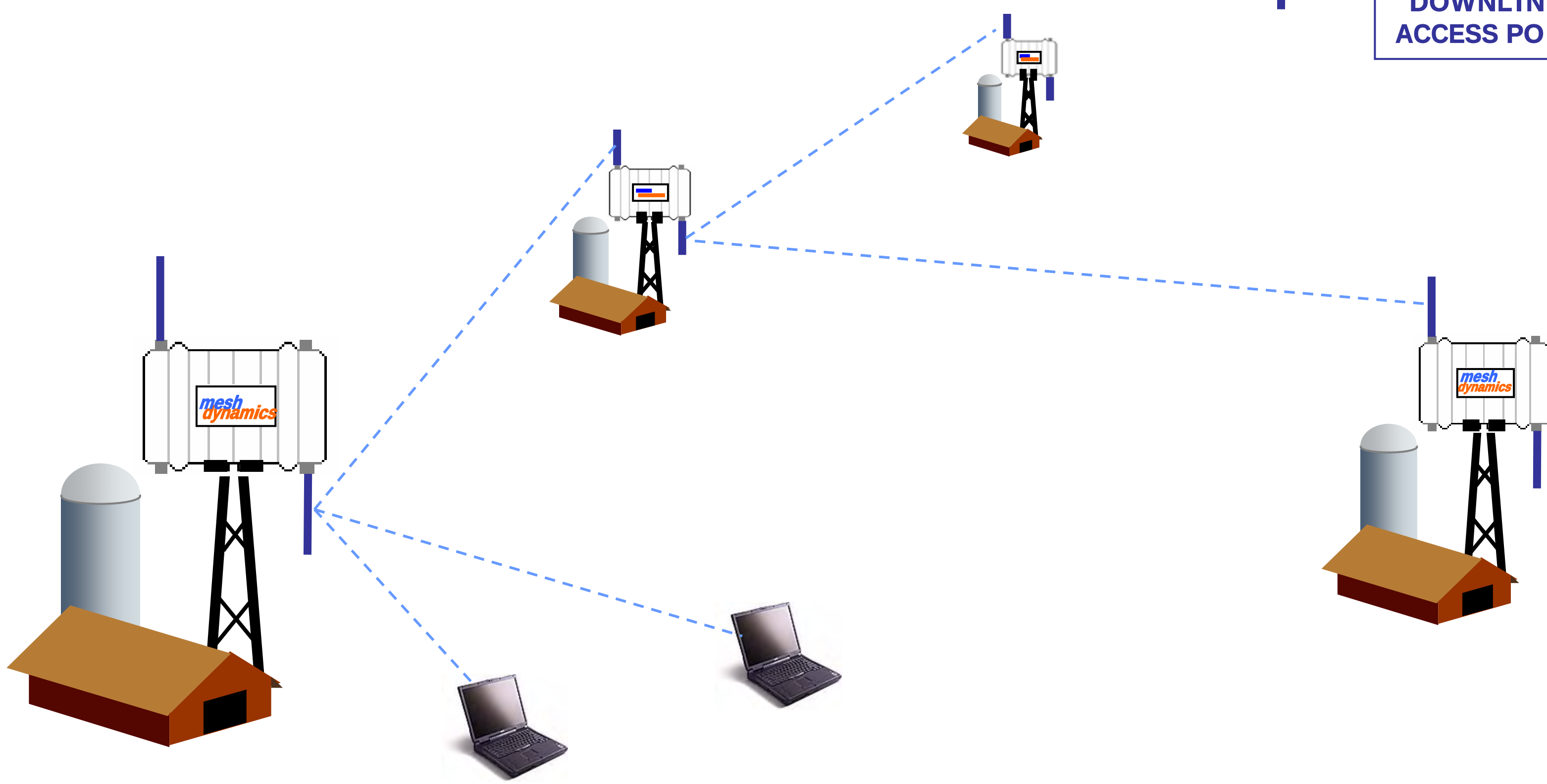


FUNCTIONALITY AND MODEL NUMBERS

MD4220-IIxx

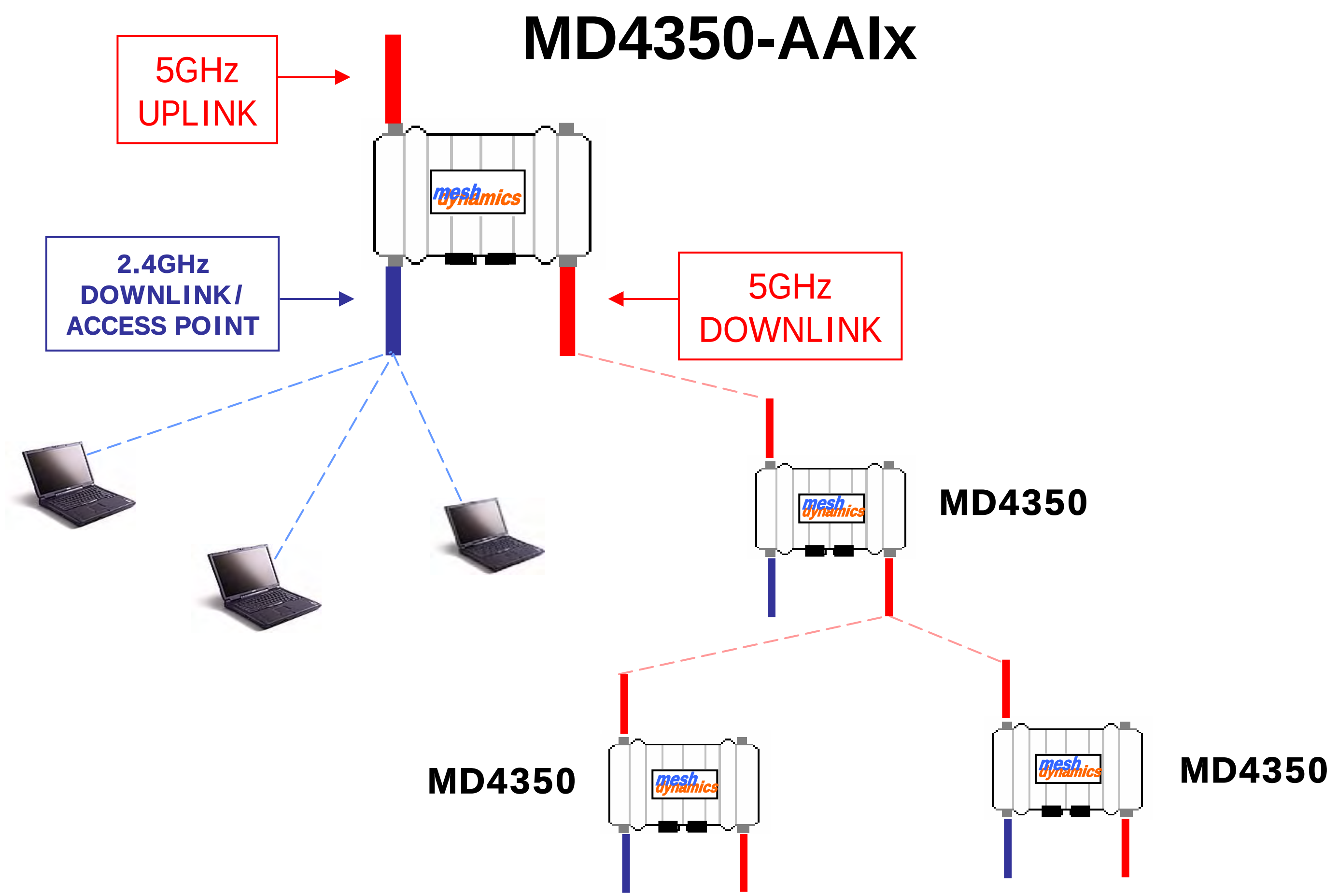
The **MD4220-IIxx** has one 2.4GHz uplink and one 2.4GHz downlink. The ability of 2.4GHz to propagate longer distances make this node ideal for applications where there are fewer wireless clients that are dispersed over a very large area, such as in rural settings.



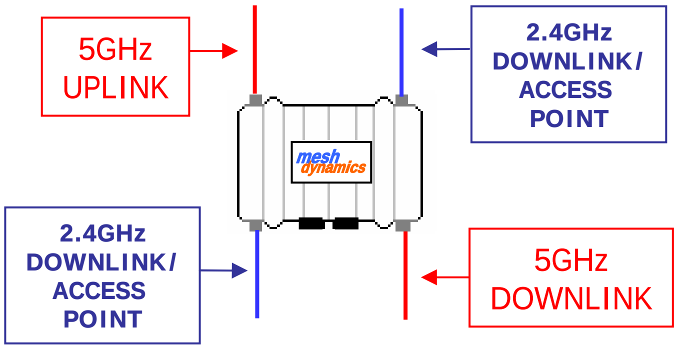


FUNCTIONALITY AND MODEL NUMBERS

The **MD4350-AAIx** has one 5GHz uplink, one 5GHz downlink, and one 2.4GHz AP radio. This is this basically the "standard" 3rd generation mesh node. The 3rd generation backhaul is formed, and 2.4GHz wireless clients can access the AP radios on the nodes.

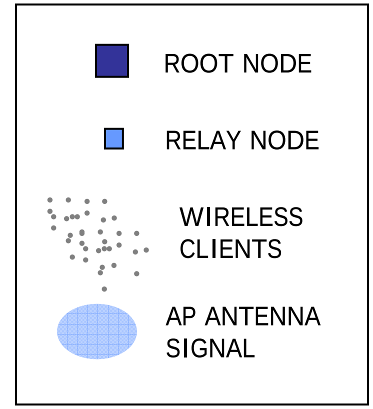


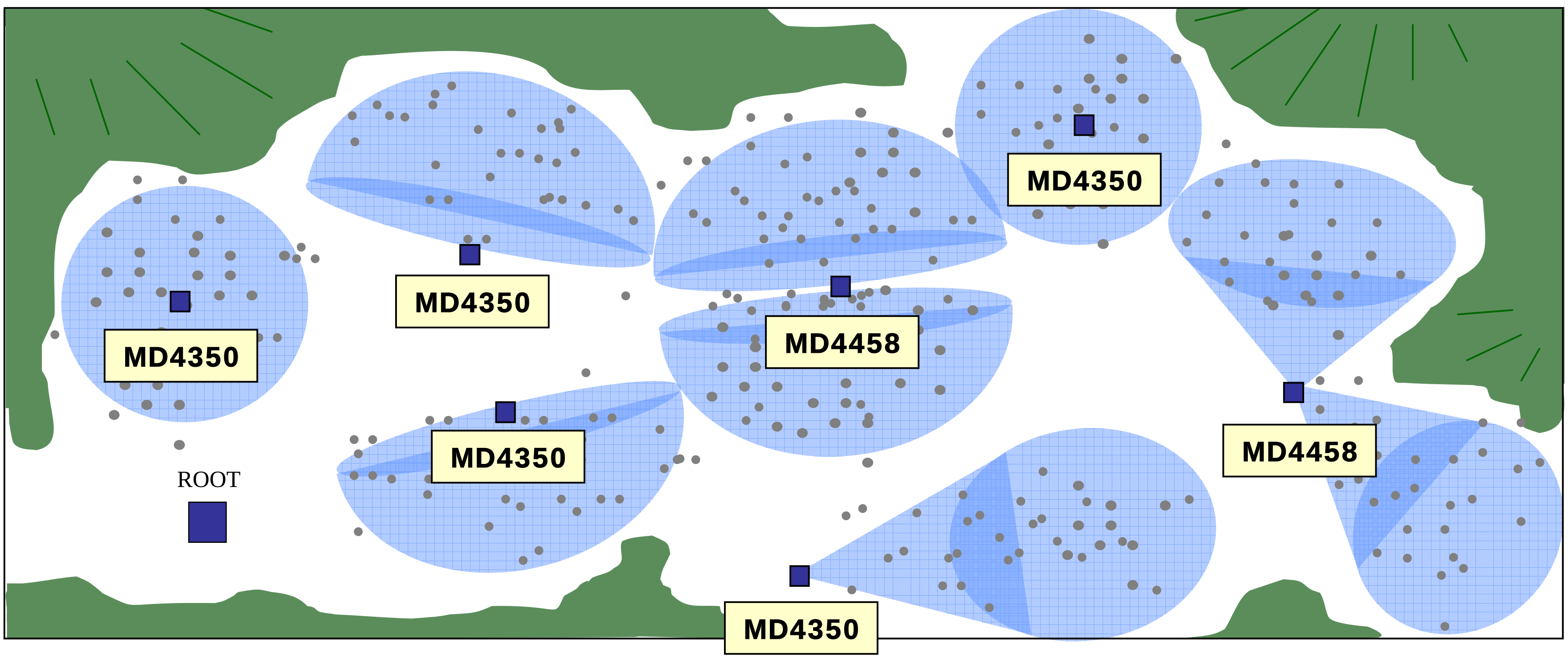
FUNCTIONALITY AND MODEL NUMBERS



MD4458-AAII

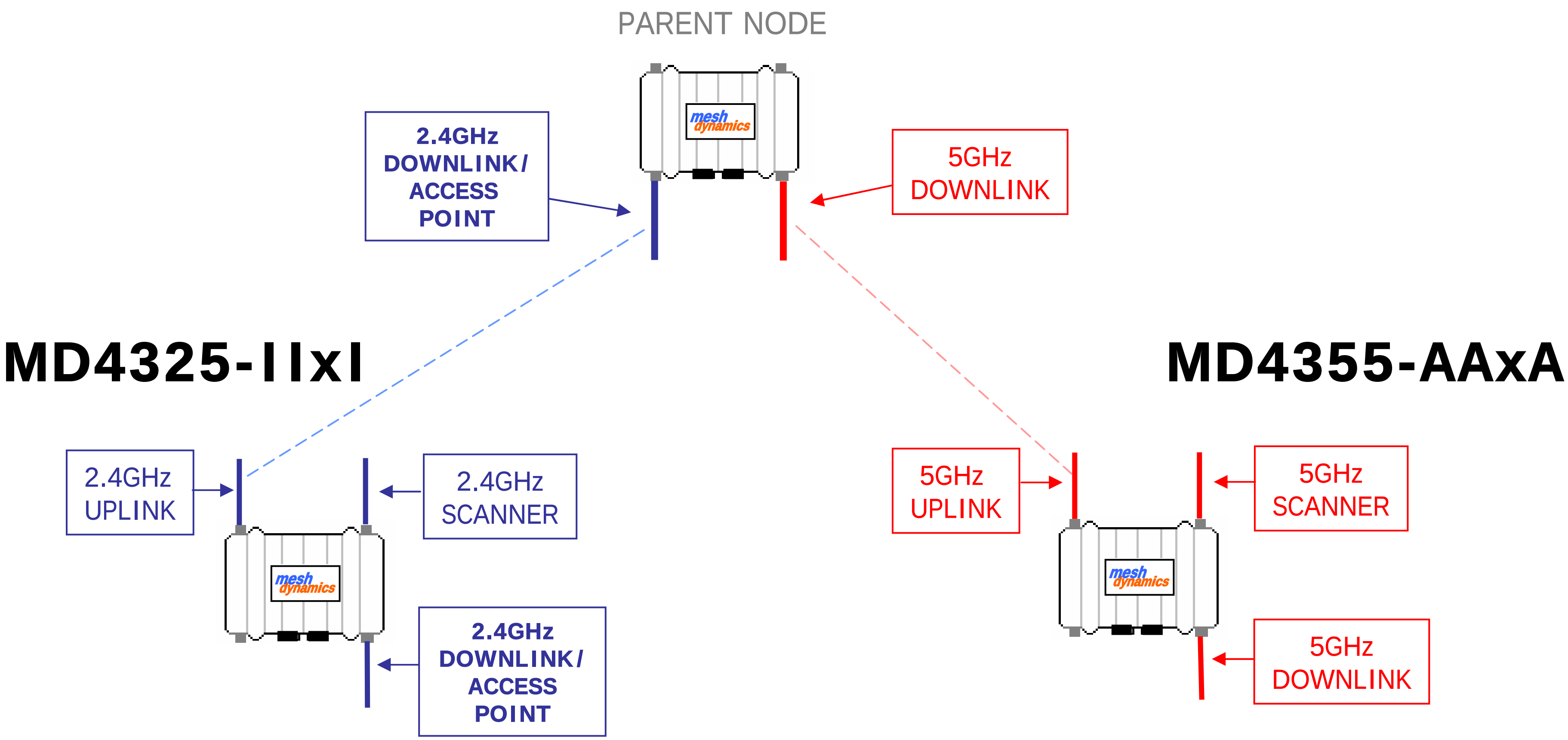
The MD4350-AAIx and the MD4458-AAII offer one and two AP radios, respectively. Antennas can be selected for these radios to optimize client coverage relative to the location of the node. ***Signal spreads of the AP radios on the MD4458-AAII should <u>not</u> overlap. A client that sees both signals can suffer throughput issues.**





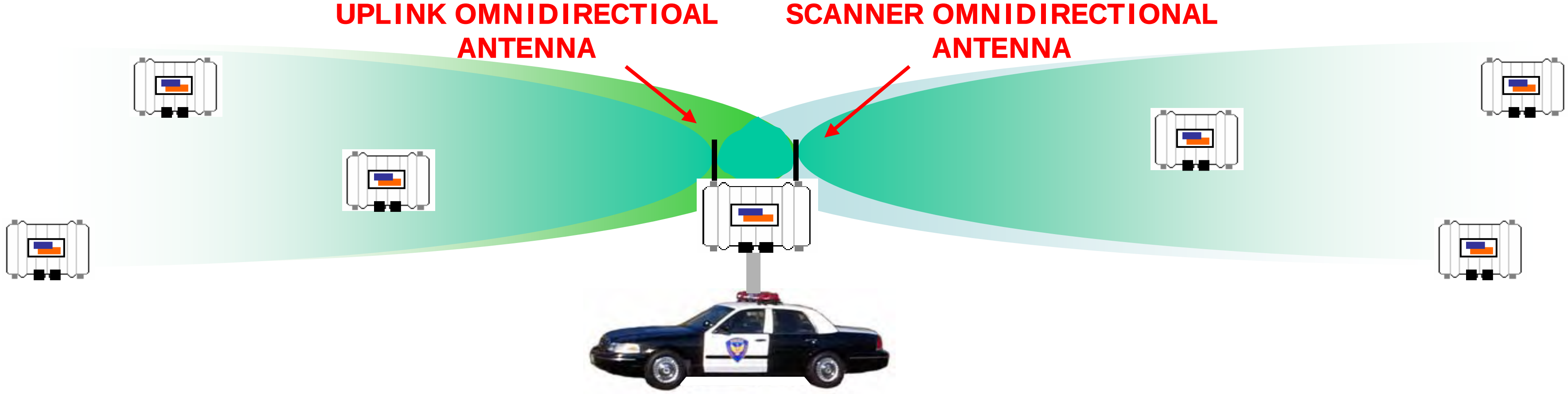
FUNCTIONALITY AND MODEL NUMBERS

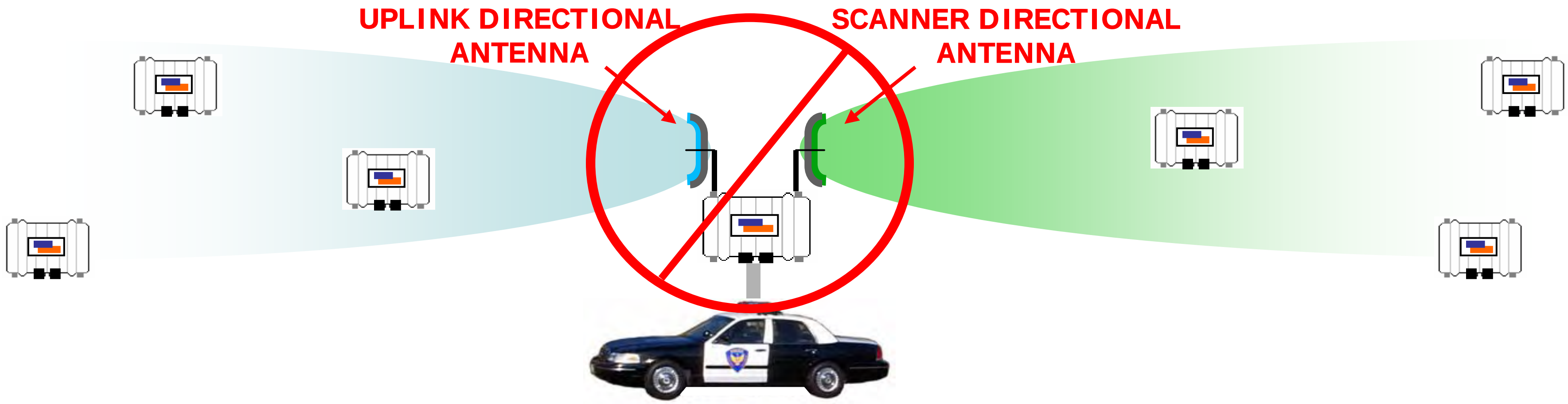
A mobile mesh node has the ability to associate to either the **downlink** radio of a parent node, or the **AP** radio of the parent node. It is therefore important to consider the signal coverage of the radios (downlink, or AP) to which the mobile node will associate. If it is decided that the mobile nodes will associate to the *AP* radios, which are typically 2.4GHz, the **MD4325-IIxI** should be selected as the mobile node. If the mobile node is to associate to the *downlink* radios, which are typically 5GHz, the **MD4355-AAxA** should be selected.



FUNCTIONALITY AND MODEL NUMBERS

The uplink and scanner radios of a mobile mesh node must be able to see the *same RF environment*. This is necessary in order for the node to make optimal switching decisions. This implies that the antennas selected for each radio must be of the same type, and oriented in the same direction (if applicable). For example, if directional antennas are used for both uplink and scanner radios, but each are pointed in opposite directions, the scanner radio will scan for potential parent nodes that the uplink's antenna cannot see.

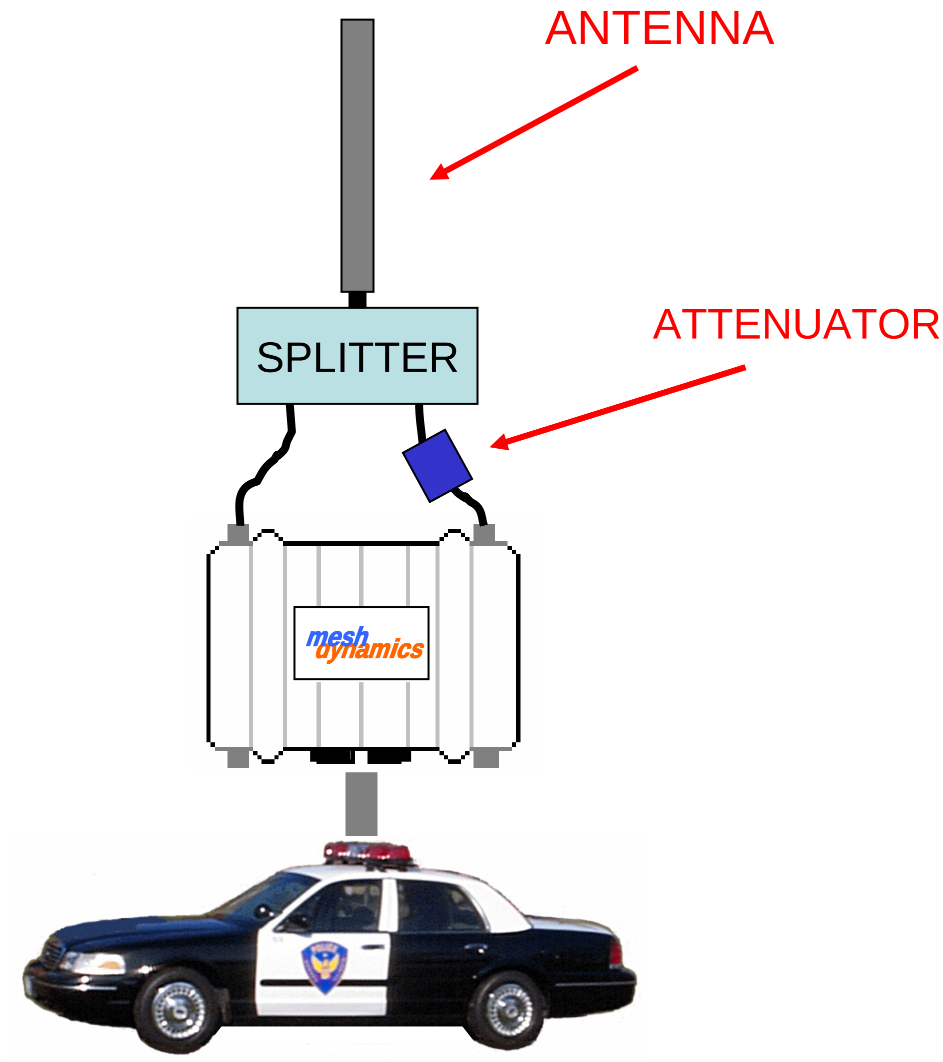




FUNCTIONALITY AND MODEL NUMBERS

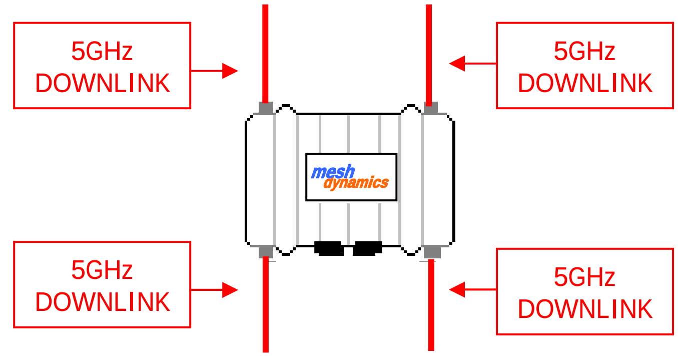
Another solution to having the uplink antenna and the scanner antenna see the same RF environment is to implement a splitter to combine the two radios into one antenna.

If a splitter is used, it should have good isolation (>20dB), otherwise, the scanner radio card could get damaged from the uplink radio's transmissions. If no splitter can be found with enough isolation, an attenuator (10-15dB) can be placed between the splitter and the scanner radio antenna port.



FUNCTIONALITY AND MODEL NUMBERS

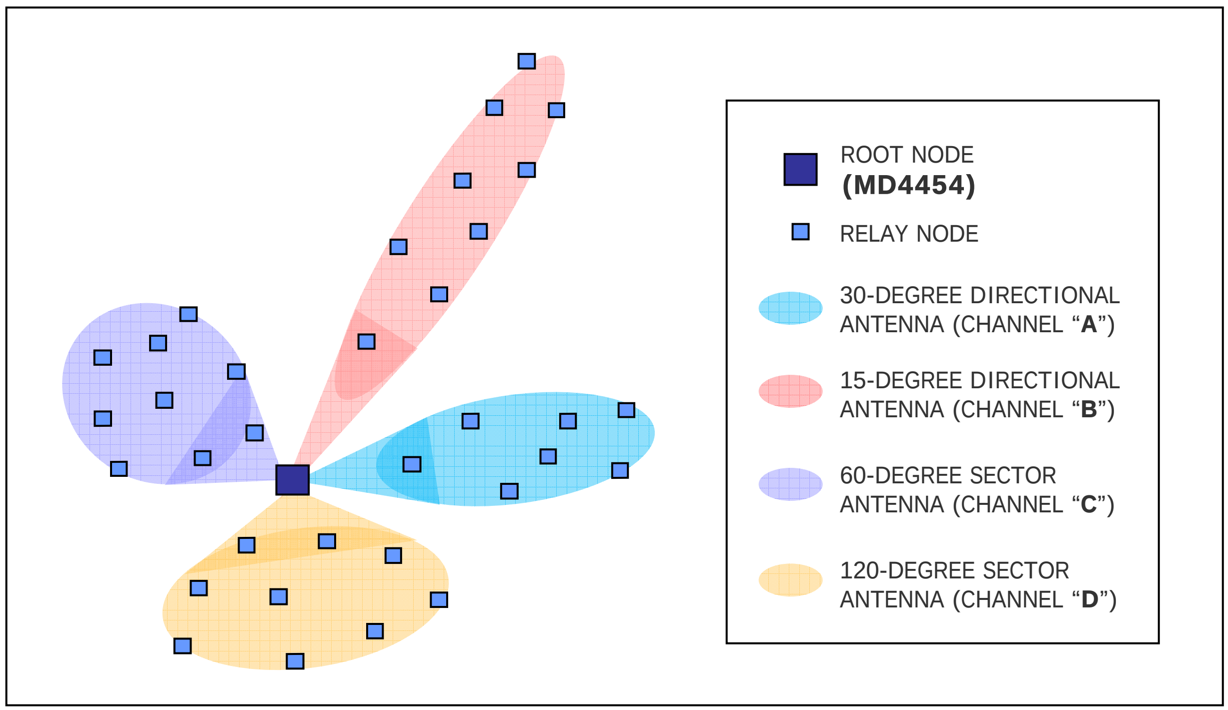
When a large mesh is fed through a single bandwidth source, or if a large amount of bandwidth is desired in general, it is often beneficial to incorporate a root node that has multiple downlink radios. There are two significant advantages of this:



MD4454-AAAA

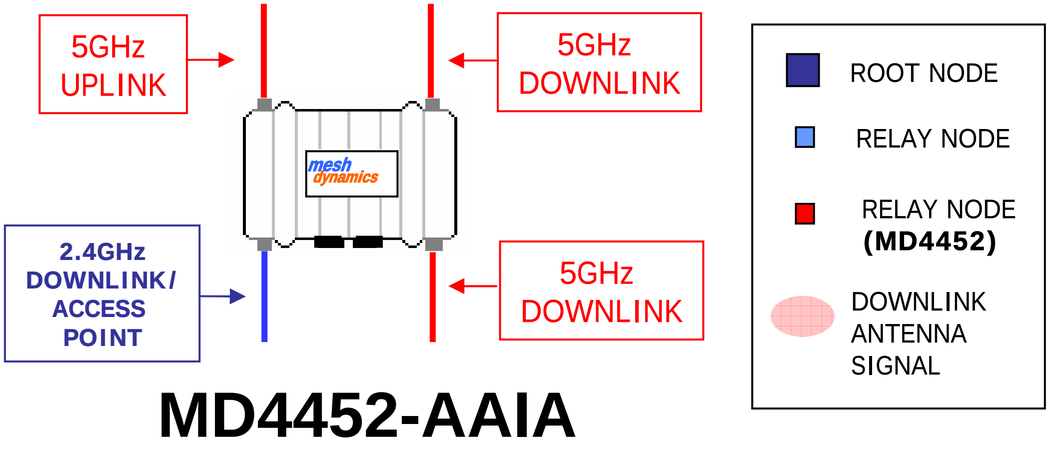
1) Maximization of Bandwidth Each *single* downlink radio can support ~22Mbps of TCP/IP throughput (802.11a, 802.11g) on a particular channel. Each *additional* downlink radio will support another ~22Mbps of throughput on other separate channels. In the illustration below, the root node has four downlink radios (model number MD4454-AAAA), therefore, ~88Mbps of TCP/IP throughput is being fed into the mesh.

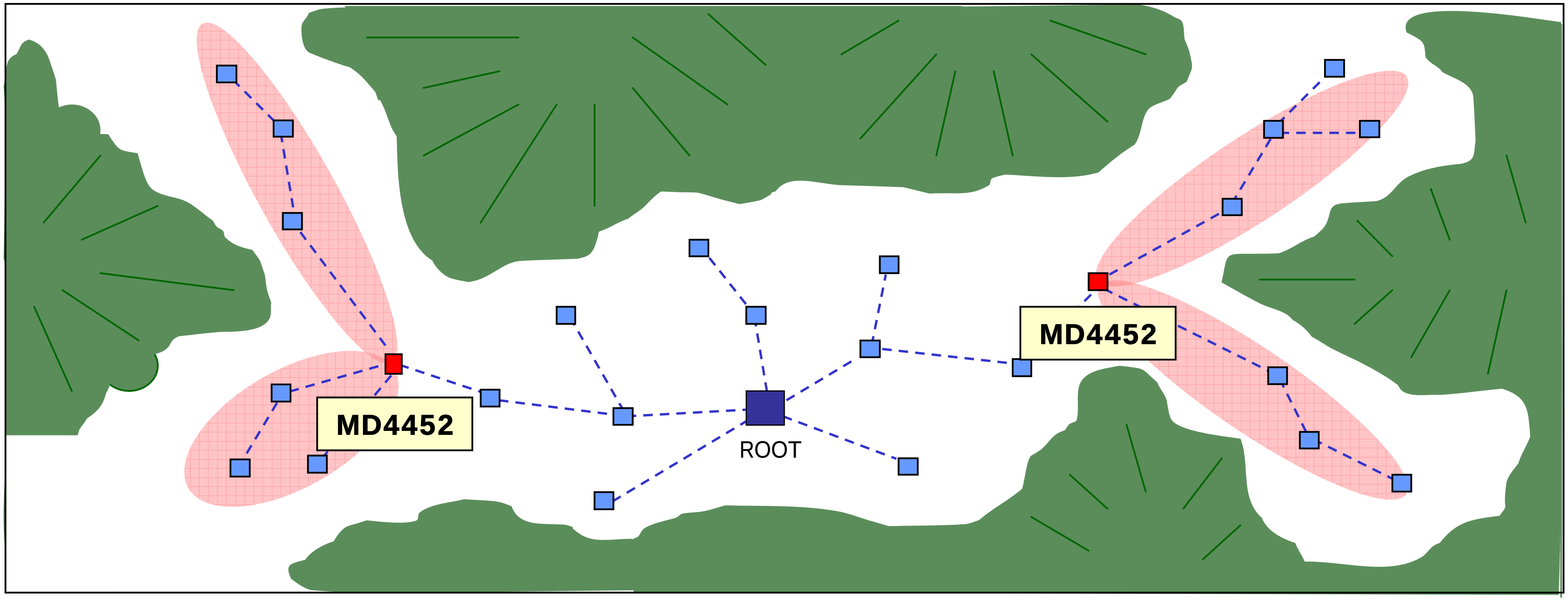
2) Optimization of Coverage When child nodes are dispersed in various directions and distances from a root node, appropriate antennas can be used to spread the signal from the downlink radios to the child nodes. In the illustration to the right, sector and directional antennas are used. ***Signal spreads should not overlap.



FUNCTIONALITY AND MODEL NUMBERS

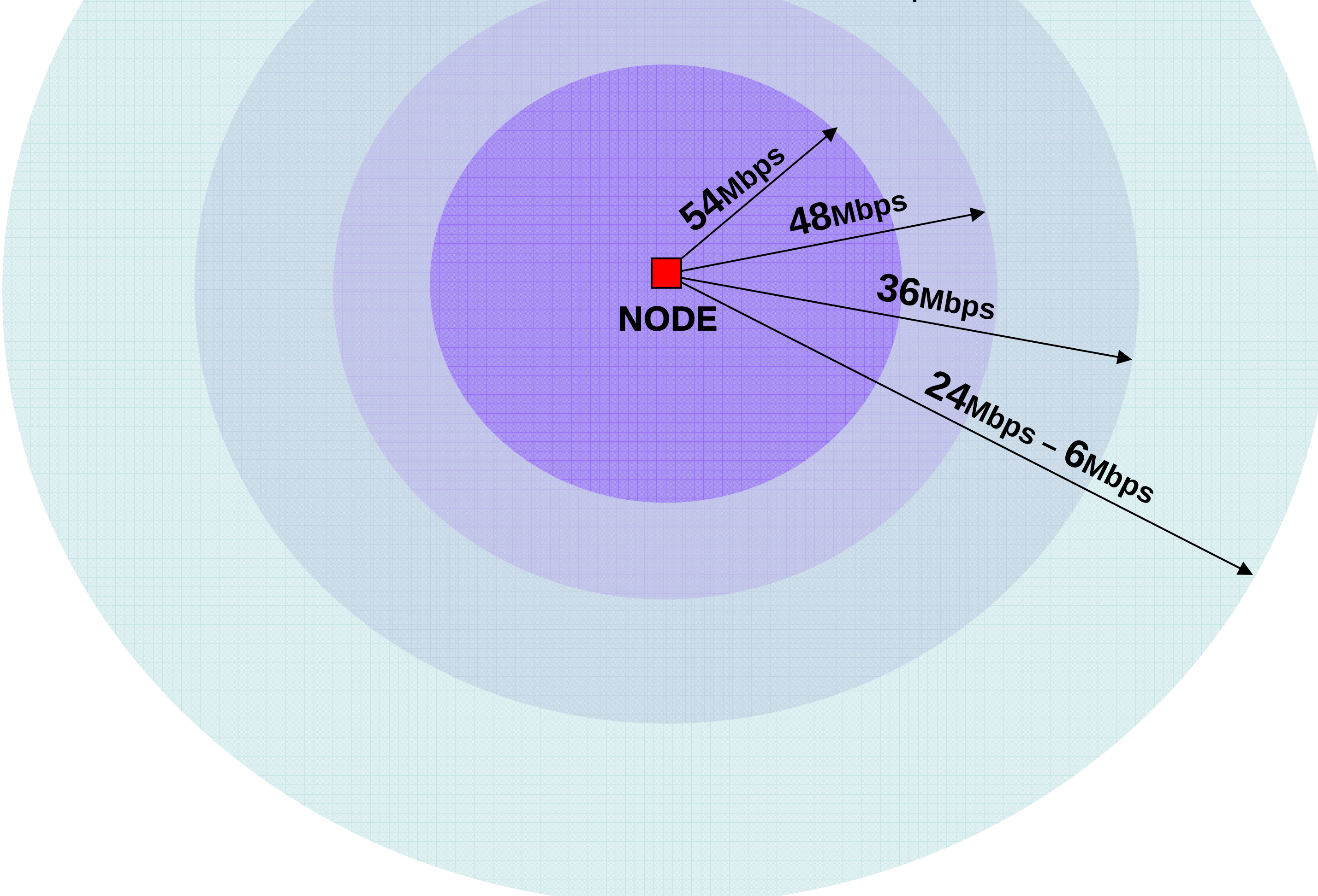
The “backhaul structure” of a mesh can also benefit from a *relay node* having multiple downlink radios. A node with a second downlink antenna allows a branching of the backhaul; directional antennas can be used to shoot the backhaul to different clusters of child nodes. The MD4452-AAIA has an additional downlink radio. In the below illustration, it can be seen how the use of multiple downlinks can help optimize the backhaul structure of a mesh.





DATA RATE AND RANGE

A radio's transmit power increases inversely with the data rate at which it is transmitting; the lower the data rate, the higher the transmit power of the radio. In addition, a radio card is able to receive lower data rates with a much higher sensitivity. The combination of these two factors ***dramatically*** increases the node-to-node distance when lower data rates are implemented.



5GHz Channels
(POWER AND FREQUENCIES)

- Difference in power between *lower* 5GHz channels (52, 60), and *upper* 5GHz channels (149, 157, 165)

The MeshDynamics backhaul uses 802.11a channels 52, 60, 149, 157, and 165. By MeshDynamics experimental results (as well as being due to regulation), channels 52 and 60 put out roughly 3dBm less than channels 149, 157, and 165. This difference in transmit power output can be helpful in optimizing link quality.

- Necessary antennas for 5GHz (5.250-5.845GHz)

Many 5GHz antennas offered 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 5GHz antennas that are rated for both parts of the spectrum.

CUSTOM CHANNELS
(BENEFITS)

The Meshdynamics RF Editor allows the creation of custom channels. These channels can have a user-defined center frequency, and a channel width of **5**MHz, **10**MHz, **20**MHz, or **40**MHz.

There are two benefits of having custom channels:

MORE THROUGHPUT

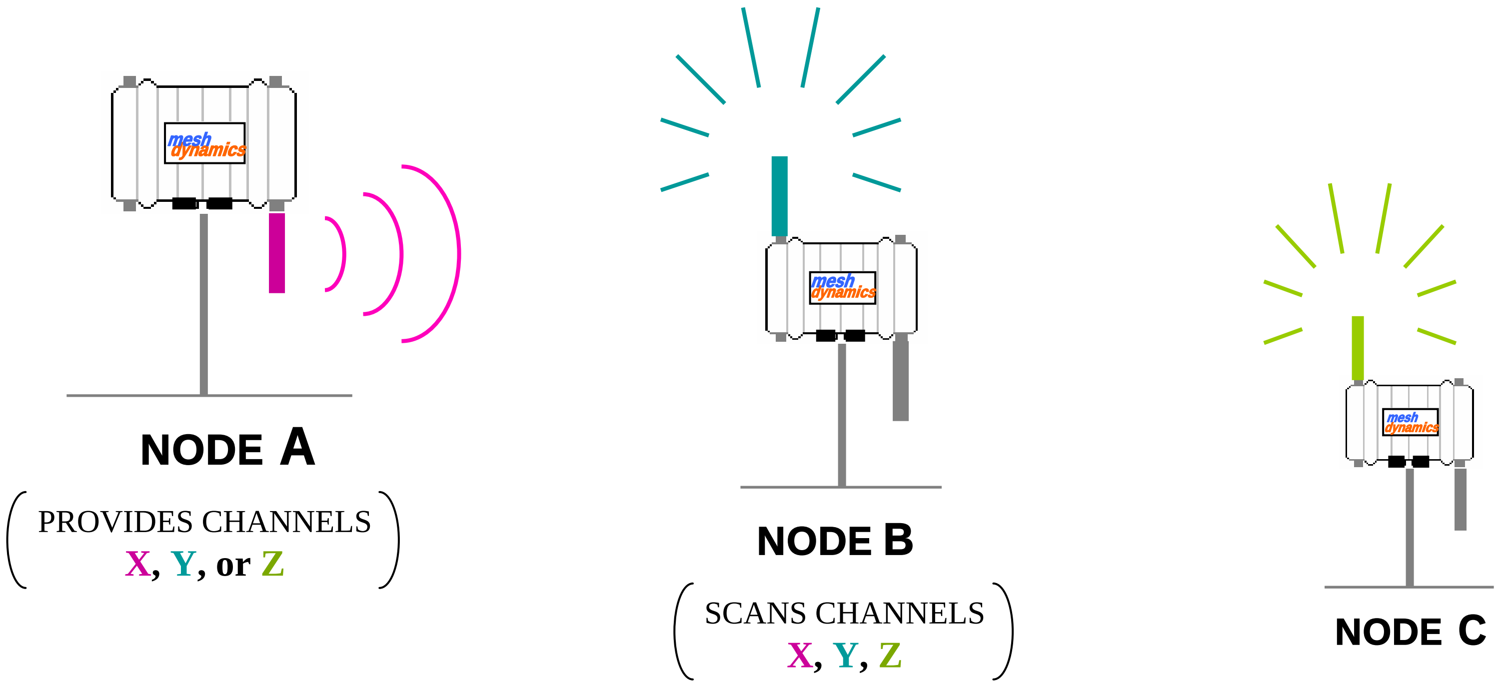
A 40MHz-wide channel will support ~40Mbps of throughput, whereas the standard 20MHz-wide 802.11a/g channels only support ~22Mbps. This higher-bandwidth feature is typically used in point-to-point links, but can also be used in a mesh if properly engineered. *** Conversely, a 10MHz channel will support ~11Mbps, and a 5MHz channel will support ~5.5Mbps.

MORE BACKHAUL CHANNELS

Since narrower channels occupy less room in a given RF spectrum, more channels can be made available for the backhaul when using 5 or 10MHz-wide channels. Although rarely needed, using narrower channels can help avoid interference and maintain even network throughput in deployments that have a high node density.

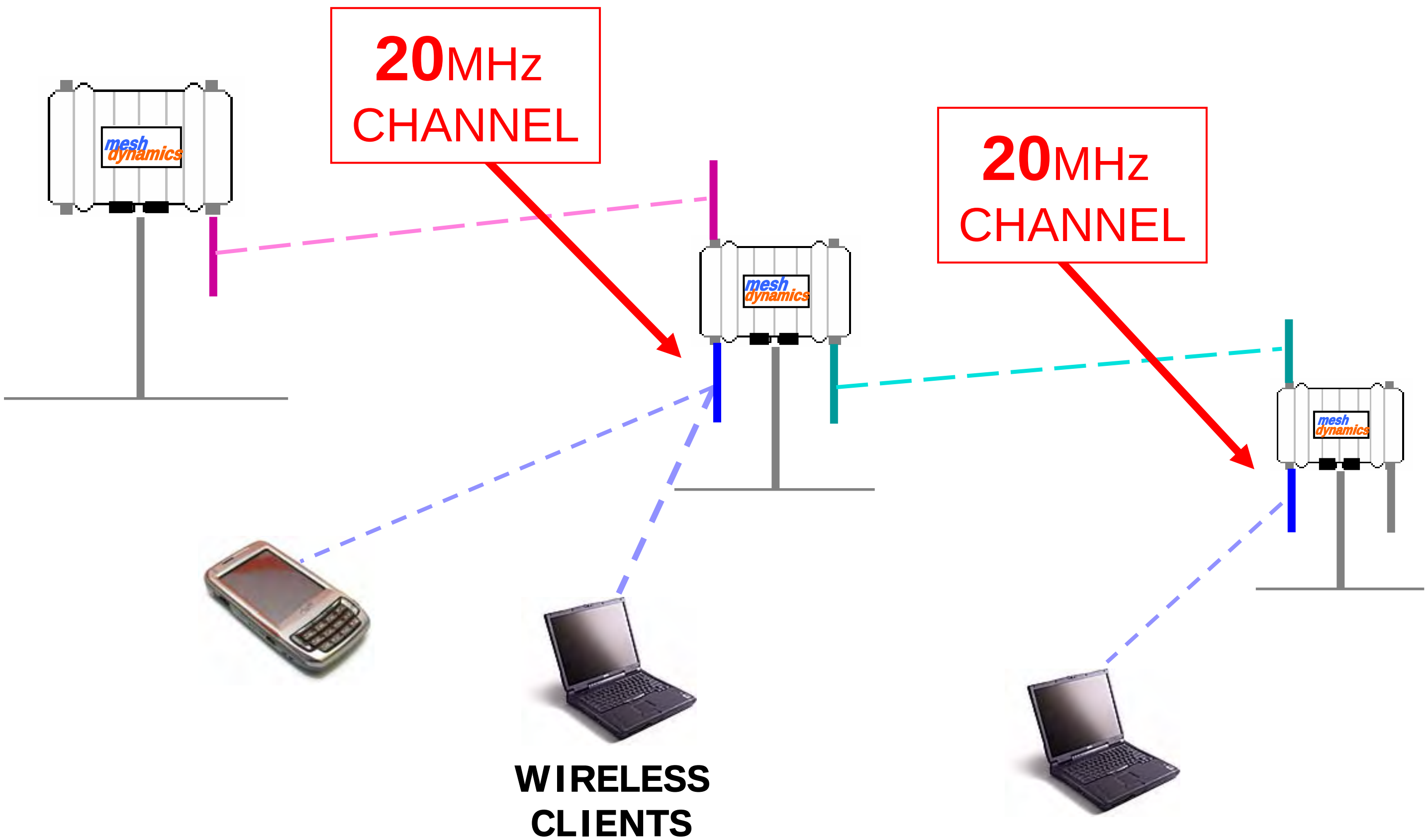
CUSTOM CHANNELS
(BACKHAUL CONTINUITY)

In order for a mesh to function properly with custom channels, **all created channels must be implemented across the backhaul**. In other words, node "B" will only scan the channels that were created on its *uplink* radio. Node "A" needs to provide those channels on its downlink radio for node "B" to grab onto. This is the same situation between node "B" and node "C". The RF Editor will overwrite the default 802.11a and 802.11b/g channel lists with the newly created channels, thus each uplink and downlink radio in the mesh needs to support the same custom channels.



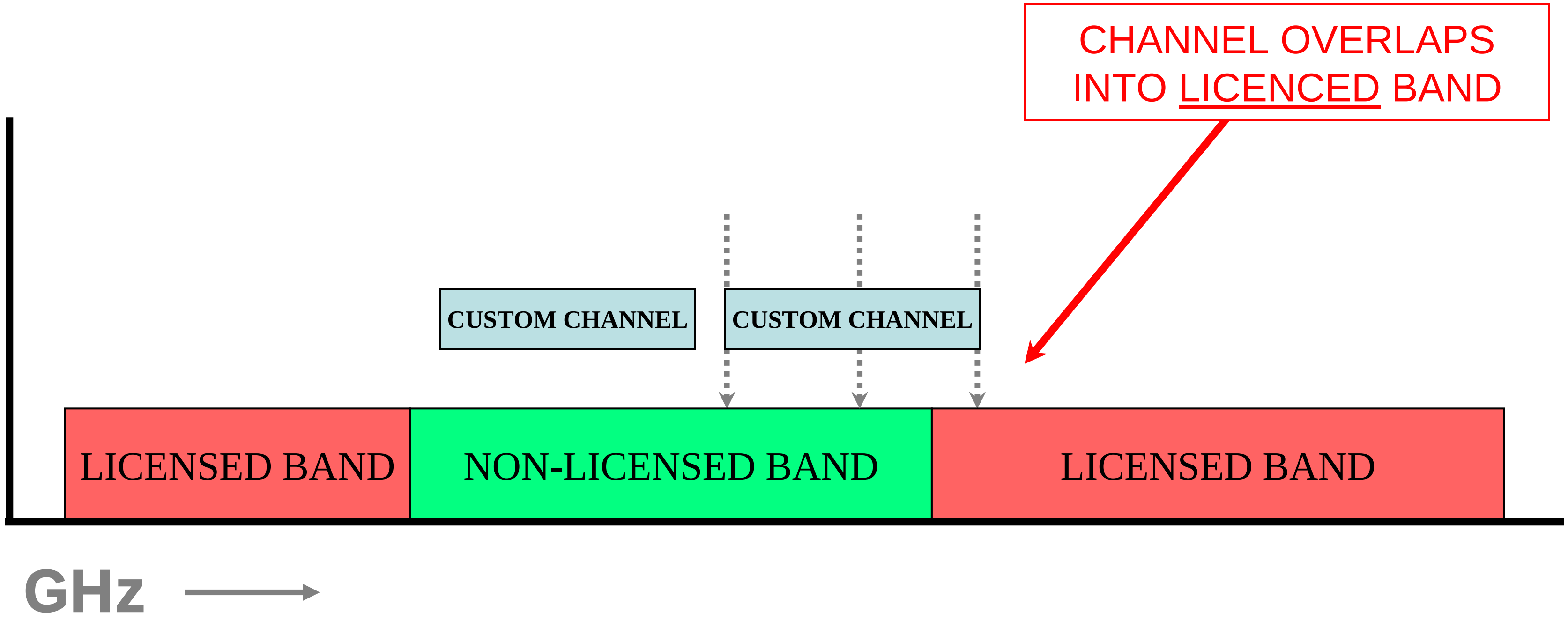
CUSTOM CHANNELS
(PROVIDING 802.11a/b/g SERVICE)

While the MD4000 can handle custom channels across the *backhaul*, wireless clients typically require normal 20MHz-wide 802.11a/b/g channels for association. This is important to keep in mind when providing wireless clients with service while using a custom-channel backhaul; there must be a dedicated radio on the node that supports a standard 20MHz-wide 802.11a/b/g channel.



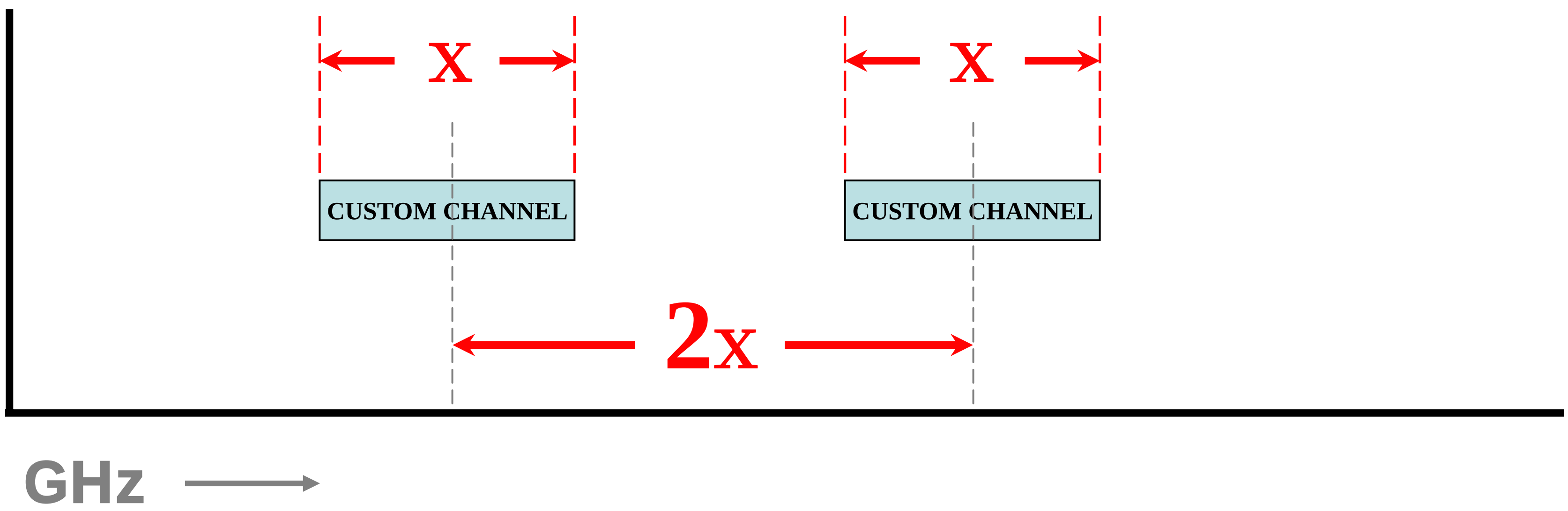
CUSTOM CHANNELS
(SRECTRUM AWARENESS)

The center frequency of a custom channel can be chosen to fall within a non-licensed band, however, it is possible for the same channel to overlap into a licensed band if the channel *width* is wide enough. This must be considered when creating custom channels. The center frequencies should be far enough from the edges of the non-licensed bands to account for the channel widths of the channels.



CUSTOM CHANNELS
(CHANNEL SEPARATION)

As with the *standard* non-overlapping 802.11a/b/g channels used by the backhaul, custom channels must also be non-overlapping. It is recommended that adjacent custom channels have center frequencies that are separated by twice the width of each channel. For example, two adjacent 10MHz-wide channels should be placed 20MHz apart. If adjacent channels are moved too close together, there may be interference between a node's uplink and downlink radios, therefore effecting throughput along the backhaul.



CUSTOM CHANNELS
(RADIO CARD LIMITATIONS)

The MD4000 uses the Wistron DCMA-82 radio card. Custom channels must be created *within* the frequency limitations of this card which are given below.

WISTRON DCMA-82
2.400-2.483GHz
4.940-4.989GHz*
5.150-5.350 & **5.470-5.850**GHz

*The 4.9GHz Public Safety band is only to be used by licensed customers.

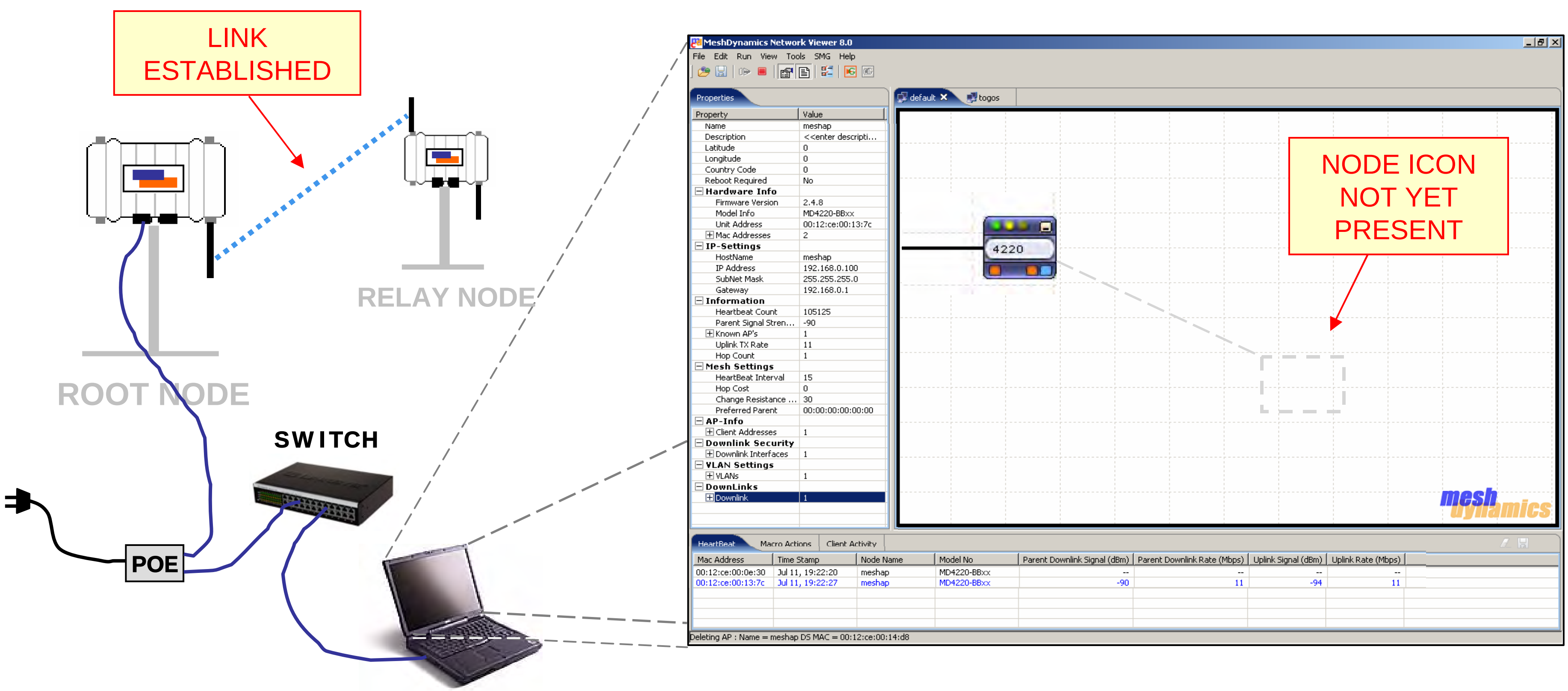
CUSTOM CHANNELS (PROPER ANTENNAS)

It is important to remember that the antennas used for transmitting and receiving the signals from custom channels be rated appropriately. If custom channels are created on a node that does not have properly-rated antennas, this can leave the node stranded and inaccessible from any potential parent nodes after the node boots up and the created channels take effect.

NETWORK VIEWER BASICS (HEARTBEATS)

The Network Viewer will not show any node icons until “heartbeats” are received. A heartbeat is a broadcast packet sent from each node every 15 seconds (by default) that contains information about itself. A node will send its first heartbeat about one to two minutes after boot up.

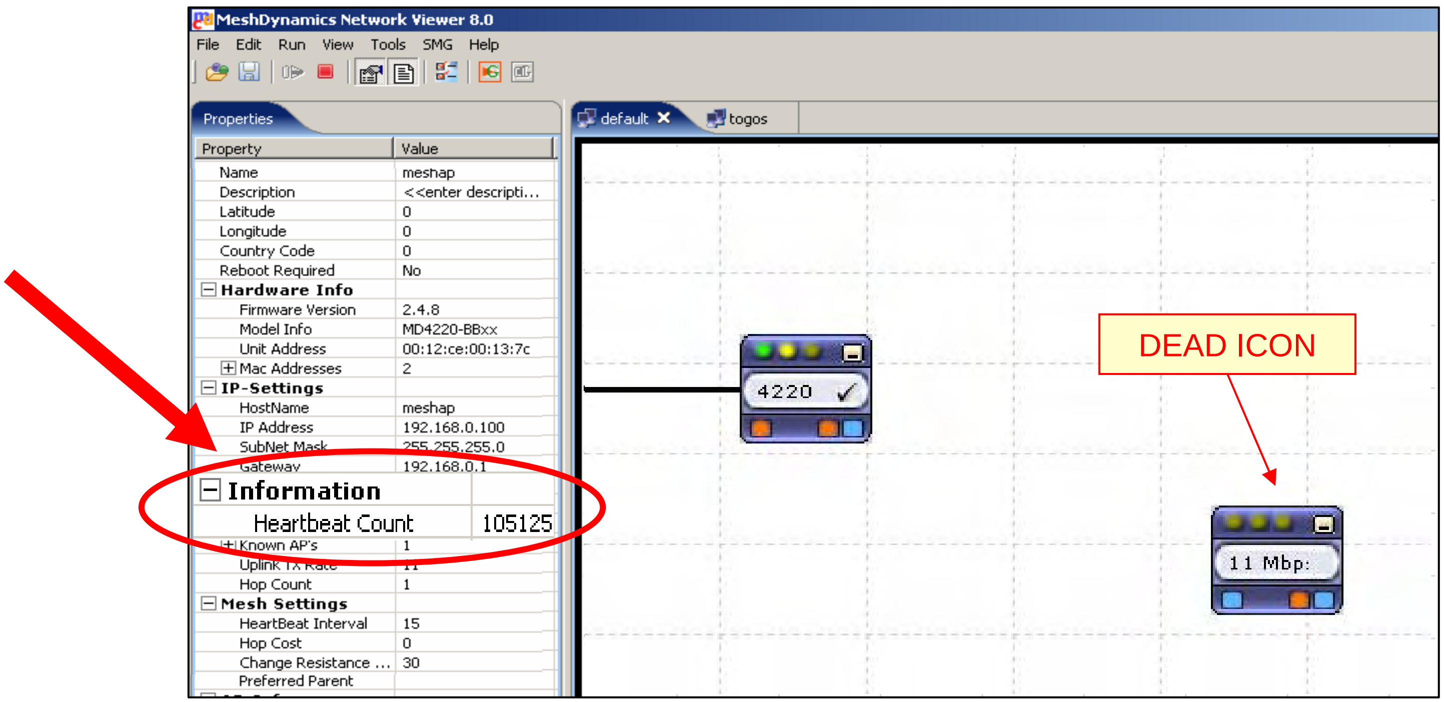
Since the heartbeats come every 15 seconds, the information displayed on the Network Viewer is not necessarily real-time. For management or troubleshooting purposes, the heartbeat rate can be set to a more frequent value so that more up-to-date information about the nodes is received.



NETWORK VIEWER BASICS (HEARTBEATS)

If the Network Viewer does not receive three consecutive heartbeats from a given node, that node will be declared dead and its icon will turn gray. All connector lines and neighbor lines will disappear from that node.

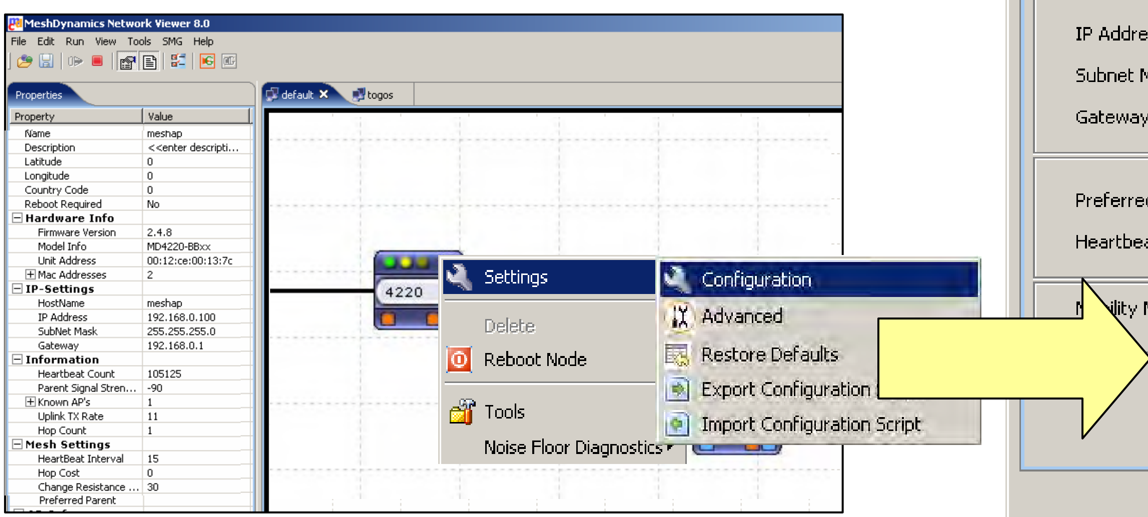
Note that just because three heartbeats were missed, the node is not necessarily dead, it just means that *three heartbeats were missed*. This could be the result of many things: RF interference, unplugged network cable, or the laptop's firewall to name a few. To see if the node actually died or rebooted, check the heartbeat count when the node's icon comes back up. If the heartbeat count is low (relative to the time the node should have been alive) then the node did in fact "die" or reboot. If the heartbeat count is high, it just means that three consecutive heartbeats were missed.

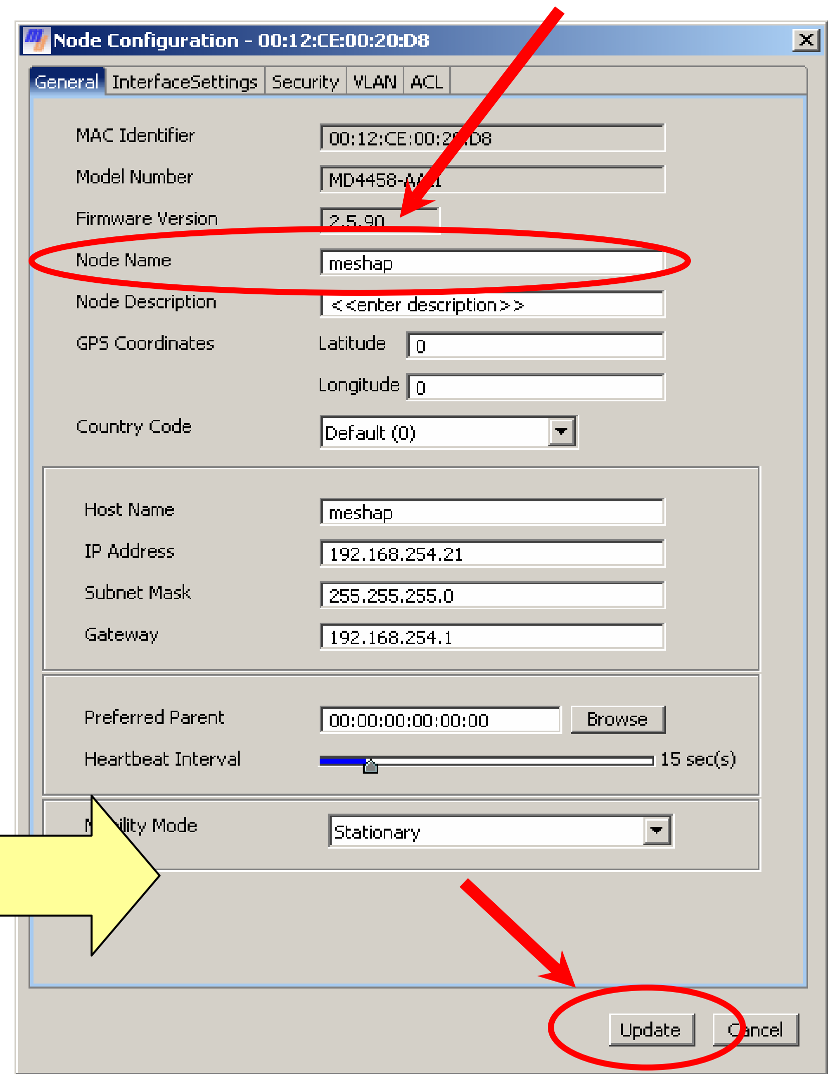


NETWORK VIEWER BASICS (NODE NAME)

Nodes can be assigned names that will appear inside their message windows as well as under the properties tab. This is helpful for identifying and configuring a particular node within a mesh. For example, a node icon could be named “Moon Tower”, or “Car 54”.

Right-click on the node icon and select “Settings”, then “Configuration”. In the resulting pop-up window, type in the desired node name in the designated space, then click “Update” at the bottom of the window.

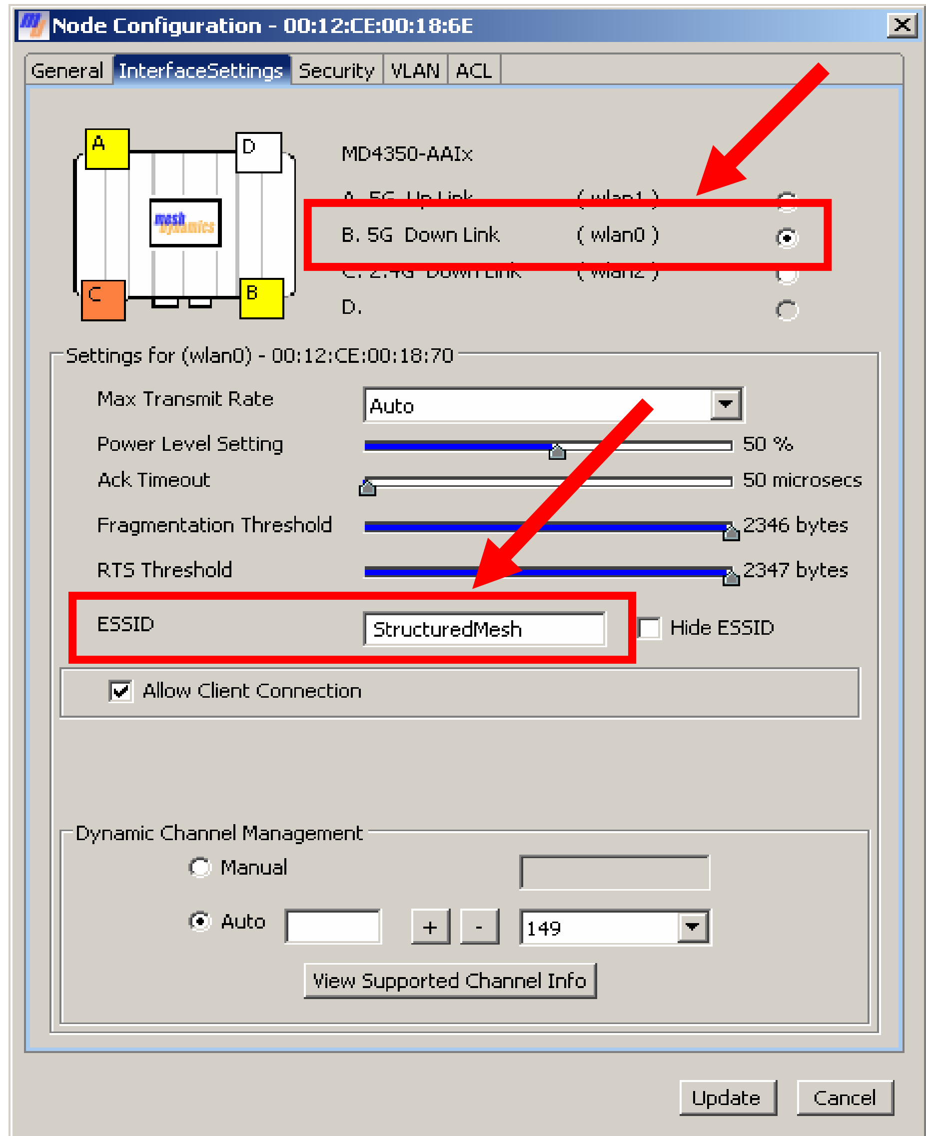




NETWORK VIEWER BASICS (ESSID)

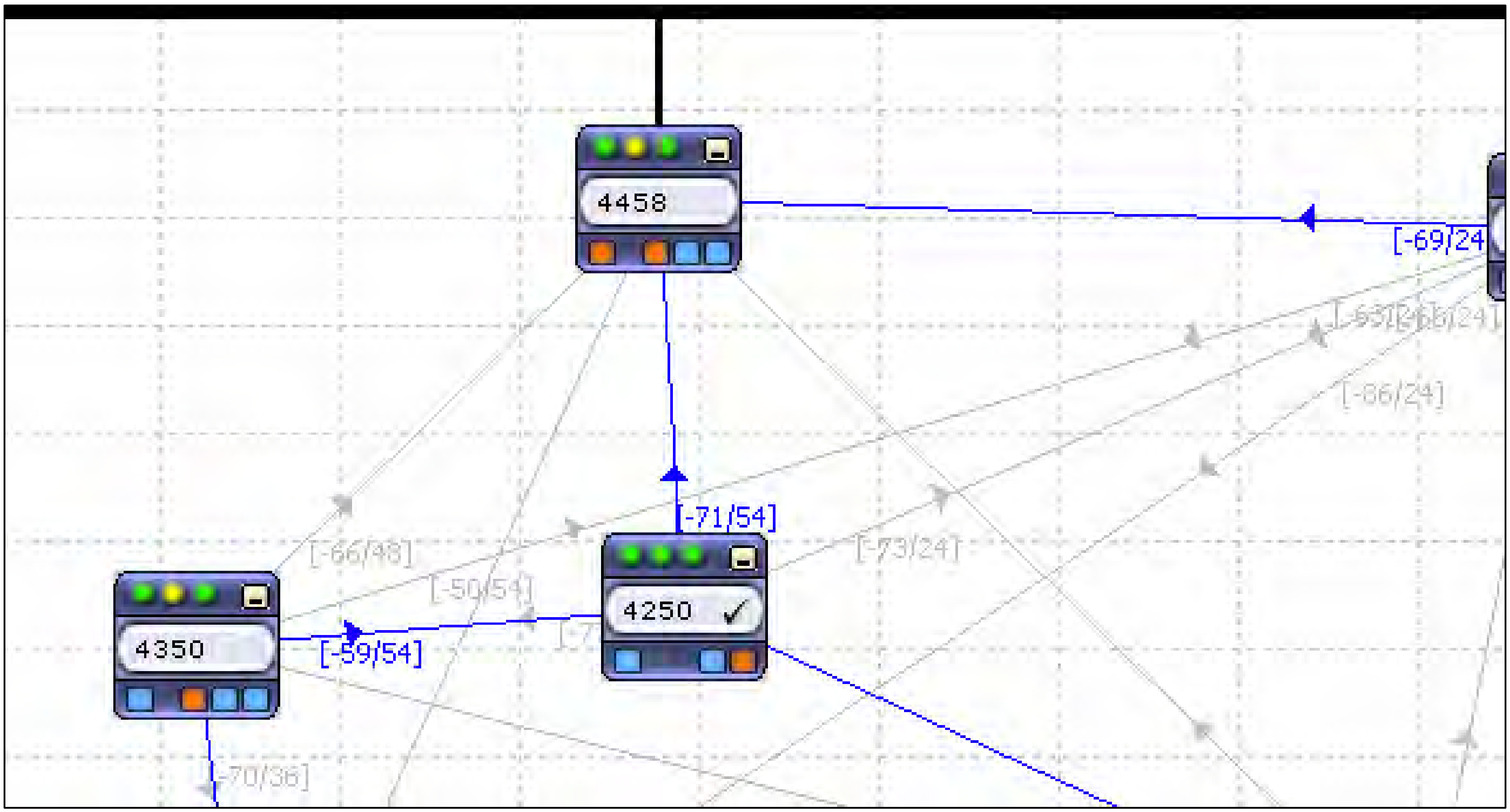
Every downlink or AP radio of a node can be assigned an ESSID. The created ESSID will take the place of the default ESSID of “StructuredMesh”.

The ESSIDs are set from the “Interface Settings” tab which is also in the node’s Configuration window.



NETWORK VIEWER BASICS
(CONNECTION LINES)

Node icons can have three types of lines coming from them: wired-network-connection lines (black) which only occur with root nodes, association lines (blue), and neighbor lines (gray). The blue association lines show the actual backhaul path of data flow. The gray lines represent the *potential* backhaul paths.

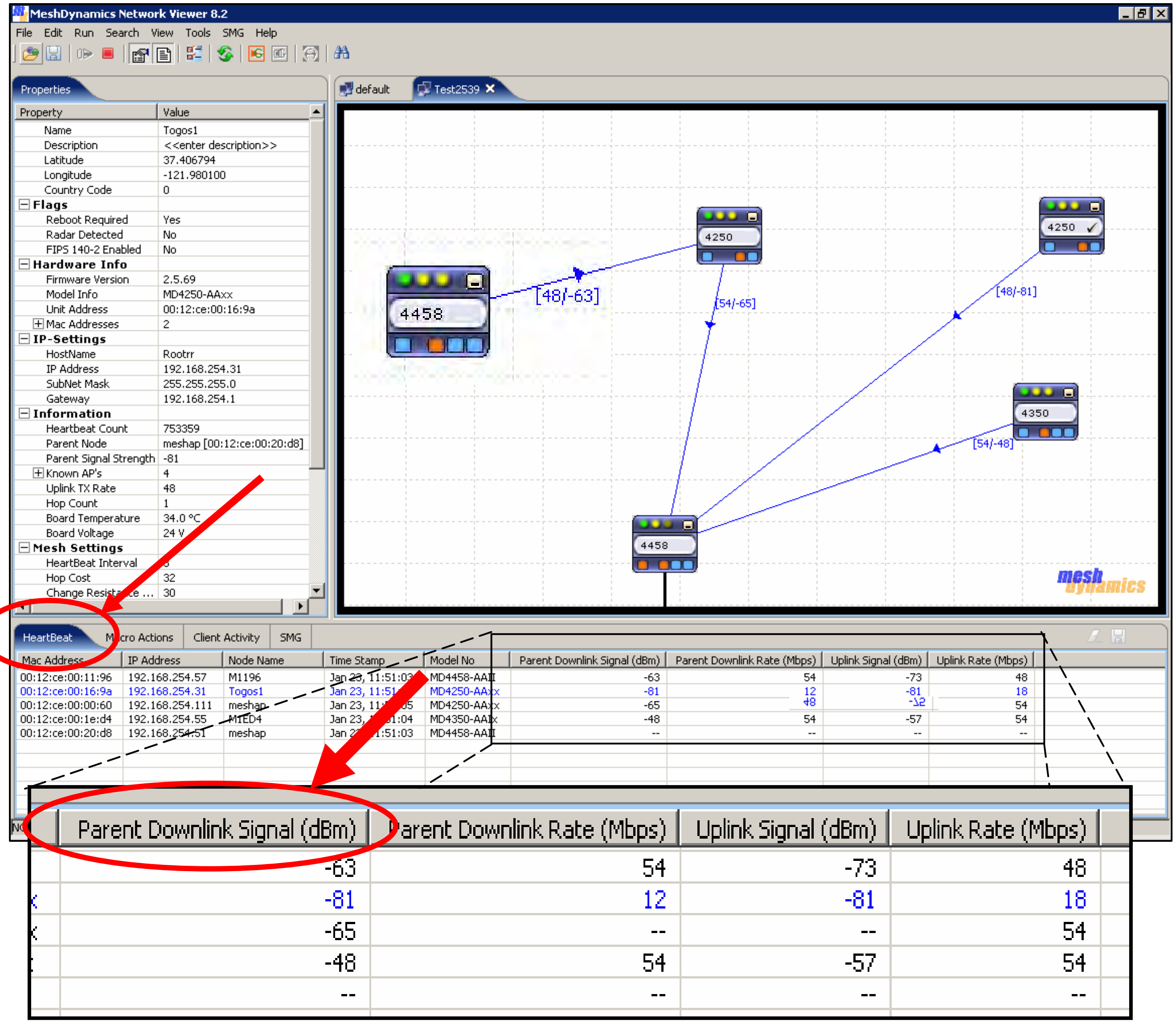


NETWORK VIEWER BASICS (CONNECTION LINES)

Each node-to-node link has four associated values which are shown under the Heartbeat tab:

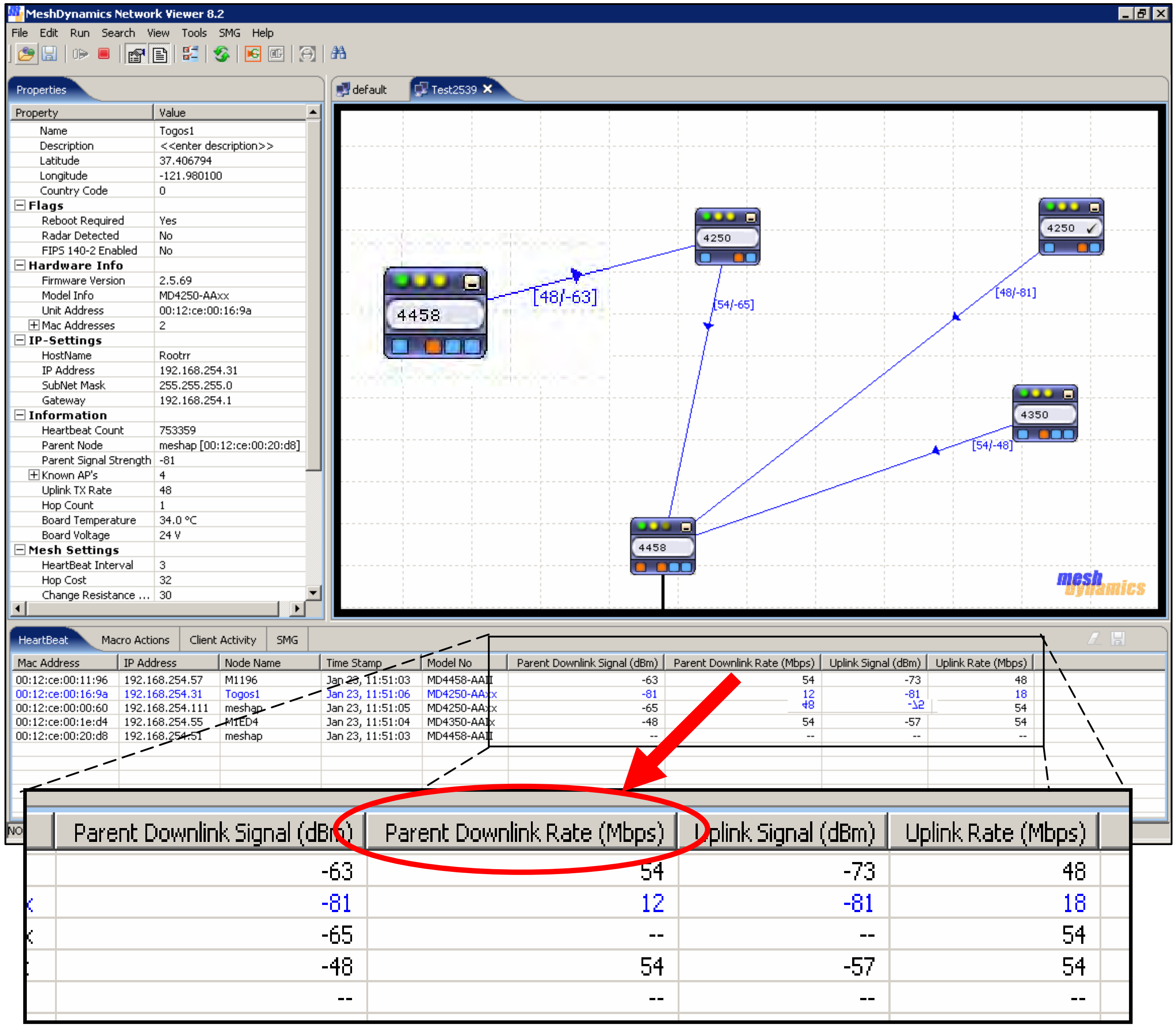
Parent Downlink Signal
Parent Downlink Rate
Uplink Signal
Uplink Rate

The parent downlink signal is the *signal strength that a particular child node sees from its parent node*. This will vary from child-to-child since 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.



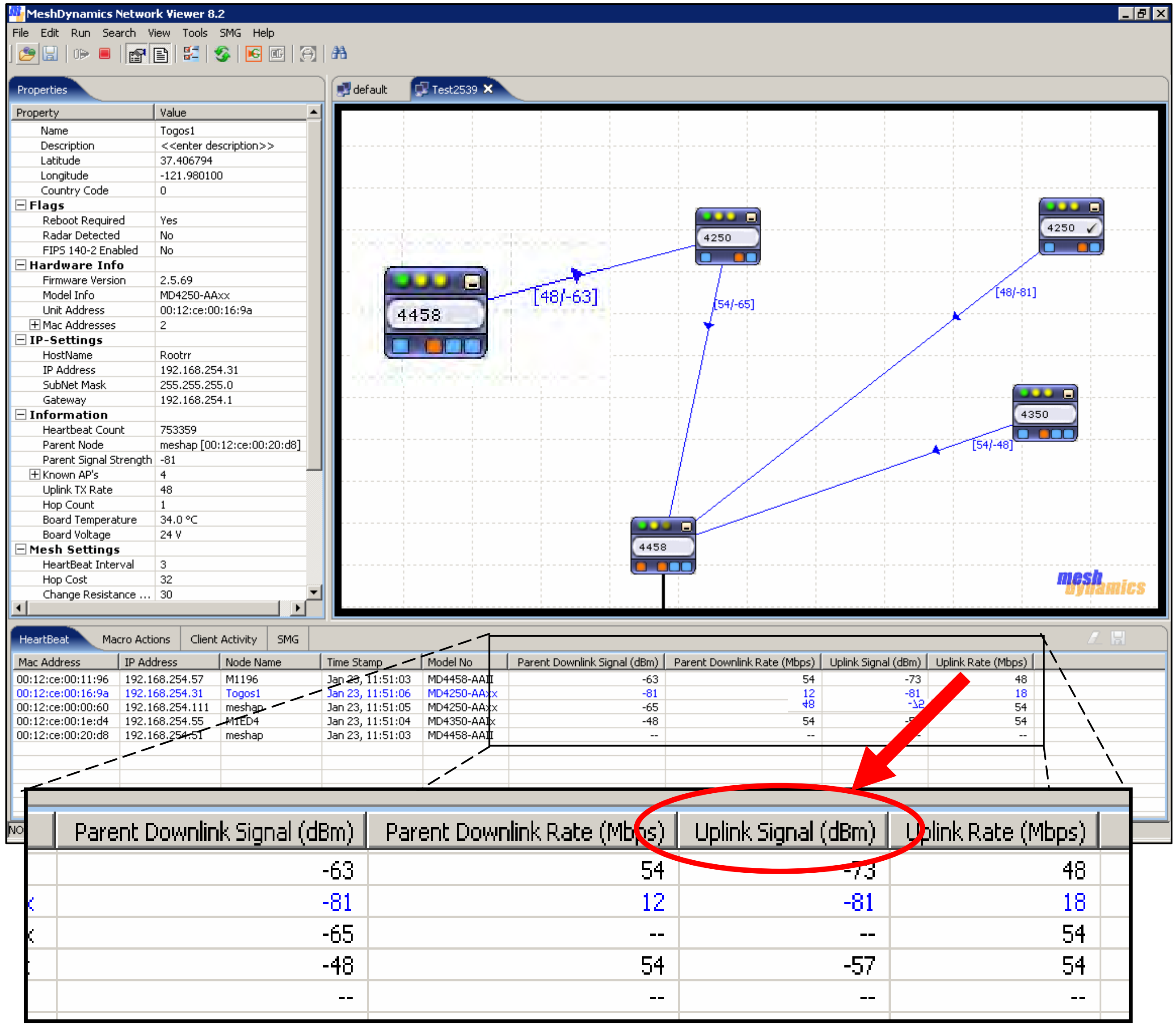
NETWORK VIEWER BASICS (CONNECTION LINES)

The parent downlink rate is the connectivity of the link in the direction from the parent node to the child node.



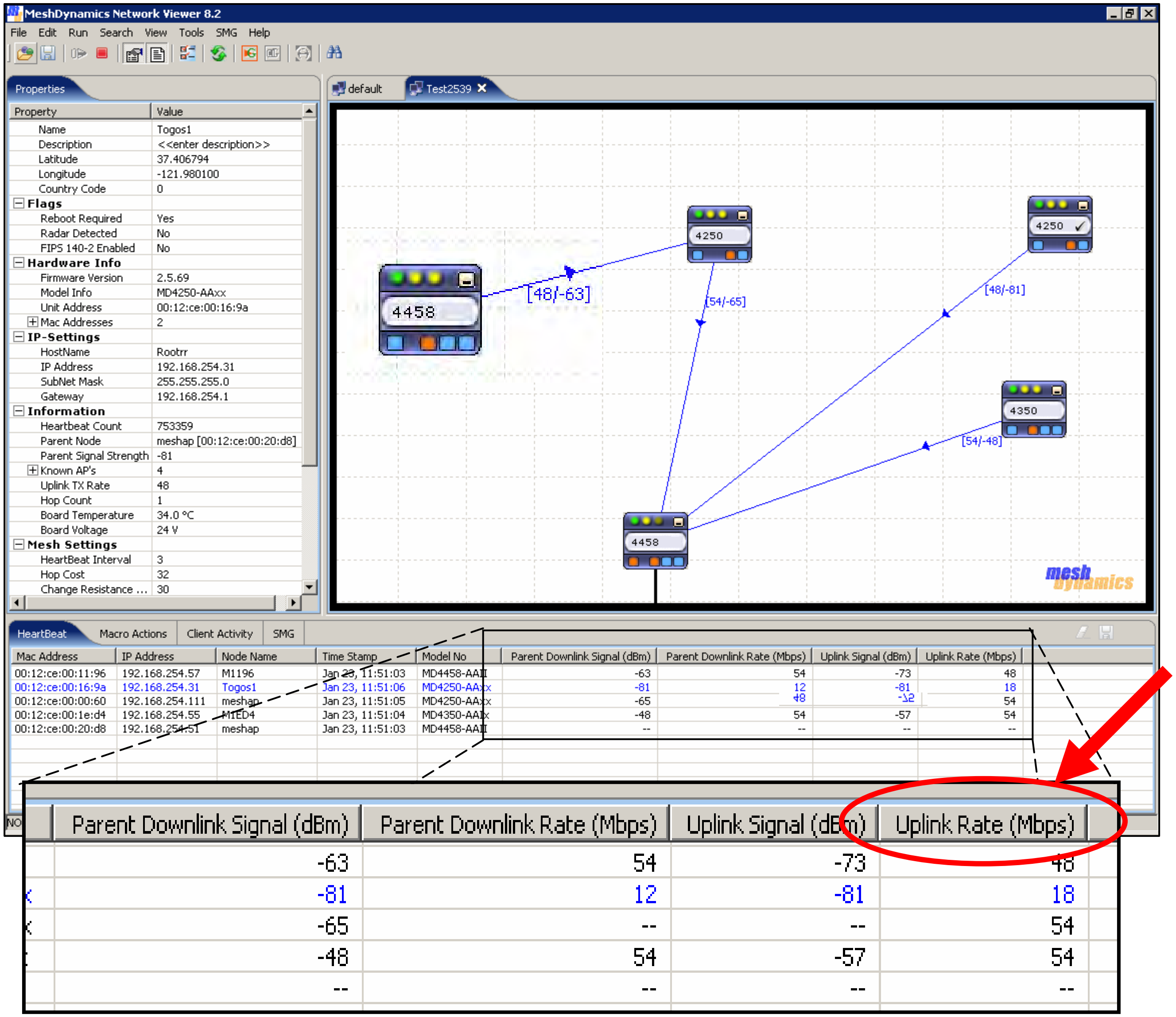
NETWORK VIEWER BASICS (CONNECTION LINES)

The uplink signal 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.



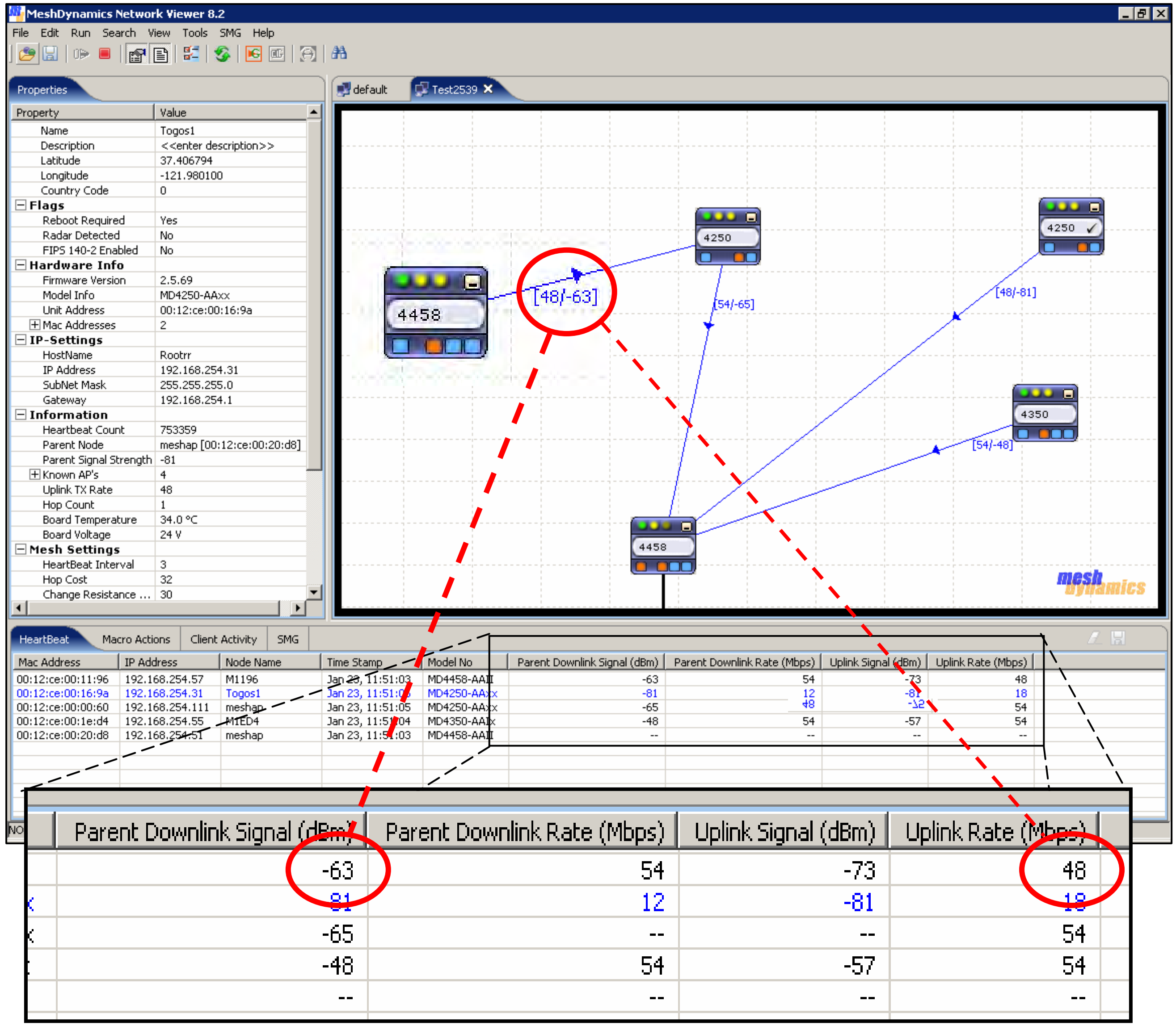
NETWORK VIEWER BASICS
(CONNECTION LINES)

The uplink rate is the connectivity of the link in the direction from the child node to the parent node.



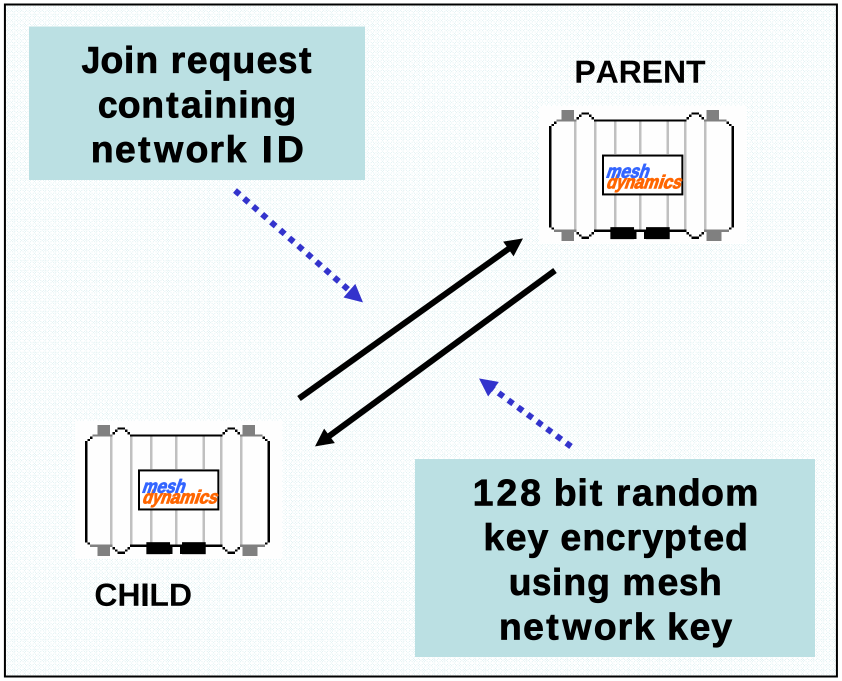
NETWORK VIEWER BASICS
(CONNECTION LINES)

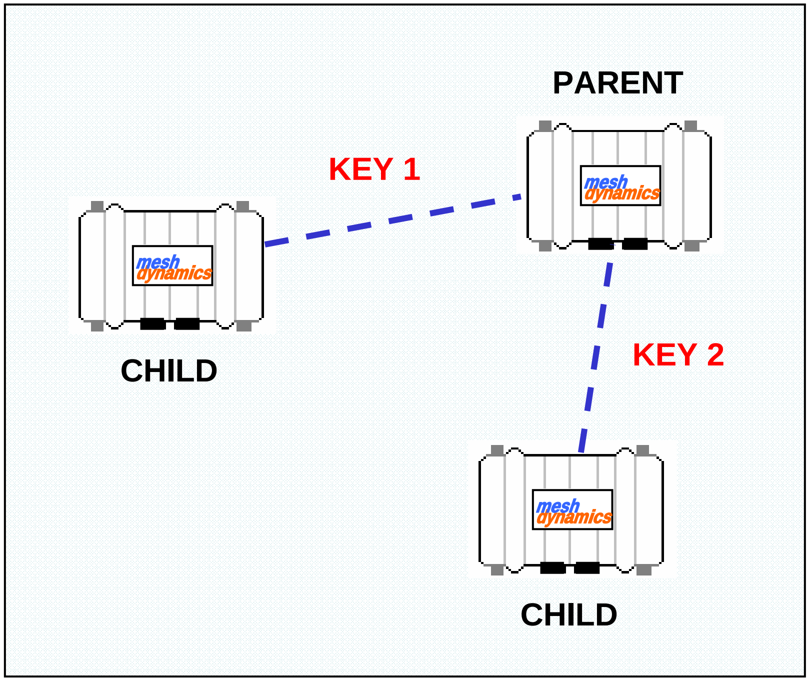
It is important to remember that only *two* of the four link values are shown on the association lines: the parent downlink signal, and the uplink rate. When troubleshooting links, it is necessary to look under the Heartbeat tab to see all four link values.



BACKHAUL SECURITY

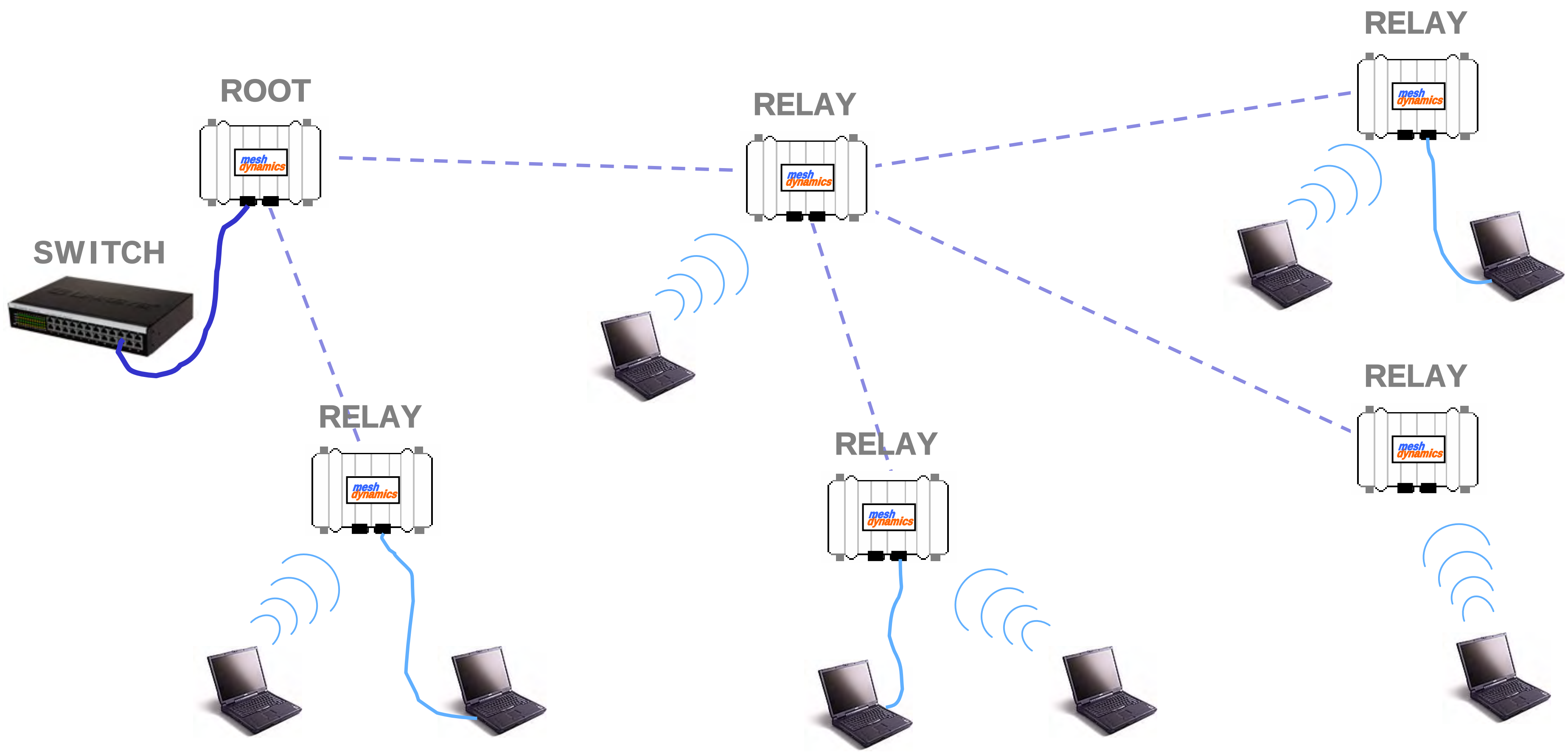
All backhaul links have hardware based AES-CCMP encryption with 128 bit temporal key which is randomly generated during link formation. Every backhaul link uses different key, and the key is distributed via a secure AES channel





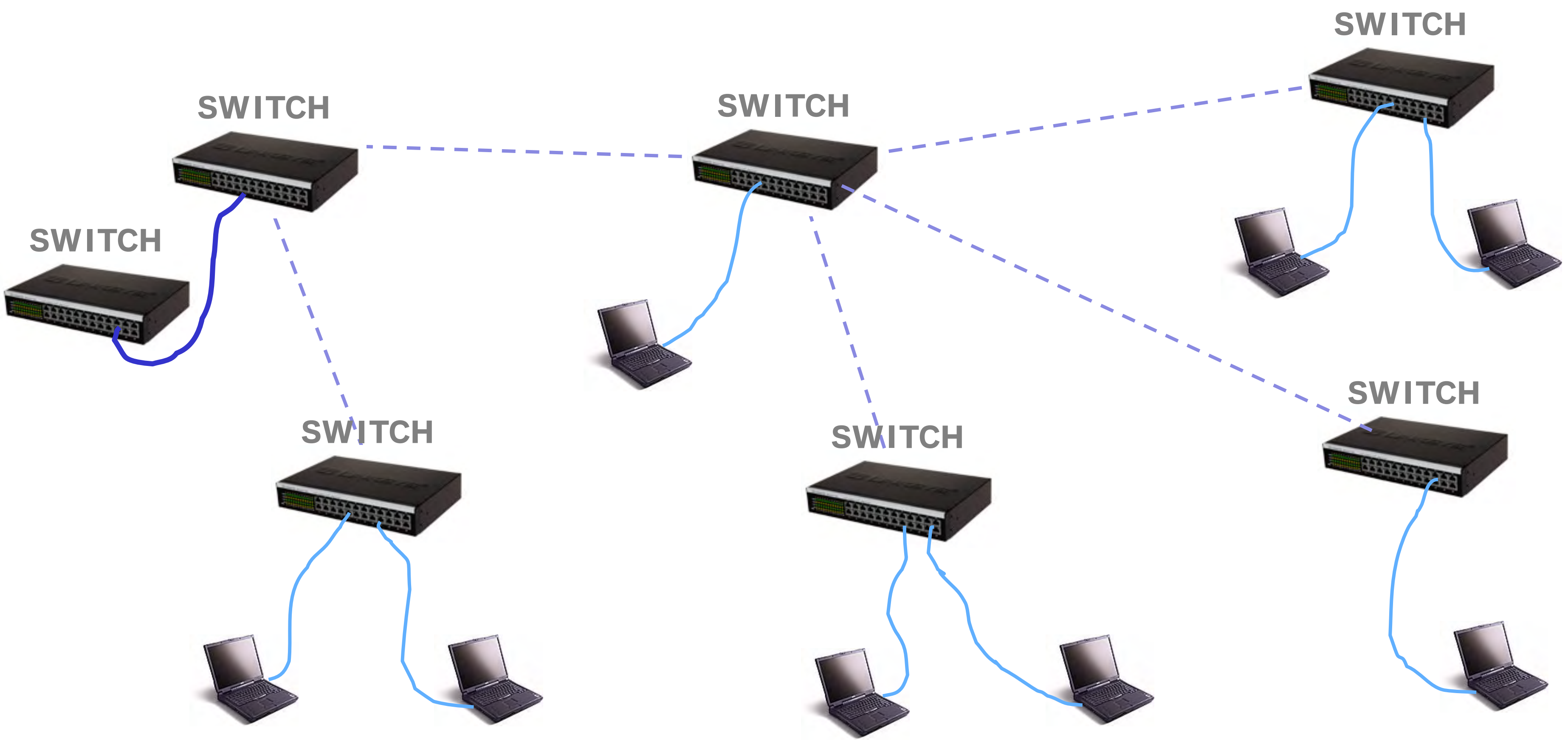
LAYER-TWO BRIDGE

The MD4000 acts as a layer two bridge that is transparent to layer three.



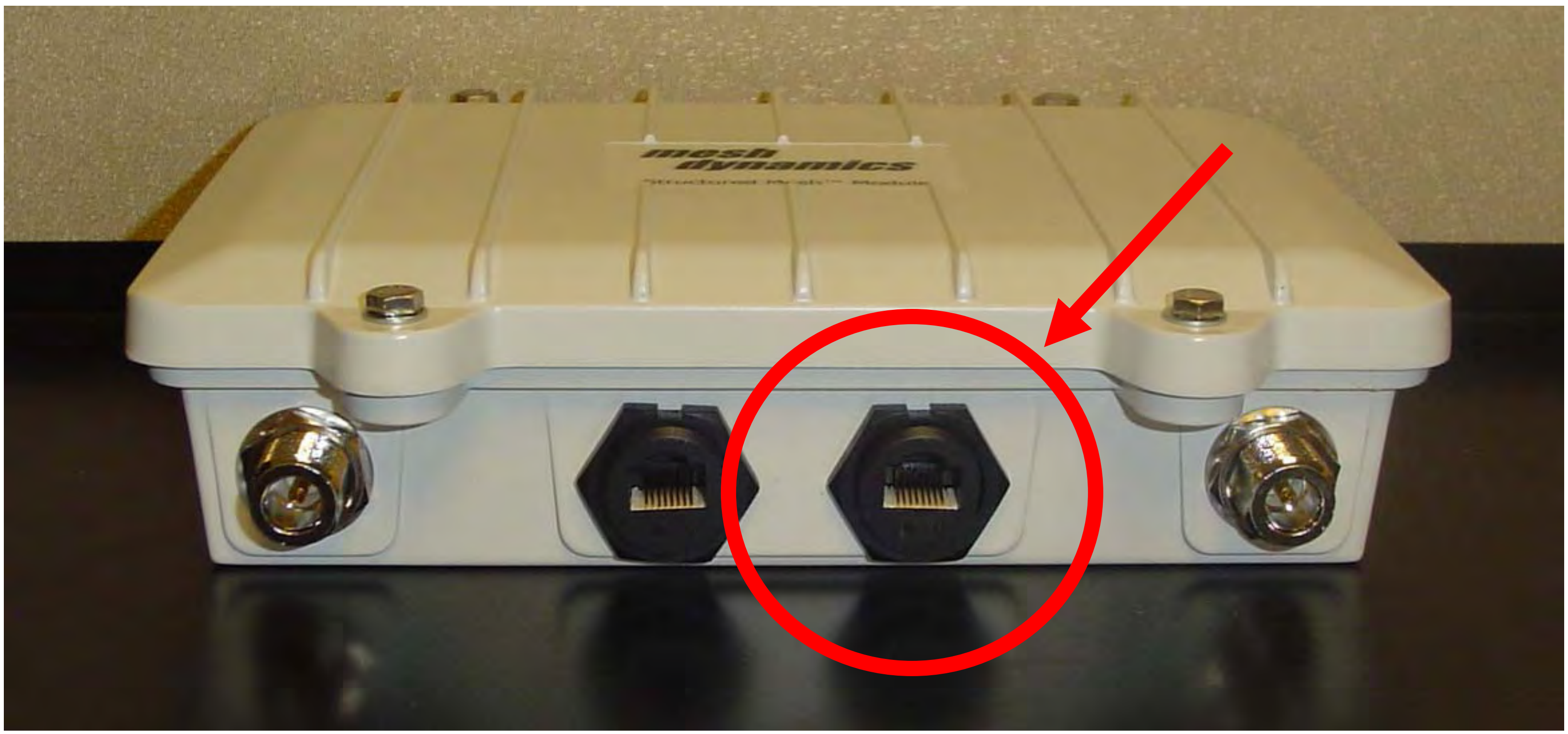
LAYER-TWO BRIDGE

The mesh can be visualized as a system of switches that connects all clients (wired, or wireless) to the wired network behind the root node, and to each other.



CLIENT ETHERNET PORT

The right-hand Ethernet port on the MD4000 bridges any Ethernet device, including switches, hubs, cameras, and sensors. Switches are used to link multiple devices to the node.



IP ADDRESSING

Although it is possible to assign an IP address to the nodes, they DO NOT require it for basic operation since they are layer two devices.

A unique IP address for each node *is* needed for firmware upgrades, running trouble shooting commands, RADIUS authentication, and the MeshDynamics Network Viewer Performance Test.

IP addresses are statically assigned using the Network Viewer.