

# Your First AREDN™ Mesh Node

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A very *basic* “Amateur Radio Emergency Data Network,” or AREDN, mesh node needs a radio, antenna, Power Over Ethernet (PoE) injector (*i.e.*, the power supply), a long STP Ethernet Cat5e (or better) cable to reach your antenna/radio, and one or two short UTP Ethernet Cat5e jumpers. All these items are available on Amazon for less than \$200 total. Use <https://smile.amazon.com/> to support the ARRL® or your favorite charity. Use the following links (but note that they may need updating or have expired) and then check for lower prices and/or Amazon Prime resellers. [eBay](#) can also be a good source. [Ubiquiti](#)® devices currently have a wide range of support. For permanent, infrastructure mesh nodes consider the more capable transceivers with at least 64MB of memory that support multiple input/multiple output (MIMO) antennas or parabolic dishes – ask for recommendations. [MikroTik](#) devices are also quite capable and very popular, and full support has now been added for some [GL.iNet](#) and [TP-Link](#) devices.

## Hardware

1. Ubiquiti® Bullet M2 transceiver, <https://smile.amazon.com/gp/product/B002SYS22E>, \$72. You don’t want the “Titanium” version; while weatherproof, it’s more expensive and has no indicator lights. The lights are very helpful diagnostic tools. The older XM chipset ships in a dark gray OEM box and the newer XW chipset ships in a white OEM box; use Ubiquiti’s AirOS® Web Interface to confirm. See <https://www.arednmesh.org/content/supported-platform-matrix> for supported devices and chipsets. These transceivers attach *directly* to the antenna and produce up to 28dBm of gain. Note that some XW chipsets only produce 25dBm of gain. These older 32MB devices only support single input/single output (SISO) antennas and have limited memory for additional package installation.
2. A 2.4 GHz omnidirectional vertical antenna with 12dBi gain (\$37) or 15dBi gain (\$57), <https://smile.amazon.com/TP-Link-Outdoor-Omni-directional-Antenna-TL-ANT2412D/dp/B004I5J2XY/>. The 12dBi antenna will give you up to 40dBm total gain, or 10W EIRP, and the 15dBi antenna is good for almost 20W EIRP. A Ubiquiti® PowerBeam PBE-M2-400, a 16” dish used for directional links, can provide up to 28dBm + 18dBi = 40W EIRP across a 45 to 50-degree sector. An omnidirectional vertical antenna is probably best for tactical or ad hoc environments, *e.g.*, aid stations at the Marine Corps Marathon, so other nodes can route through your node automatically without you knowing where they’re located *and* vice versa. But if you know where other nodes are located then directional antennas can be an asset, and make the difference between having a path or not having a path.
3. For a transceiver with an integrated *directional* antenna across a 60-degree sector, consider the Ubiquiti® NanoStation M2 (only about 8W EIRP but the small size makes it a great test node) or a PowerBeam (40W EIRP). If you’re buying a NanoStation M2 get the XW chipset that has 64MB memory. For *omnidirectional* 2x2 MIMO nodes, the Ubiquiti® Rocket M2 (up to 28dBm of gain) with their AMO-2G13 13dBi antenna or a [MikroTik](#) BaseBox2 with an [Altelix](#)™ AU2G15M2-PRO 15dBi antenna are good choices. The latter combination provides up to 32W EIRP and includes a PoE injector. For MIMO antennas, transceiver “chain 0” is horizontally polarized and “chain 1” is vertically polarized in the Northern Virginia area; this might be a standard.

4. The [MikroTik](#) “hAP ac lite” RouterBOARD (RB952Ui-5ac2nD) is a low-power but amazingly capable dual-concurrent access point and router with 0.5 Amp passive PoE on Eth5 for another device like a NanoStation. This 64MB device does VLANs and tunneling, and comes with a 24VDC 1.2A power supply. It provides a 2.4 GHz link to Part 97 AREDN™ nodes and a 5.8 GHz access point (AP) for Part 15 devices. The AP can be configured to allow devices to connect to the AREDN side or to connect the AREDN side to a router where internet is available – this makes ntp available to your AREDN nodes. The international version (\$49) from the Ebay resellers or the slightly cheaper U.S. version from Amazon are *equivalent* when flashed with the AREDN™ firmware; the frequency differences are based on a MikroTik firmware lock and not a hardware lock. This is also true of the MikroTik BaseBox devices.
5. Ubiquiti® 24VDC, 24W PoE injector, <https://smile.amazon.com/gp/product/B004EFHN66> (\$14), model **POE-24-24W**. The model POE-24-24W-G injector has a gigabit LAN connection but we’re not there yet, so don’t spend the extra money unless you want to. Yes, you want the 24VDC injector that can produce up to 1.0 Amp output for a Bullet M2 or a Rocket M2. The higher voltage compensates for the drop over very long Ethernet cable runs. The NanoStation M2 *includes* a 0.5 Amp PoE, however an attached IP camera might need a 1.0 Amp PoE to power both devices. The BaseBox2 also comes with a PoE. These PoE injectors require 120VAC (or 240VAC) input so you’ll need an inverter or generator in the field. There are multi-port switches that have built-in PoE ports which could be handy for connecting multiple devices but this will get you going at minimum cost. An alternative for a field environment is a 12VDC to 24VDC boost converter that puts out at least 24W like <https://smile.amazon.com/dp/product/B00PZ022XS/> (\$58); just add battery, charge controller, and solar panel! Note that some AREDN™ devices *will* operate down to 11VDC or so over a *short* Cat5e cable. You can add PowerPole connectors to a MikroTik hAP and run it off 12VDC with no problems.
6. Your “feedline” (there’s no coaxial cable!) is *shielded* twisted pair (STP) Cat5e straight cable like <https://smile.amazon.com/gp/product/B00A6ULZG2>. Fifty feet is around \$30 (other lengths are available). Also see <https://smile.amazon.com/Outdoor-Ethernet-SNANSHI-1000Mbit-Waterproof/dp/B06ZZ1SKD6/> for lengths of STP Cat7 cable up to 200 feet (50 feet is \$26). RF at 2.4 GHz is downconverted to a digital signal in the transceiver to minimize loss. You might be able to get away with unshielded (UTP) cable, but for long runs in any kind of RF environment or permanent installations STP (and direct bury STP) is good insurance. This cable will go from the PoE injector’s “POE” port to the transceiver to transfer data to/from your laptop and to supply 24VDC power. A \$20 network cable tester like <https://smile.amazon.com/NETWORK-CABLE-TESTER-RJ45-RJ11/dp/B00CJIBLSQ> is useful for confirming pair and ground continuity. Also handy is a \$17 PoE voltage test device like <https://smile.amazon.com/gp/product/B013P3DBQS/>. An ethernet surge protector like a Ubiquiti® ETH-SP-G2 is also good insurance for permanent installations. The G2 model has twice the discharge current rating of the older ETH-SP device for the same price, around \$13 on Amazon.

7. A short, straight (not the “crossover” type) UTP Cat5e jumper to get from the PoE injector’s “LAN” port to your laptop. Do you *really* need to order one of these? Surely you have about ten of these stashed away somewhere; they came with every DSL modem or WiFi router you ever bought! A second short jumper is handy for flashing your node through the “POE” port but, at some point, you do need to test the long STP cable.
8. Note that once your mesh node is operational, you might not need a laptop (or a smartphone) connected to the “LAN” port on the PoE; your node could simply be a relay somewhere to provide connectivity for other AREDN™ mesh nodes. If you have two directional/sector nodes like NanoStations on a mast to act as relays, or perhaps to create a bridge from 5.9 GHz to 2.4 GHz, simply jump the two LAN ports on the PoE injectors with a short length of Cat5e cable. The AREDN™ firmware will *automatically* create the bridge via DtD! USB to gigabit Ethernet adapters are available on Amazon for connecting a smartphone to your node. The Firefox browser app (*not* Chrome) on my Samsung Galaxy phone works great for this.
9. You’ll also need appropriate PVC pieces (and PVC cement) to fashion a mounting bracket for the antenna. Find what you need at Home Depot or Lowe’s. A short piece of 1.5” i.d. Schedule 40 PVC pipe fits nicely on a 4’ aluminum military mast section. If necessary, use reducers and sufficient 1.0” i.d. PVC pipe to mount your antenna. A weatherproof SockitboX, like <https://smile.amazon.com/gp/product/B006EUHS96> for \$20, might be handy for keeping the PoE dry.

## Software

First of all, use Firefox and *not* Chrome or some other browser. Chrome, in particular, tries to negotiate an https connection and this can cause issues with the URL <http://localnode.local.mesh:8080> that you’ll use later. Next, be sure that any device which uses an external antenna is attached to either an antenna or a good dummy load, *e.g.*, MFJ-262BN (good to 3.0 GHz). Note that a dummy load makes a nice *antenna* at 2.4 GHz and your device will definitely connect to nearby nodes! AREDN™ firmware is at the “Software-Download” drop-down at <https://www.arednmesh.org>. If you have a new device with OEM firmware, the AREDN™ firmware available at <http://downloads.arednmesh.org/firmware/ubnt/html/stable.html> can be uploaded with TFTP. The *initial* AREDN™ firmware load will be the device-specific “factory” binary. The instructions at <https://help.ubnt.com/hc/en-us/articles/204911324-airMAX-How-to-reset-your-device-with-TFTP-firmware-recovery> describe how to first put your device in “recovery mode” and then use TFTP with various operating systems. Also see <https://www.arednmesh.org/content/tftp-firmware-installation>. Just substitute the appropriate AREDN™ binary instead of the Ubiquiti® AirOS® binary. Subsequent updates will be the “sysupgrade” binary and uploaded *directly* via the already installed AREDN™ firmware’s UI; all your current settings *should* be preserved. Know whether your Ubiquiti® device uses the XM or XW chipset and do *not* install the wrong binary! Also, be *sure* to mark your device as “XM” or “XW”, if applicable, for future firmware upgrades so you won’t forget! MikroTik devices use a *very* different flashing procedure so look at <https://www.arednmesh.org/content/installation-instructions-mikrotik-devices> before attempting to flash these devices. Your AREDN™ username and initial password is “root” and “hsmm”. You’ll need to change your password on the *initial* reboot but do *not* change the username; you need to be “root” to make updates.

A naming convention for mesh nodes is “callsign-device-antenna type-serial number or tactical location” so my Bullet M2 is named “N8IK-BM2-OMNI-100”. My NanoStation M2 could be “N8IK-AID8-NSM2” and a PowerBeam dish could be “N8IK-PBEM2-DISH-200”. Other nodes then get an idea of what capability or location they can anticipate when routing through me. Your callsign is the only *required* item in the node name per the FCC regulations at 47 CFR §97.119. It’s *critical* that you move your channel to **-2** (2.397 GHz) and set the channel width to **10 MHz** so that you’re not overlapping WiFi channel +1 *and* still staying in the Part 97 area of the 2.4 GHz band which starts at 2.390 GHz. All the other reachable 2.4 GHz mesh nodes will also be on WiFi channel **-2** using 10 MHz bandwidth; *i.e.*, your SSID *must* be “AREDN-10-v3”. If your device runs at 5.9 GHz, note that most 5cm AREDN™ mesh nodes seem to be at WiFi channel 180 (at 5.900 GHz) with a 20 MHz bandwidth. In this case your SSID *must* be “AREDN-20-v3”. Also, use the slider on the lower left of the Setup page to set the “Distance to FARTHEST Neighbor” to at least 5 miles (or leave at 0 for “automatic”). Next, click on “Save Changes” and then “Reboot” the node. The “highest signal strength” LED 4 will initially blink and then go steady green when a Ubiquiti® device successfully boots. When you’re connected to a mesh, a Ubiquiti® device will also display steady *red* on the “lowest signal strength” LED 1. On most devices the “activity” LED may blink green, and the “power” LED will be steady green. Note that some devices require rebooting several times when loading new firmware (or with each service package like iperfspeed).

Using Firefox, create a browser bookmark called <http://localnode.local.mesh:8080> (not https) to get to your node (or to any other node) easily. Also, upload the MeshChat package available at [https://github.com/kn6plv/meshchat/raw/master/meshchat\\_2.0\\_all.ipk](https://github.com/kn6plv/meshchat/raw/master/meshchat_2.0_all.ipk). Then enable it as an http, and not https, “Advertised Service” with a Zone Name of “MeshChat” (no quotes and be sure to *delete* the default “dash plus four random digits”) on TCP port 8080 as shown below. You can only chat with other devices in the *same* Zone, *i.e.*, “MeshChat”.



Also useful for testing transfer speed is “iperfspeed”. Install the package [https://github.com/kn6plv/iperfspeed/raw/master/iperfspeed\\_0.6-lua\\_all.ipk](https://github.com/kn6plv/iperfspeed/raw/master/iperfspeed_0.6-lua_all.ipk), wait for the response requesting a reboot, and then reboot the node. Simply click on the service to test the transfer speed between nodes. Designate one node as the server and another as the client; speeds should be symmetric. You can also run iperfspeed with one node as both client and server to see if it’s installed correctly.

A firmware upgrade requires reinstallation of MeshChat and iperfspeed since there may be firmware version dependencies. The advertised services should automatically be available. However, you will have to recreate any advertised services if you change your node’s name.

Finally, take some time to read the current AREDN™ documentation on the screen [here](#) or the PDF [here](#). It's detailed and very good.

73, Ian N8IK

Latest version of this doc with clickable links is available at <http://n8ik.net/mesh.php>.