Site Survey Guide

This Guide is intended to assist a customer or installer in determining the quantity of Checkbox Hotspot units required for proper 802.11b/g wireless coverage of a site. A Checkbox site installation will consist of one "Master" unit and additional Mesh Node units to extend the wireless coverage area to include as much of a site as required. Additional wiring is not required when adding Mesh nodes, each Mesh node will automatically find a wireless path back to the Master unit (and on out to the Internet) through intervening Mesh nodes. Each Mesh node will supply wireless coverage to clients while simultaneously extending the range for additional Mesh nodes to connect through.

Determining the quantity of Checkbox Hotspot units required to obtain proper wireless coverage of a specific site is dependent on a variety of factors:

- Coverage area of the site
- Building construction materials
- Radio interference within the site

The first two bits of information are reasonably easy to obtain. A site map with a scale or information describing the size, floor count, and a description of the construction materials used in the walls, floors, and ceiling. Locations of other obstructoins like elevator shafts, machine rooms, and firewalls are also useful. With this information, a reasonable estimate of the quantity of units required for good 802.11b/g wireless coverage of the site can be made. Radio interference is very difficult to ascertain, but outside of extreme cases, if you plan for a proper coverage of the site this factor can usually be discounted. In any case, it is rare that you can control the ambient level of "radio noise", so the only viable option you have is to increase the 802.11b/g signal levels by adding more units.

Some general understanding of 802.11b/g wireless principles is required to conduct a site survey and predict what results you can expect from an installation based on your site survey.

The 802.11b/g 2.4 Ghz frequency range is close to the same frequency band as microwaves, although much lower in power than microwave towers and ovens. It is an unlicensed frequency range (you don't need a radio license to operate your laptop or access point), used for cordless phones, cordless stereo headsets, and wireless computer communications.

This band is regulated for "maximum transmission power" by various government agencies around the world. You may hear the terms "wattage" bandied about by many, but that is not 100% relevant to the regulations. The regulations measure something called "equivalent isotropically radiated power", or EIRP for short. Although wattage is related to this measurement, it is EIRP that is measured, usually in "decibels per meter" (dbm). Consider the differences when using a 10 amp stereo amplifier driving low efficiency speakers vs driving high efficiency speakers. The same "power" is used to drive the speakers, but the amount of "sound" (in dbm) you get out of it is quite different. This band is regulated for a maximum "dbm" output at the antenna, not the "wattage" going into the antenna.

Finally, wireless transmissions over this band are a two way communication, not a one way affair. When considering factors involved in a good “connection”, you must remember that the radio and antenna on the user's laptop or computer are the primary factor in determining that you have good coverage. These radios are typically much lower in power and range than any wireless access point.

You will need one Checkbox Master unit for each site installation. This Master unit connects to an existing high speed Internet connection. For additional area coverage, you will add one or more Mesh Nodes to extend the wireless coverage. These Mesh Nodes do not require anything more than power. They will wirelessly interconnect and automatically find a connection path back to the Master unit, and on out to the Internet. Each Mesh node also supports client laptops in their “area” of coverage.

Because of the radio and antenna characteristics of the Checkbox Master and Mesh Nodes, any good wireless connection between them will mean that a laptop (with a lower powered radio) at any point between or “in the bubble” around these nodes will usually have a good connection back out to the Master and the Internet (baring other obstructions). A site survey will approximate the placement of each of the mesh nodes so each unit has a good wireless connection path to the “upstream” Master and also give the wireless coverage your site would like to have. Usually this is full site coverage, but can be more limited, perhaps to the lobby or restaurant area or poolside or conference area.

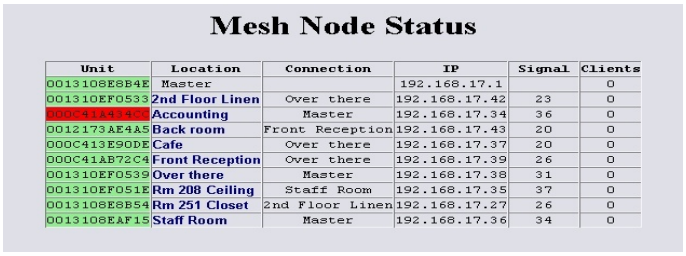
So how far apart should you place each unit?

That is the tricky question, and frequently the hardest part of a site survey. Construction type and intervening walls is of paramount importance to answer this question. Open spaces like campgrounds, golf courses, and marinas (or large conference halls) are fairly easy to estimate, just draw touching 300 foot (100 meter) circles over a property map and you will have located the approximate optimum positioning of the Mesh Nodes. Inside a structure like a hotel or motel, you will have to consider the construction type. Walls of any sort will attenuate the signal and decrease the range of both the Mesh Node interconnections and the range of client laptops. If the walls (or floors) are constructed of concrete (perhaps with reinforcing iron rebar), the range is again reduced. Throw in a stucco wall with a wire mesh backing (used to hold the stucco to the walls) and you might have a nasty little wireless radio cage that will attenuate the signal by 75% or more. Even the angle the signals traverse through a wall can affect signal strength; consider that a signal passing straight through a 4” wall has only 4” of material to traverse, while a signal passing at a 45% angle through that same wall has to traverse 8” of wall material. Not only does your access point have to punch a signal through these walls, but the client's lower powered laptop also has to transmit a return signal through those same walls.

So, the definitive answer to how many units for proper coverage of a site? With the preceding in mind, the right answer is nearly always; “**it depends**”.

A working answer.

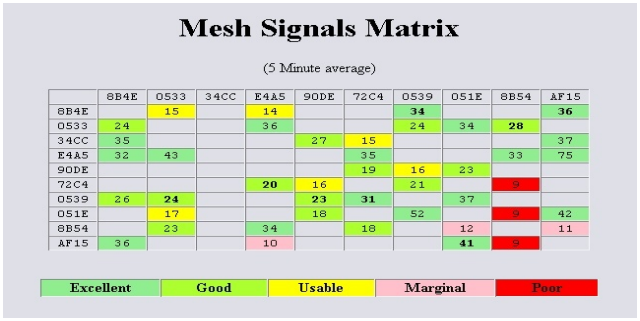
The best way to answer the question is to use the units themselves to determine placement. There are status displays in the administration panels that monitor the health of your Mesh. It shows the automatically adjusted “best path” for each unit, signal strength between units, if any units are unavailable, and how the Mesh has automatically routed around unavailable units. Checkbox Mesh Management automates nearly everything, except physically placing the units for you.



Mesh Node Status

Unit	Location	Connection	IP	Signal	Clients
0013108E8B4E	Master		192.168.17.1		0
001310EF0533	2nd Floor Linen	Over there	192.168.17.42	23	0
000C41A434C0	Accounting	Master	192.168.17.34	36	0
0012173AE4A5	Back room	Front Reception	192.168.17.43	20	0
000C413E90DE	Cafe	Over there	192.168.17.37	20	0
000C41AB72C4	Front Reception	Over there	192.168.17.39	26	0
001310EF0539	Over there	Master	192.168.17.38	31	0
001310EF051E	Rm 208 Ceiling	Staff Room	192.168.17.35	37	0
0013108E8B54	Rm 251 Closet	2nd Floor Linen	192.168.17.27	26	0
0013108EAF15	Staff Room	Master	192.168.17.36	34	0

The Mesh status display shows the general health of units, the current “upstream” connection and the instant receive signal strength from that connection. (In the above example, the accounting department seems to have unplugged that unit - again. The unit will automatically recover when they plug it back in.)



Mesh Signals Matrix

(5 Minute average)

	8B4E	0533	34CC	E4A5	90DE	72C4	0539	051E	8B54	AF15
8B4E		15		14			**34**			**36**
0533	24			36			24	34	**28**	
34CC	35				27	15				37
E4A5	32	43				35			33	75
90DE						19	16	23		
72C4				**20**	16		21		9	
0539	26	**24**			**23**	**31**		37		
051E		17			18		52		9	42
8B54		23		34		18		12		11
AF15	36			10				**41**	9	

Excellent | Good | Usable | Marginal | Poor

The Mesh Signals Matrix page shows a 5 minute average of signal strength between the various Mesh Nodes and the Master unit. Reading down the columns is the receive signal strength at a particular unit and reading across rows is the unit it is receiving from. Unit identifier is the last 4 characters of the MAC address listed on the bottom of the unit. Start by plugging in a Master and work your way out adding Mesh Nodes until you have full coverage of your site. Use the Mesh Signals page to optimize placement and signal strength for each additional node. If each mesh node in your site has a good signal (green) in it's upstream connection (the highlighted box in the signals matrix) you will have good signal strength for all clients within range of that node. Keep in mind that each node will have a “bubble” shape around it, so client laptops will usually get a good connection from above and below the units as well as to the sides. Once you reach the edges of your site, you can use a wireless laptop to verify that you have a good client connection from the outer edge to the nearest node.

This is a very good mechanism to get the “definitive answer” as to how many nodes you will need to cover a specific site. The mesh will tell you when it is working right, in the specific environment it is working in. There are no guesses, just a validation of client laptop access at the edges. You don't have to worry about construction materials or amount of walls, the mesh “tells you like it is”.

Unfortunately it doesn't help when you are “estimating” how many units you will need before you are ready to install.

Sample Survey Guidelines.

Here are some general guidelines based on experiences with installations that obtained good wireless coverage for the site. Keep in mind that you will have to adapt to each site topology and construction. You can always add additional units at a later time, or overestimate and use any "extras" for another site or better coverage.

- 2 floors, standard wood construction, single building motel about 300 ft (100 meters) long by 60 ft (20 meters) wide, office and Master unit at one end. Usually a Master unit and 2-3 mesh nodes is all that is required. As a general rule of thumb, you can expect approximately 100 ft (30-35 meters) through 3-4 walls for indoor coverage for this type of construction.

- Same as above, but with 2 parallel "wings" of the same size as the above building, separated by 150 ft of open parking lot, and a single office building centered between the wings. Usually a Master in the office, and 3-4 nodes per wing will give good coverage. Position one of the nodes in each of the wings so that it is closest to the "wireless hop" to the Master in the office and place the other units down each of the wings. Coverage for the "courtyard parking lot" between the wings will come from the master plus all of the nodes in the wings. A Master and 6-8 Mesh nodes will cover this site.

- 3 floor hotel, concrete with rebar reinforced floors, single building 300 ft long and 80 ft wide. Interior walls standard wood construction. Office with the Master located at one end. This site can usually be done with a Master and 4-5 mesh nodes. Run your mesh nodes down the middle floor, but place them close enough together that the "angle of penetration" through the concrete ceiling and floors doesn't attenuate the signal too much to reach (and receive from) the client laptops. Interestingly, this same quantity works just about as well if the walls separating the rooms are the thicker "quiet" type of walls. You have already placed your units closer together to obtain a sharper "angle of penetration" through the concrete floor and ceiling, and this same closer placement works to your advantage in penetrating the thicker walls between the units on the same floor.

- Same as above, but with 2 parallel wings and close off the end into a "U" shape. Office in the bottom of the "U", and an 8 inch cinder block firewall covered with stucco separating each of the "wings" from the main office. With this setup, you will need a master in the office, and 2 Mesh nodes situated fairly close to the firewalls in the "office section". Punching through the firewalls will attenuate the signal strength so that you will only be able to get 20-40 ft (6 to 12 meters) of good signal strength through into the wings. Keep in mind you can also position these units at (or in) the ceiling on the first floor and penetrate through the firewall and concrete ceiling into rooms on the second floor. Add additional Mesh nodes at this point and continue down the wings, same as above. Total is one Master and 10-12 mesh nodes.

- 6 floors, 400 ft by 400 ft, rebar reinforced concrete floors, extra thick "quiet" walls between rooms. Usually this can be done with a Master and 24-30 Mesh nodes. Position Mesh nodes on the first, third, and fifth floors, about 30-40 ft in from each of the corners. Add mesh nodes on the first floor in an "angle" from a central Master out to the corner Mesh nodes on the first floor. Add additional units on the third and fifth floor to obtain proper guest laptop coverage. In a building of this size, hallways and large open spaces can work to your advantage, while elevator shafts and firewalls present disadvantages. Placement planning to take advantage of any open spaces and carefully mapping around dense obstructions may make a significant difference in the quantity of units required. Alternately, you could place the Mesh nodes on the second and forth floors only, and live with perhaps usable but somewhat weaker signals to the sixth floor clients.

Keynotes and additional information.

The larger the site, the more options you have in the topology of unit placements. Different sites may benefit from some experimentation at install time. Mesh nodes are easy to move around, it is useful to do so and track the results on the mesh node status screens. It will take 5 minutes for the signal strengths to settle into an average of the values after moving a mesh node.

It is better to populate a mesh with more mesh nodes than absolutely required, it is the transmit strength and distance from the lower powered client laptops to the various nodes that has the most impact on connection stability and speed. Mesh nodes and the Master unit have better radios and antennas than the majority of client laptops.

It is easy to add additional mesh nodes to an existing mesh, just plug it in. Brand new mesh nodes will require a mesh with an SSID of "hotspot" (no quotes, case sensitive). If you have changed this from the default and are adding new mesh nodes, you should temporarily set your mesh SSID to the default value to allow the new mesh node to join your mesh. Once your additional node(s) have joined in (see mesh status display), you can change the SSID back to your site specific one.

Popular 2.4 Ghz cordless phones are a frequent source of radio interference in the 2.4 Ghz range, and lower quality or aged units are often identified with radio interference. If staff has a requirement to use cordless phones, it is recommended that newer 5.8 Ghz phones or older 900Mhz phones be used. As an interim measure, you can set your Hotspot Mesh to use channel 11 (see Network Setup and Wireless on the administration pages), we have found the interference from these 2.4 Ghz phones sometimes seems to be reduced on this channel.

Place units as high up as you can get them. Suspended ceiling panels are ideal for placement. This places the units above minor obstructions like furniture, appliances, and fixtures. It also removes them from casual customer sight, which may help prevent any units from "growing legs".

High Gain Directional Antennas

If you have a large distance to cover, perhaps to the golf course or restaurant across the street, you can add high gain directional antennas to 2 Mesh Units and "point" them at each other to make the long "hop". Directional antennas are perfect for this purpose, since it "focuses" all the signal into a tight beam that can cross longer distances. Since 802.11 wireless communication is a two way connection, you will need a directional antenna at each end of your "long hop". Once you have connected through the "long hop" you can distribute to additional mesh nodes and client laptops on the other side of the hop. Checkbox units have 2 antenna inputs, and will automatically use the "best" one for communication with the appropriate client or wireless connection. You can have a high gain antenna attached to one of the inputs and a normal "omni directional" antenna attached to the other input.
In environments with low radio interference, for example across a small lake, high gain directional antennas have achieved usable wireless connections of up to ½ mile.

Client laptop connections will rarely benefit from high gain antennas on the access point, very few laptops have a high gain antenna attached for the return signal.