B E S T   P R A C T I C E   G U I D E

Wireless Mesh

This document was developed as a best practice guide for Ruckus Smart Mesh Networking™ installations. It includes real-world deployments and suggestions on coverage, capacity, technology choice (802.11n versus 802.11g), and other topics — to aid in the optimum reliability and performance of a Smart Mesh Network infrastructure.

Introduction

A wireless mesh network is a peer-to-peer, multi-hop wireless network in which participant nodes or access points cooperate to route packets.

Indoor wireless networking, while not a new concept, has always been an attractive option for enterprises interested more cost-effectively building or extending wireless LANs to areas where Ethernet cabling does not existing or is cost prohibitive.

However indoor wireless mesh networking has largely floundered within the enterprise due to the inability of Wi-Fi systems to provide reliable and adaptive connections through the RF domain which effectively serves as the network backbone within a wireless mesh infrastructure.

Recent technical advances in the area of smart antenna arrays and RF signal path control overcome these issues — providing the ability to construct a reliable wireless mesh backbone that delivers consistent system-wide performance by constantly steering signal over the best paths thereby ensuring that the best connections between intermediate nodes are used. These advances have become known as "Smart Mesh Networking."

Smart Mesh networks are therefore different from traditional mesh networks in two fundamental aspects: 1) their ability to automatically adapt link layer wireless connections between mesh nodes by routing over the best signal path at any given time to reduce packet loss and 2) the ability to minimize mesh hops through the use of high-gain, directional "smart" antennas. This allows mesh nodes to be placed farther apart, reducing the number of hops required to cover a given area as well as reducing the capital and operational costs associated with constructing a conventional indoor wireless mesh network. In a Ruckus Smart Mesh Network, the routing nodes (i.e., the Ruckus APs forming the network), or "mesh nodes", effectively form the network's backbone. Clients (e.g., laptops, mobile devices) connect to the mesh nodes and use the backbone to communicate with each other, and, if permitted, with nodes on the Internet. The Smart Mesh Network enables clients to reach other systems by creating an internetwork of connections between nodes using the RF spectrum. These connections or path allow client traffic to 'hop' between nodes. Shown in Fig. 1 below is a typical mesh topology.

Smart Mesh networks offers many advantages, the biggest of which is the ability to reduce, and in some cases eliminate, the need for Ethernet cabling to connect Wi-Fi access points.

Smart Mesh Networks are also self-healing. If any node fails, the system recognizes the failure and automatically re-routes data over another available "best" or fastest path

Smart Mesh Networks are self-organizing. When a new node appears, it automatically registers with the WLAN system and is transparently integrated into the network.

This document (that should be used in conjunction with the ***Ruckus Wireless ZoneDirector User Guide***) was developed as a best practice guide for Ruckus Smart Mesh installations. It includes real-world deployment and operational suggestions — in the areas of coverage area, capacity, number of APs, technology choice (802.11n versus 802.11g), and others — to aid in the optimum reliability and performance of a Smart Mesh network infrastructure.

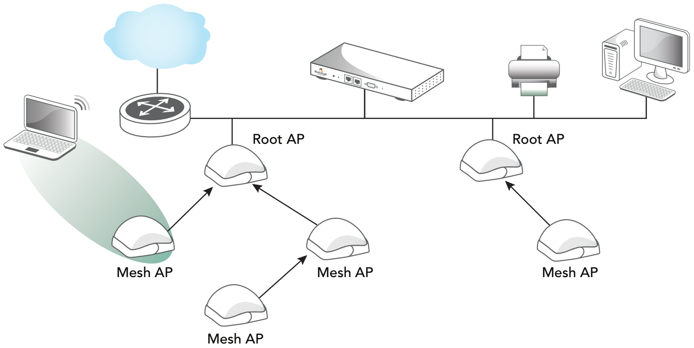


Figure 1: Mesh — Standard Topology

Mesh Networking Terms

Term	Definition
Mesh Node	A Ruckus ZoneFlex™ AP with mesh capability enabled. Ruckus ZoneFlex models that provide mesh capability include: ZoneFlex 7962 (indoor, dual-band 802.11n), ZoneFlex 7762 (outdoor, dual-band 802.11n), ZoneFlex 2942 (indoor 802.11g), ZoneFlex 2741 (outdoor 802.11g), and the Ruckus ZoneFlex 2925 desktop model.
Root Access Point (Root AP, or RAP)	A ZoneFlex AP physically wired to the L2/L3 network, acting as the entry point to the local area network.
Mesh Access Point (Mesh AP, or MAP)	A Wi-Fi access point that has no physical Ethernet connection, acting as a mesh node communicating to a ZoneDirector™ through its wireless interface.
Mesh Tree	The internetwork of mesh nodes and root APs forming the wireless LAN. Each Mesh AP has exactly one uplink to another Mesh AP or Root AP. Each Mesh AP or Root AP could have multiple Mesh APs connecting to it. Thus, the resulting topology is a tree-like topology. The maximum allowed depth of a mesh tree is 8, although best practice depth is typically smaller at outlined in this document. A ZoneDirector can manage more than one mesh tree. The only limitation of how many mesh trees it can manage is dependent on the number of APs a ZoneDirector can manage. For example, a ZD1006 can manage a mesh tree of 6 APs or two mesh trees of 3 APs each.
Hop	The transit of a data packet through a mesh access point or node. The "hop count" for a given client's data traffic is typically defined by the number of wireless mesh links a data packet travels from one Mesh AP to the Root AP. For example, if the Root AP is the uplink of Mesh AP 1, then Mesh AP 1 is ***one*** hop away from the Root AP. In the same scenario, if Mesh AP 1 is the uplink of Mesh AP 2, then Mesh AP 2 is ***two*** hops away from the Root AP.

Supported Mesh Topologies

Standard Topology

To extend the coverage of your Ruckus Smart WLAN, you can set up a Smart Mesh Network using the standard topology (*See Figure 1*). In this topology, the ZoneDirector and the upstream router are connected to the same wired LAN segment. Extending the reach of the WLAN can be achieved by forming and connecting multiple mesh trees to the wired LAN segment.

Wireless Bridge Topology

To bridge isolated wired LAN segments, set up a mesh network using the wireless bridge topology. In this topology, the ZoneDirector and the upstream router are on the primary wired LAN segment, and another isolated wired segment exists that needs to be bridged to the primary LAN segment. These two wired LAN segments can be bridged by forming a mesh link between the two wired segments, as shown in Figure 2.

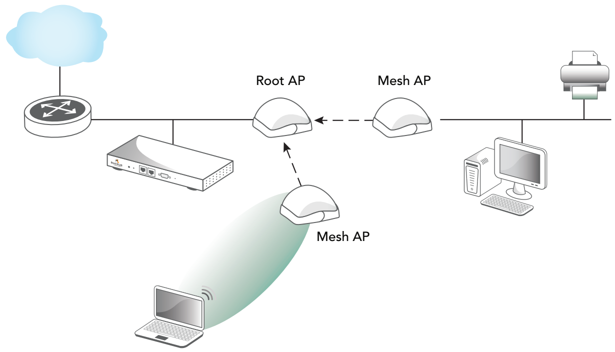


Figure 2: Smart Mesh — Valid Bridge Topology

Additional **wired** APs cannot be connected to the bridged segment, as shown in Figure 3. The problem with this configuration is that because C can reach the ZoneDirector through mesh link B-A, and because C has its Ethernet port active, it meets both conditions (ZoneDirector reachable, and Ethernet in use) to advertise that it is a root — even though it is NOT a root. As a result, this is an illegal topology.

However, additional wireless MAPs may be added in this physical location for additional coverage and capacity. In the example in Figure 3, RAP-C is NOT ALLOWED, as it is connected via Ethernet to this bridged wired segment. However using wireless MAP-D to extend the mesh is ALLOWED.

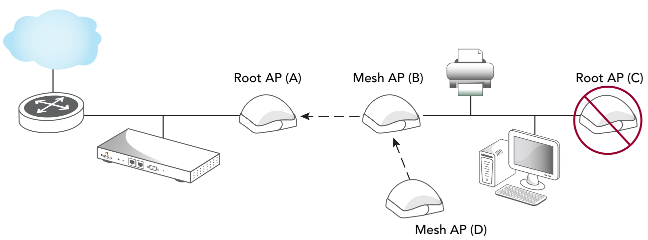


Figure 3: Mesh — Illegal Bridge Topology

Choosing the Right AP Model

Ruckus supports both 802.11g, and the newer, faster, dual-band 802.11n APs with which to form a Smart Mesh network. In the dual-band models, ZoneFlex 7962 (indoor) or the 7762 (outdoor), mesh links run on the 5 GHz band, with client access at 2.4 and 5 GHz. Smart Meshing also works with 802.11g APs, the Ruckus ZoneFlex 2942 and 2925 (indoor) or the 2741 (outdoor). These products can be used to form a highly reliable Smart Mesh network.

It's important to note that 802.11g and 802.11n technology cannot be mixed in a mesh topology. All nodes in a mesh must be dual-band 802.11n (ZF 7962 or 7762), or single band 802.11ng (ZF 7942) or 802.11g (ZF 2942 or 2741 or 2925).

In summary, build your mesh network as follow:

i. Ensure that all APs are dual-band 802.11n — model ZF 7962 or 7762 (can mix)

ii. Ensure that all APs are single band 802.11ng — model ZF 7942

iii. Ensure that all APs are 802.11g — model ZF 2942 or 2741 or 2942 (can mix)

NOTE: The above restrictions apply only to AP-AP communcation as part of a mesh — not to AP-Client communication. For example, there is no problem for 802.11g clients to connect to an 802.11n mesh.

Indoor Planning: Calculating the Number of APs Required

Optimizing coverage and performance are critical aspects to planning a Smart Mesh infrastructure. Calculating the number of total APs (RAPs and MAPs) that are needed to provide adequate coverage and performance for a given property is the one of the first steps.

If the goal is to support Internet grade connections for casual Web browsing, a design that delivers 1 Mbps of throughput in the entire coverage area is adequate. For Enterprise grade connections, plan for 10 Mbps of throughput. Wireless is a shared medium, of course, so this aggregate bandwidth will be shared amongst the concurrent users at any given time. So if the network is designed to support 10 Mbps, it would support 1 user at 10 Mbps, or 10 users at 1 Mbps each. In reality, due to statistical multiplexing (just like the phone system — the fact that not all users are using the network concurrently, if an oversubscription ratio of 4:1 is used, such a network could actually support 40 users @ 1Mbps.

To plan for coverage and performance, understanding wireless mesh technology and its impact on performance is essential. A Root AP (RAP) in a Smart Mesh network has all its bandwidth available for downlink because the uplink is wired.

However for mesh APs (MAPs), the available wireless bandwidth must be shared between the uplink and the downlink. This degrades performance of a mesh AP as compared to a root. However, from a coverage perspective, it is no different to estimate the number of APs needed, regardless of a mesh or traditional non-mesh (i.e., all root) topology.

A simple and easy-to-use AP calculator, provided on the Big Dogs Partner Portal, helps determine how many Smart Mesh nodes (APs) are required for a given indoor area. It can be accessed at: http://partners.ruckuswireless.com/sales_tools/quoting_guide.

The ZoneFlex AP calculator, as shown below, requires administrators to fill in some parameters regarding the environment such as square feet to cover, etc. After filling in these simple metrics, the program automatically generates the number of APs needed as well as a budgetary cost.

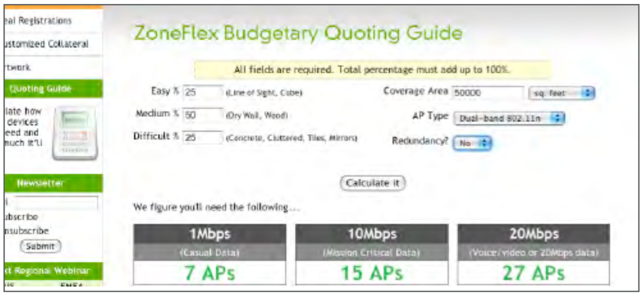


Figure 4: ZoneFlex Budgetary Quoting Guide

Outdoor Planning: Calculating the Number of APs Required

For outdoor planning, a different methodology should be used to calculate the number of APs required. We will focus on calculating the minimum number of APs required for coverage at the desired performance level. If more capacity is needed, additional APs (MAPs and RAPs) may be added to the network.

It is practical to consider a fixed area initially for the design, like 1 sq km. We will go through an outdoor design to cover 1 sq km below, and this basic template can then be used to extend the network to an arbitrarily large area.

First the user must define the performance levels (throughput) needed for the application. Ruckus provides a tool for estimating the throughput for a given coverage (distance) from the selected model of AP. This calculator tool is found at http://www.ruckuswireless.com/tools/performance-calculator.

The tool can be used to estimate throughput at a certain distance for a mesh link (AP to AP) or for an AP to client link. Because the mesh links are the backbone of the wireless network, it is important to design the mesh links conservatively to ensure optimum performance. Ruckus recommends maximum mesh link distances of 350 meters for our outdoor 2741 and 7762 APs. For a 1 sq km area, the topology looks like the one shown below:

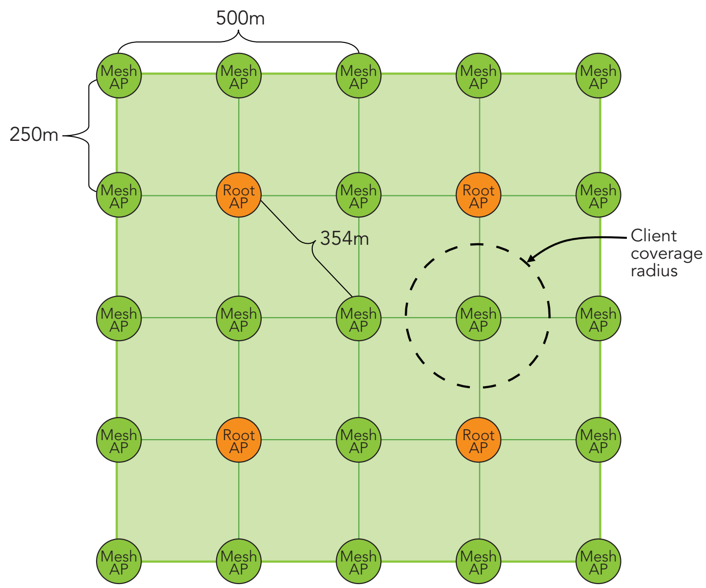


Figure 5: Root Placement

Also shown in the topology above is four roots — this ensures there is no more than a 1-hop mesh AP anywhere in this 1 x 1 km area.

Using the calculator, we can estimate the performance of the above design. For the mesh links (AP to AP), the calculator parameters are entered as below. It is assumed in this example that the APs are located outdoors, LOS, with no obstructions in between.

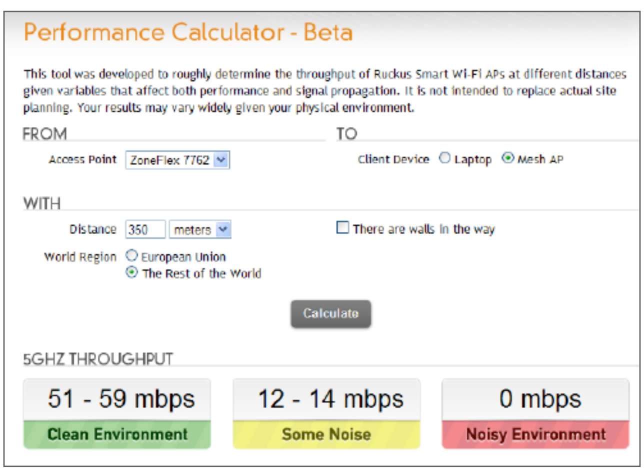


Figure 6: ZoneFlex Performance Calculator

Mesh performance to the first hop is seen to be around 50 Mbps.

For client performance at 150m, the calculator is run as follows:

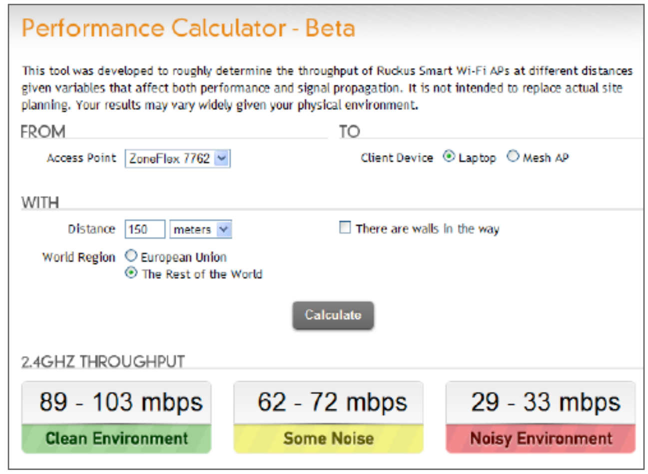


Figure 7: Client performance at 150m

Assuming the client is an 802.11ng, and more susceptible to noise than an AP, we could expect client throughputs around 60 Mbps. However, since the mesh performance is capped at 50 Mbps, this puts an upper bound of 50 Mbps on the client.

For 802.11g clients, you may use the following trick to estimate the performance. Leaving everything else the same on the calculator, select the 2741 802.11g AP from the pull-down menu. This shows that an 802.11g client at 150m can expect around 28 Mbps.

It should be pointed out that the client-AP will be non-LOS more often than not, as compared to the outdoor mesh APs, which may be mounted on rooftops or poles and therefore have a good LOS link. For challenging (real-world) client connections, we recommend using a CPE product (e.g. Ruckus 2211) to enhance client performance.

Placement and Layout Considerations:

i. **Utilize two (2) or more RAPs:** To prevent having a single point-of-failure, it is best to have two (2) or more RAPs so that there are alternate paths to the wired network. In the example above, the number of RAPs should be increased from one (1) to two (2) to meet this best practice.

ii. **Deploy as many roots as possible:** As shown in Table 2, the more roots in the mesh topology, the higher the performance. Therefore, as far as possible, try to wire as many APs as is convenient. A useful way to look at this is a RAP:MAP ratio. Since all MAP traffic has to ultimately egress from the roots, it is useful to maintain a reasonable RAP:MAP ratio. For example, RAP:MAP of 1:3 would be best, 1:5 would be reasonable, and 1:7 or worse is not recommended.

iii. **Design for a three-hop maximum:** Avoid excessive hops in your mesh topology. In general, the goal should be to have the lowest number of hops, provided other considerations (like signal >= 25%) are met. Limiting the number of hops to three (3) or less is best practice — 1 or 2 hops is ideal.

iv. **Bring in the backhaul to the middle of coverage area:** This allows the placement of the root AP towards the middle of a coverage area to minimize the # hops required to reach some MAPs.

v. **Distribute roots evenly throughout coverage area.** If there are multiple roots within the Smart Mesh, ensure the roots are evenly dispersed throughout the coverage area (not clumped up close together in one area). Figure 8 illustrates an ideal scenario, along with a not-so-ideal scenario. While the purpose of a mesh network is to provide coverage in areas that are hard to wire, the ideal may not be possible. But as far as possible, evenly spaced out root APs are preferable.

vi. **Do not mount wireless backhaul near the AP.** If the customer's network utilizes a wireless backhaul technology for broadband access, it is recommended to not mount the broadband wireless modem right next to a Ruckus AP. A distance of 10' or more would be desirable.

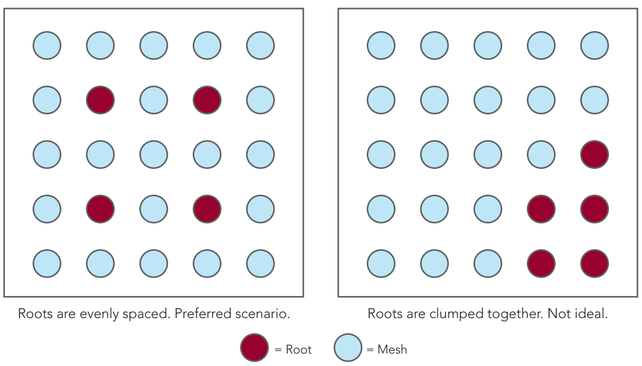


Figure 8: Root Placement

Signal Quality Verification

The above guidelines for planning will result in a well-designed Smart Mesh infrastructure. Once the SmartMesh is deployed there are useful parameters within the system GUI that should be monitored to ensure the mesh is operating optimally. One such parameter is the "signal value" in the ZoneDirector. Signal is a measurement of the link quality of the MAP's uplink.

To view the signal parameter in the Zone Director GUI, navigate to the Monitor --> Access Points section. Then, click on the MAP being tested (click the MAC address) to see the Access Point detail screen, as shown below. There are two best practice observations that should be met:

Signal Value Best Practice

i. **Ensure signal >= 25%:** The signal value under **Neighbor APs** that shows **Connected** should be 25% or better. If the value is lower, the AP needs to be placed closer, or moved to avoid an obstruction so the value of signal to 25% or better. For a more conservative design, you may use 30% as your signal benchmark.

ii. **Ensure a minimum of two uplink options for every MAP:** In addition, under **Neighbor APs**, it is best practice that there exists an alternate path for this Smart Mesh uplink. This alternate path must also have a signal value of 25% or better. In other words, there should be at least two possible links that the MAP can use for uplink and both must have a signal value of 25% or better.

iii. **AP-AP throughput of 12 Mbps:** In addition to the signal value recommendations, it is recommended to test actual throughput between the mesh links to verify reliable operation. The ZoneDirector GUI allows the operator to run SpeedFlex between any RAP-MAP, or MAP-MAP pair. It is recommended that a throughput of 12 Mbps is achieved on any pair of parent-child APs.

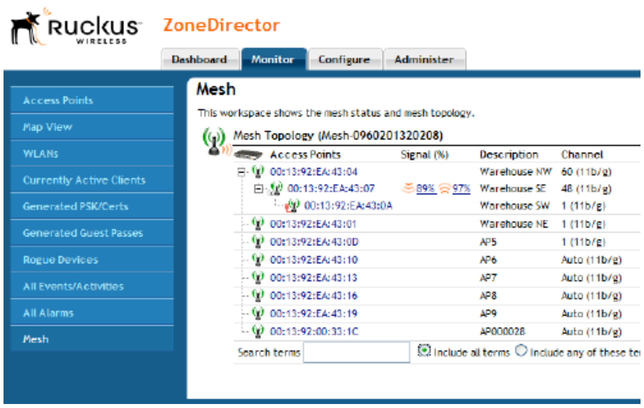


Figure 9: Mesh status and topology

Channel and Tx Power Best Practice

There are no channel and power settings to worry about — the Mesh APs automatically select the best channel and power settings. The APs use 802.11h to communicate with each other to ensure that the entire mesh tree synchronously changes channels, thus not stranding any AP. Also, preference is given to the busiest roots when it comes to assigning channel.

Mounting and Orientation of APs

It is important that the APs be mounted with the correct orientation to ensure that reliable mesh links can be formed. There are five ZoneFlex AP models that support Smart Mesh Networking:

- dual-band 802.11abgn: ZoneFlex 7962 (indoor) and ZoneFlex 7762 (outdoor)
- single-band 802.11ng: ZoneFlex 7942
- 802.11g: ZoneFlex 2942 (indoor), ZoneFlex 2741 (outdoor), and ZoneFlex 2925 (desktop model)

In general, these and other Ruckus APs are very tolerant to a variety of mounting and orientation options due to Ruckus' use of its unique BeamFlex™ technology in which the RF signal is dynamically concentrated and focused towards the other end of the RF link.

The bottom line regarding orientation and placement is that during the planning phase, it is advisable to use the Signal quality as your benchmark, as explained in the Signal Quality Verification section. Ensure that the Signal is better than 25% for trouble-free operation. For a more conservative design, and for larger mesh networks, use 30% signal as the benchmark.

For additional mounting details, please also consult the *Quick Setup Guide* and the *Wall and Ceiling Mounting Instructions* that came in the AP box.

Indoor APs – Typical Case: Horizontal Orientation

For the ZoneFlex 7962, 7942 and 2942, the APs are typically oriented such that their dome is pointing straight down.

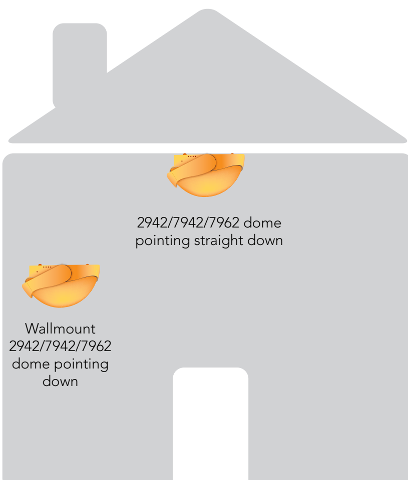


Figure 10: ZoneFlex 2942/7942/7962 Horizontal Orientation

For the ZoneFlex 2925, the AP is typically oriented so that the FCC/CE label, or the serial number and MAC label on the underside of the unit, is horizontally oriented, as shown in figure 11.

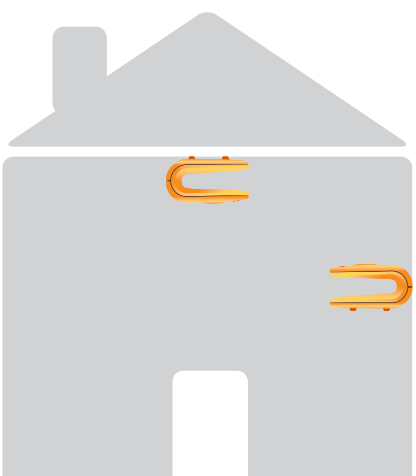


Figure 11: ZoneFlex 2925 Horizontal Orientation

Indoor APs – Less Typical Vertical Orientation

A less typical vertical orientation may be used in certain cases where it is not possible for mechanical or aesthetic reasons to use the typical orientation. In such cases, the indoor APs may be mounted vertically, and will still provide good coverage. Examples of vertical mounting are shown in Figures 12 and 13.

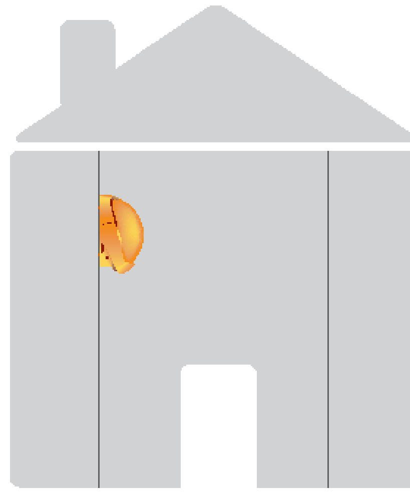


Figure 12: ZoneFlex 2942/7942 Vertical Orientation

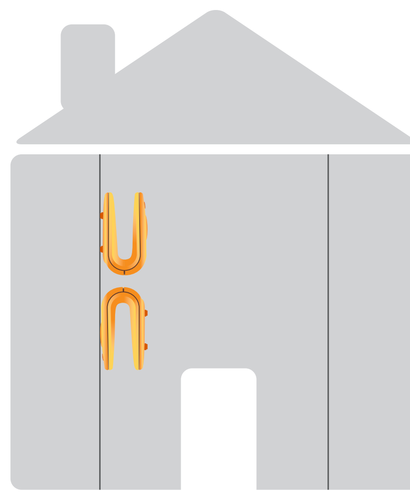
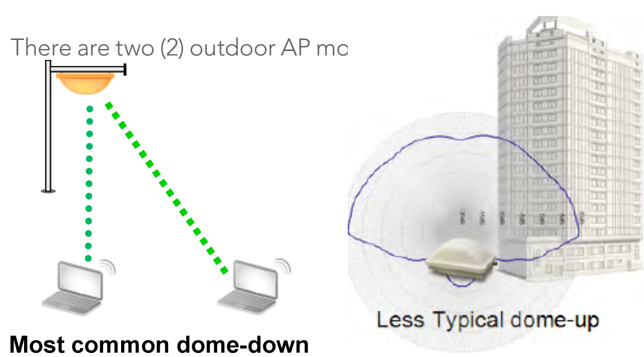


Figure 13: ZoneFlex 2925 Vertical Orientation

Outdoor APs – Horizontal Orientation

There are two (2) outdoor AP mc



and the ZoneFlex 2741. In both cases, a typical orientation is horizontal, as shown in Figure 14.

The most common placement of the outdoor AP is on a roof-top or on top of a pole, or some other elevated location, and with the dome pointing down. This has the benefit of good quality, LOS mesh links.

Less common is to place the AP on a lower elevation and point upwards towards the face of a building. However, this is a perfectly acceptable way to mount the AP, and is used to provide service in many hotels and apartments.

Below are some ways to mount the Ruckus outdoor AP — on roof-tops, cell towers, or light poles.

Elevation of RAPs and MAPs

In addition to orientation, it is important to pay attention to the elevation of an AP for reliable mesh operation. Large differences in elevation should be avoided. Whether deployed as an indoor mesh, an outdoor mesh, or a mixed indoor-outdoor mesh, MAPs and RAPs should all be at a similar elevation from the ground, if possible.

Additional Outdoor Best Practices

For outdoor deployments, it is important to consider some additional best practices around surge suppression, and power sources, including solar.

Surge Suppressors

When deploying APs outdoors, it is advisable to use surge suppressors on the POE Ethernet cable that is carrying power and data to the AP. These should be installed in-line into the cabling, and are typically grounded. Please follow the manufacturer's recommendations for installation and operation. A well-known supplier of such parts is Transtector. More details can be found at http://www.transtector.com/ProductData?class=Ethernet

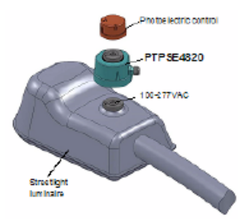
Power Sources

Street Light Power Options

If the APs are to be mounted on street light poles, and power needs to be sourced from the poles, there is typically AC available at the top of the pole (light unit), where there is normally a photo-electric control unit plugged in. There are products on the market that plug into this AC receptacle and provide 802.3af output that can be used to power the AP. The photo-electric unit is plugged back into this unit, as shown in the picture.

Make sure the voltages in the country you are operating meet the specifications of the PoE street light power module — AC voltage could vary from 100V to 480V. The basic steps are as follows — provided as a general guideline. Make sure to follow the manufacturer's steps for this.

1. Turn off power
2. Unscrew existing photo-electric control
3. Replace with Streetlight POE injector device
4. Put back the photo-electric control
5. Run outdoor Ethernet cable to Access Point



6. Cover the photo-electric control to verify lamp is able to arc

Two vendors that make such devices are www.sbwireless.com and www.fpolc.com

Solar Power Best Practice

There are many instances where it may be required to power the AP off alternate energy sources like wind or solar.

There are a number of good options for solar panels and associated equipment. With some care in the planning and design of a solar system, there is no reason this cannot be a reliable source of power for an outdoor AP.

Some of the key issues for a reliable design are:

- Desired service level?
- Budget for project
- Average peak sun hours for location?
- How many possible days of no sun?
- How much current is needed?
  - Base line
  - Headroom for future products
  - Total current of system
- High Temp of the year

- Low temp of the year
- Highest Humidity of the year

Let us use an example to design a system. Let us assume the following requirements for this example design:

1. 24 by 7 by 365 up time
2. Longest June 21-14H, Shortest Dec 21-10H
   a. Refer to average peak sun hours for location, 8H
3. Built to withstand 3 days of no sun
4. Maximum current draw for system
   a. 3A
   b. How much headroom for future, 1A
   c. Total 4A
5. High temp of 50°C
6. Low temp of 0°C
7. Max Humidity 90%

Average Peak Sun Hours Per Day

The simple chart below can be used to estimate the daily charging time in hours. Shown in the chart are conservative numbers. Actual charging time is more due to more daylight hours in a day.

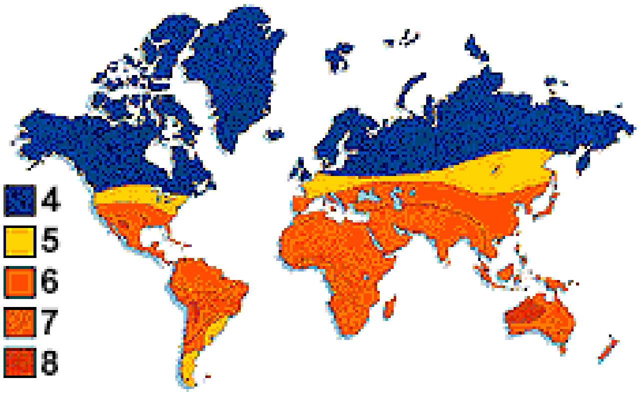
With the design requirements and information above, and assuming units run-time is 24 hours per day (unit in service for 24 out of 24 hours per day), the table below will help us size the batteries and solar panels.

From the table, we can compute how many amps per day are used, what kind of battery is appropriate size, and what kind of solar panel can re-charge the battery. So from left to right, here's how to read the first row, for example:

- 2741 draws 1A, over 24 hours that is 24 Ah.
- For a Group 24 battery, with up to 75% drain allowed (75% of 70-85 Ah), it will be able to keep the unit powered and running for 2 whole days, even if no sun.
- If we used the 65W panel, which can put back 36A over a 10 hour sun period in a day, we could re-charge up to 1 day's battery charge loss, in approx. ½ day.

Below is shown, our sample system design. Also provided are links to vendors who manufacture the different components. The solar charge controller is recommended to prevent over-charging the battery. The vendor links are repeated here:

Solar panels:
http://www.ecodirect.com/BP-Solar-SX-365J-65-Watt-12-Volt-p/bp-solar-sx-365j.htm



				Deep cycle battery types, current per cell "amp hours" @ 24 Hours, Backup power if no sun @ 75% drain			Solar panel size/number of hours of charging time		
Product	Unit current drain "dcA"	Run time "Hours"	Amps per day usage	Group 24 70-85Ah $99 avg	Group 27 85-105Ah $160 avg	Group 31 95-125Ah $200 avg	80W, 4.6A max $450	65W, 3.7A max $400	
2741/7731	1A	24	24	2 days of no sun @ 85Ah	3 days of no sun @105Ah	4 days of no sun @125Ah	10 hours 46A day	10 hours 36A day	Full sun on system, it will recharge in 1/2 a day
7762	1.5A	24	36	1 day of no sun @85Ah	2 days of no sun @105Ah	3 days of no sun @125Ah	10 hours 46A day	10 hours 36A day	Full sun on system, it will recharge in 3/4 of a day
NOTE:	Based on back panel info, but might be less	How many hours unit will run a day, typical is 24 hours	Take max current* the number of hours	Not good to take deep cycle batteries below 75% discharge, also depends on type of batteries, see MFG instructions, above is worst case. Much larger batteries are available, 4-D and 8-D have up to 225Ah			Lots of different types and outputs. Note product's DC voltage limits, high and low, to ensure product is not damaged		

Battery Information
http://www.windsun.com/Batteries/Battery_FAQ.htm#AGM,%20or%20Absorbed%20Glass%20Mat%20Batteries

http://www.google.com/products?client=safari&rls=en&q=group+27+AGM+battery&oe=UTF-8&um=1&ie=UTF-8&ei=5x1OS4_6BYvKsAPskNzOBw&sa=X&oi=product_result_group&ct=image&resnum=3&ved=0CB8QzAMwAg

Solar Charge Controller
http://www.morningstarcorp.com/en/products

Sample system

Solar panel

- This is a BP 65W 12vdc panel — $390

  http://www.ecodirect.com/BP-Solar-SX-365J-65-Watt-12-Volt-p/bp-solar-sx-365j.htm

Solar charge controller <10A, 12Vdc

- Used to keep expensive batteries safe from over charging — $89

  http://www.morningstarcorp.com/en/products

12VDC Group 27 battery — $189

- AGM batteries best to use, robust, but $$$
- Fully recharged (95% or better) even after 30 days of being totally discharged
- Sealed, no liquid to spill

  http://www.google.com/products?client=safari&rls=en&q=group+27+AGM+battery&oe=UTF-8&um=1&ie=UTF-8&ei=5x10S4_6BYvKsAPskNzOBw&sa=X&oi=product_result_group&ct=image&resnum=3&ved=0CB8QzAMwAg

  http://www.windsun.com/Batteries/Battery_FAQ.htm#AGM,%20or%20Absorbed%Glass%20Mat%20Batteries

Finally, some additional issues and recommendations:

- Our products list max current, general usage is lower
- Wide range of performance vs. cost per system, understanding where to spend the money is critical
- Shade can reduce a solar panels output by 50%, so doing a site survey is a must
- High quality solar charger will keep voltages under control, keep from damaging batteries and Ruckus units

Following these Smart Mesh best practices will ensure that infrastructure is well-designed with the capacity and reliability required for enterprise applications. Below is a checklist that summarizes these Smart Mesh best practices:

BEST PRACTICE CHECKLIST

1. Ensure you do not have any illegal bridge topologies in your Smart Mesh network.
2. Ensure sure Smart Mesh APs are mounted with the optimum orien-tation for maxi-mum coverage.
3. Try to place Smart Mesh APs at the same (or close to the same) elevation from ground.
4. Don't mix 802.11n and 802.11g APs within the Smart Mesh. They will NOT mesh properly.
5. Calculate the number of RAPs and MAPs required using the instructions and exam-ples provided.
6. Deploy two or more root APs so there is an alternate path for reli-ability, even when capacity and coverage only require one.
7. Avoid excessive mesh hops. Ideally keep the mesh hop count to three hops or less.
8. Deploy as many roots as feasible for better performance.
9. Place a root AP near the middle of a coverage area to minimize the number of hops required reach any given MAP.
10. For multiple root APs, ensure the roots are distributed evenly throughout the cov-erage area.
11. Use the signal quality measurement to ensure that the connected MAP uplink is 25% or better.
12. Try to maintain more than one uplink path for every MAP, ensuring the signal value of the alternate path is also 25% or better.
13. Use a surge suppressor outdoors for safety.
14. Follow the solar best practices for a reliable design.

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