Multi-Floor Deployments

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This chapter discusses challenges in deployments that involve multiple floors. Recommendations on what to keep in mind while designing for RF network are also discussed.

Not every venue is a simple office space with uniform ceilings and rectangular shapes. Furthermore, most venues have aesthetic restrictions that limit the flexibility in placing APs.

Many venues have high ceilings that overlook many floors, which is quite common in museums, theaters, malls, etc. where there is an atrium in the middle of the building. The MSE/Cisco Prime Infrastructure can handle high ceiling deployments quite easily with the proper RF profile selected. For every floor, the "Indoor High Ceiling" RF model can be specified in the Cisco Prime Infrastructure interface, as discussed in Cisco Prime Infrastructure RF Planning Tool in Chapter 16, "Predictive Radio Frequency Planning."

Inter-floor issues arise mainly due to:

- Construction and structure of the building
- Placement of the APs

Limited Flexibility for Placing APs

High ceiling deployments have challenges with AP placement. An open, high ceiling area might limit the options for placing APs. For example, the aforementioned ceiling mounted APs that is preferred may not be an option at all and APs mounted at lower height might be the only option.

The optimal position for an AP based on our measurements may be in an area that adversely impacts the aesthetics of the venue and the venue interior designers may not allow placement of an AP at the preferred location. It may also be impossible to run power and Ethernet wiring to the intended AP location.

Inter-floor Interference Issues

In many situations, an atrium passes through multiple floors. In such venues, a wireless client on Floor-X can see APs from the floors above and below, leading to miscalculation of the floor level. This is what is usually labeled as Inter-floor interference. Basically the APs on multiple floors detect signals from a device and report their observed RSSIs to the MSE. The MSE uses these readings to calculate the

location and may end up placing the client on the wrong floor as the APs on the floor above or below the actual floor that the device belongs to may report RSSIs as strong as the APs on the actual floor. This leads to user confusion and frustration.

AP Deployment Guidelines to Mitigate Inter-floor Issues

It is recommended to deploy vertically aligned APs to give best results for inter-floor sensitive location.

- APs can be one or two meters offset per floor but in general they are in alignment.
- Design location deployment independently for every floor, only taking lift shafts, stairwells, and atriums into consideration that impact RF bleed-over.
- Avoid placing APs directly in short range of any atrium where RF can be affected depending on reflections or attenuation. Where possible place APs so as to avoid line of site to adjacent floors or other levels.
- Having APs vertically aligned on adjacent floors is not a problem. In most modern deployments, dynamic channel and power contention can be resolved by the controllers. If co-channel interference or signal strength is greater than recommended levels, then monitor mode APs should be considered.
- Care should also be given to staggered AP deployments where floor materials have weak RF absorption.

Based on past experience, here are some of the ways to eliminate inter-floor interference issues. Before embarking on this tedious, iterative process, perform several walking tests with more than one device to be absolutely sure that inter-floor issues exist and that it must be resolved. Note that the steps below can be carried out locally around the area where inter-floor interference is experienced. The floor determination on adjacent floors should also be checked before and after implementing the following recommendations:

- Try to move APs—The first, easy step in mitigating inter-floor impact is to move APs, if possible, without impacting Wi-Fi and Location coverage. This is easier said than done due to challenges in AP placement and also the inability to move them at will. Moving APs 10-20 ft. away from atriums can have a large impact on location inter-floor issue and minimal impact on Wi-Fi coverage.
- Exclude APs from location calculation—This is a logical operation that does **not** disturb the physical APs or their positions or even the Wi-Fi connectivity in an area. In this approach, the floor maps are manipulated and the APs causing inter-floor issues are removed from the floor on the Cisco Prime Infrastructure. With the removal of the AP from the floor map, the MSE never takes into account any RSSI reading from that AP that is no longer present on the floor map, even when the WLC sends the RSSI reading to the MSE. This clever approach has a few benefits.
  - It does not impact Wi-Fi coverage.
  - It does not mandate any changes in the physical AP placement.
  - It does not have any impact on the AP or the WLC.
  - If it does not work, it can always be reversed easily with configuration changes from the Cisco Prime Infrastructure.

  Obviously extensive testing must be performed across multiple floors when this approach is adopted to resolve inter-floor issues.
- Eliminate improbable location for clients (for example, atriums)—In many venues, there are areas that are unreachable for humans. A multi-level atrium is a classic example of an area that spans multiple floors but only a small part of the lowest level floor is accessible. The floor maps will still show the atrium as being part of every floor (see Figure 17-1 and Figure 17-2 of a museum). The

floor map for the Lower Level and Entry level look very similar with an area in the middle labeled "Great Hall". This Great Hall area is an open area that is visible to all floors in the museum, but it is only accessible from the Lower Level floor.

Figure 17-1 Venue with Atrium

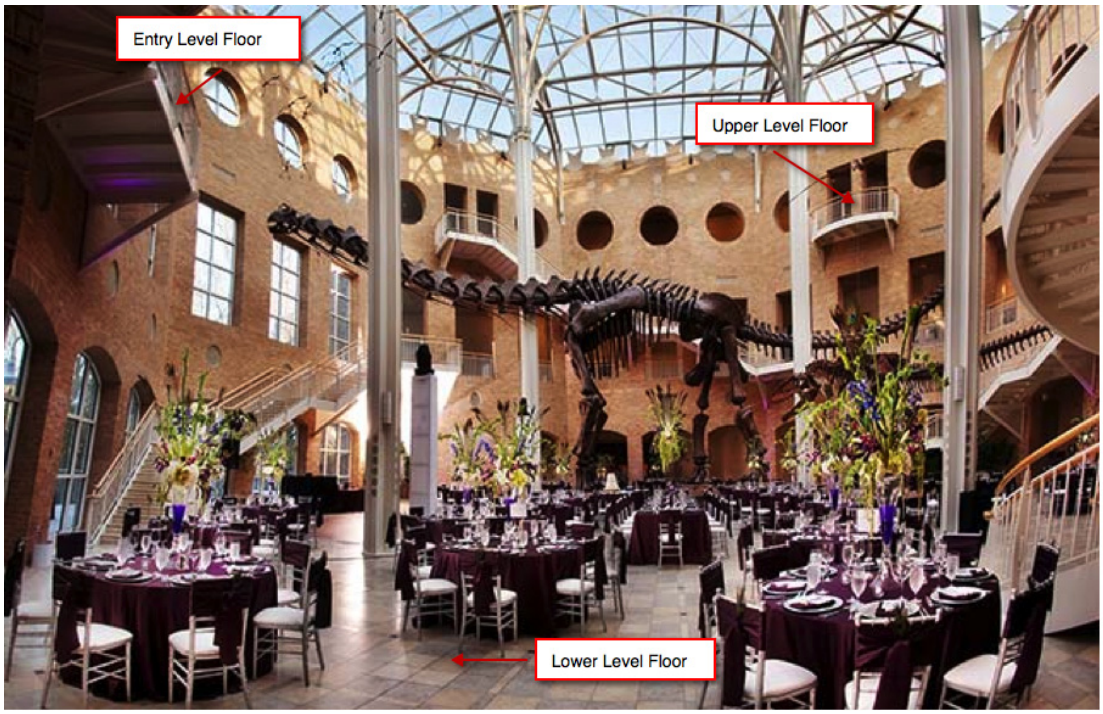
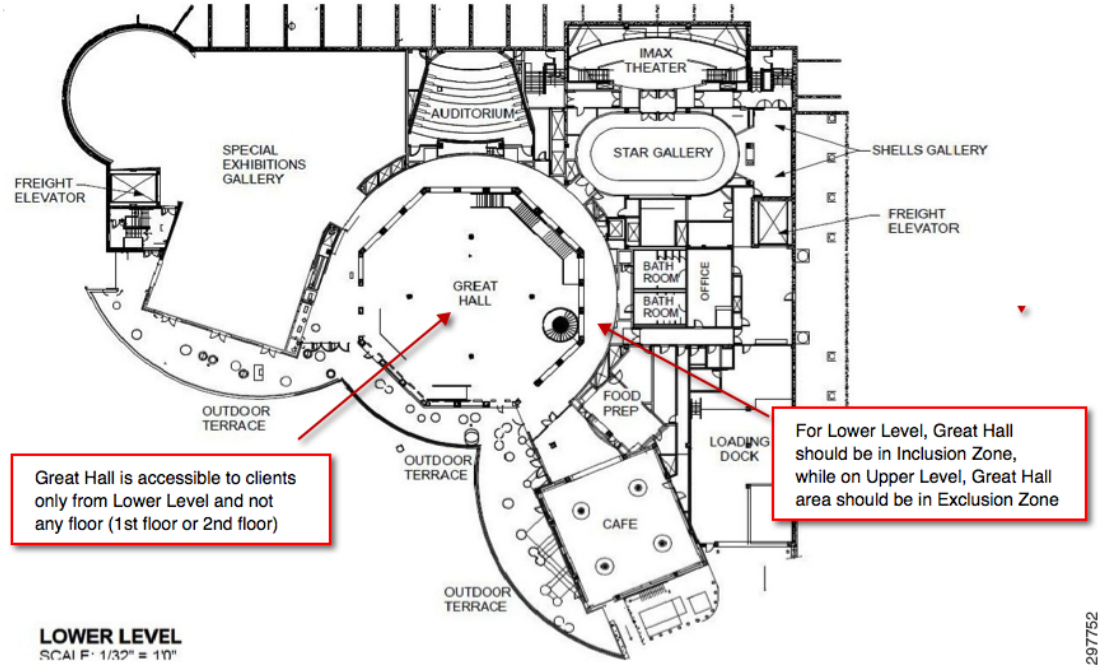


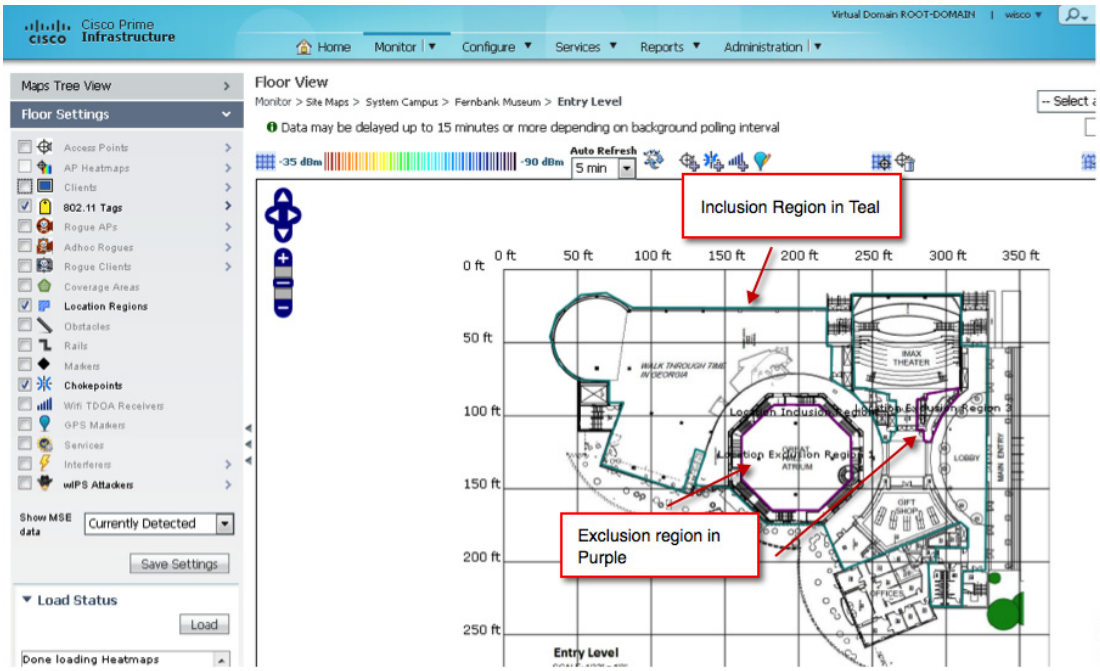
Figure 17-2 Lower Level and Upper Level Inclusion Zone



As can be seen from Figure 17-1 and Figure 17-2, a human can only be located within the "Great Hall" area only when present on the Lower Level. However due to the placement of the APs and Wi-Fi coverage, the MSE might calculate the location of a device to be on the Entry Level floor and within the Great Hall area. This is perfectly correct as per the MSE algorithms and setup, but not correct given the physical layout. Therefore the MSE must be configured to never locate a device within the Great Hall region when on the Entry Level (and Upper Level) floors. This is accomplished by drawing an Exclusion region on the floor map. By drawing such a region, we ensure that no device is ever located inside that area, even when the calculations fall within the region. This avoids annoyances and frustration for humans using an application with the MSE.

Figure 17-3 shows a picture of the museum floors with an exclusion region.

Figure 17-3 Inclusion and Exclusion Regions



Note More details on configuring inclusion and exclusion regions for a CMX deployment is covered in Inclusion and Exclusion Areas on a Floor in Chapter 24, "Configuring Cisco Prime Infrastructure."

- Limiting where clients can be located—The opposite of the previous discussion on Exclusion regions are Inclusion regions. The idea is to restrict/confine the region in which an MSE can place clients. For example, as part of normal calculation of Location, if the MSE determines that a client is outside the building (which is not likely in most cases), then the MSE is forced to place the client within the Inclusion region. Continuing with the museum example, an Inclusion region has been drawn around the entire floor plan so that MSE always places the clients within the floor plan.

Multi-Floor RF Site Survey

There are numerous factors that need to be taken into account when you survey multi-floor buildings, hospitals, and warehouses. It is important to find as much detail as possible in regard to the building construction. Some examples of typical construction methods and materials that affect the range and coverage area of APs include metallic film on window glass, leaded glass, steel-studded walls, cement floors and walls with steel reinforcement, foil-backed insulation, stairwells and elevator shafts, plumbing pipes and fixtures, and many others. Also, various types and levels of inventory can affect RF range, particularly those with high steel or water content. Some items to watch for include printer paper, cardboard boxes, pet food, paint, petroleum products, engine parts, and so forth. Ensure that the site survey is conducted at peak inventory levels or at times of highest activity. A warehouse at a 50% stocking level displays a very different RF footprint than the same facility that is completely occupied.

Similarly, an office area that is not populated has a different RF footprint than the same area when occupied. Although many parts of the site survey can be conducted without full occupation, it is essential to conduct the site survey verification and tweak key values at a time when people are present and normal activity takes place.

The higher the utilization requirements and the higher the density of users, the more important it is to have a well-designed diversity solution. When more users are present, more signals are received on the device of each user. Additional signals cause more contention, more null points, and more multipath distortion. Antenna diversity on the AP helps to minimize these conditions.

Keep these guidelines in mind when you conduct a site survey for a typical multi-floor building:

- Elevator shafts block and reflect RF signals.
- Supply rooms with inventory absorb RF signals.
- Interior offices with hard walls absorb RF signals.
- Kitchens can produce 2.4GHz interference caused by microwave ovens.
- Test labs can produce 2.4 GHz or 5 GHz interference. The problem of interference is that it increases the noise floor and decreases the SNR (signal to noise ratio) of the received signal. A higher noise floor reduces the effective range of the APs.
- Office cubicles tend to absorb and block signals.
- Class windows and partitions reflect and block RF signals.
- Bathroom tiles can absorb and block RF signals.
- Conference rooms require high AP coverage because they are a high Wi-Fi utilization area.

When you survey multi-floor facilities, APs on different floors can interfere with each other as easily as APs located on the same floor. This can be beneficial for voice and/or data deployments, but it causes problems when you deploy Context Aware. Floor separation is critical for this solution to function properly. In multi-tenant buildings, there can be security concerns that require the use of lower transmission powers and lower gain antennas to keep signals out of nearby rooms or offices.

Hospitals

The survey process for a hospital is much the same as that for an enterprise, but the layout of a hospital facility tends to differ in these ways:

- Hospital buildings often have recurrent reconstruction projects and additions. Each additional construction can require different construction materials with different levels of signal attenuation.
- Signal penetration through walls and floors in the patient areas is typically minimal, which helps create micro-cells. Consequently, AP density needs to be much higher to provide sufficient RF coverage.
- The need for bandwidth increases with the increased usage of WLAN ultrasound equipment and other portable imaging applications.
- Due to the requirement for higher AP density, cell overlap can be high, which results in channel reuse.
- Hospitals can have several types of wireless networks installed, which includes 2.4 GHz non-802.11 equipment. This equipment can cause contention with other 2.4 GHz or 5 GHz networks.
- Wall-mounted diversity patch antennas and ceiling-mounted diversity omni-directional antennas are popular, but keep in mind that diversity is required.

Warehouses

Warehouses have large open areas that often contain high storage racks. Many times these racks reach almost to the ceiling where APs are typically placed. Such storage racks can limit the area that the AP can cover. In these cases, consider placing APs on other locations besides the ceiling, such as side walls and cement pillars.

Also consider these factors when you survey a warehouse:

- Inventory levels affect the number of APs needed. Test coverage with two or three APs in estimated placement locations.
- Unexpected cell overlaps are likely because of coverage variations. The quality of the signal varies more than the strength of that signal. Clients can associate and operate better with APs farther away than with nearby APs.
- During a survey, APs and antennas usually do not have an antenna cable that connects them, but in a production environment, the AP and antenna can require antenna cables. All antenna cables have signal loss. The most accurate survey includes the type of antenna to be installed and the length of cable to be installed. A good tool to use to simulate the cable and its loss is an attenuator in a survey kit.

Manufacturing Facility

When you survey a manufacturing facility, it is similar to the surveillance of a warehouse. One key difference is that the ambient RF environment is much noisier in a manufacturing facility because of many more sources of RF interference. Also applications in a manufacturing facility typically require more bandwidth than applications used in a warehouse environment. These applications can include video imaging and wireless voice. Multipath distortion is likely to be the greatest performance problem in a manufacturing facility.

It is important that the site survey not only measures signal levels, but also generates packets and then reports packet errors in order to properly characterize the RF environment.

For areas where user traffic is high, such as office spaces, schools, retail stores, and hospitals, Cisco recommends that you place the AP out of sight and place unobtrusive antennas below the ceiling.

Note For more details, see: https://supportforums.cisco.com/sites/default/files/legacy/1/7/2/41271-Cisco%20Mobility%20Services%20Engine%20-Context%20Aware%20Mobility%20Solution%20Deployment%20Guide.pdf.