Lecture hall wireless redesign

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CWNE Essay

I. Introduction

The old wireless design of our lecture halls typically had 1-2 APs per hall, depending on size. Lectures with high attendance were known to have high utilization and offer students slow speeds because of the limited capacity.

As the university renovated a few halls every year, I took the opportunity to redesign the wireless in these rooms, as this is the best time to do so - new cables are pulled, and ceilings are changed.

The difficulty during these projects is reaching a consensus with the interior architect and finding solutions that align with my wireless design goals and the architect's aesthetic design goals.

The latest project was a lecture hall seating 280 persons.

II. Gathering requirements

My rule of thumb from experience is to have around 40-50 seats per AP in lecture halls. While most persons carry more than one device, typically, only one is active, and some students use no device during lectures. While capacity calculations using the number and type of devices and potential bandwidth requirements are in BYOD environments just guessing, my rule of thumb has served well so far in providing a good connection for all students without over-engineering a solution.

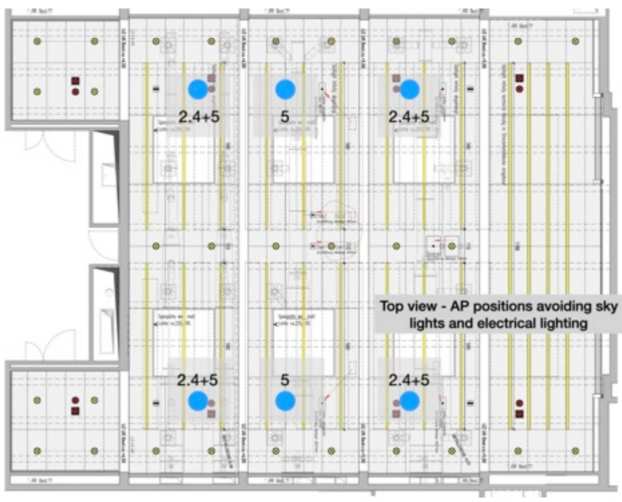
I contacted the architect responsible early to scope out which guidelines I would have to work with. It was clear that having a full AP visible was not allowed. APs have gotten pretty big and thick lately, and the architect clarified that this was a no-go. Another critical point for the architect was no visible antenna-"sticks". If something had to be visible, it had to be a shallow profile.

With these points in mind, it was clear that the solution would be patch antennas with the APs hidden. Patch antennas would work great angled on the walls or ceilings, but the architect vetoed that, as it would violate the low profile rule. So, I started planning with patch antennas flat against the ceiling. We have already used patch antennas from our WLAN vendor in past projects, and I have had good experience with them; the two types are with a 60°/60° beam width and with a 120°/60° beam width. They can be painted in different colors to better blend into the surroundings, which I have done in other rooms, but this room would have a white ceiling, so painting was unnecessary. Patch antennas also have the advantage of dividing rooms into sectors, cutting the room into multiple parts with much more precise cells than omnidirectional antennas would have. This works against sticky clients tied to the AP nearest the entry and ensures that clients below that antenna have high SNR.

III. Planning

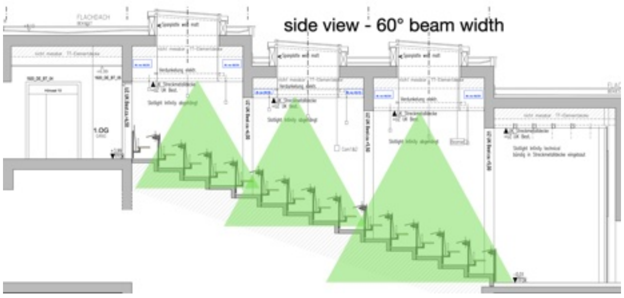
I collected the plans for the building and how the architect would modify the room, and then I got to planning. As I would need to place the antennas on the ceiling, one of the most important things is the ceiling height, which influences the size of the main beam at desk height, showing how many APs I would need to cover the whole room. Depending on the seats/AP metric and corresponding capacity, I can use more APs with the narrow beam width antenna or fewer APs with the larger beam width antenna. New skylights were also planned, which cut potential mounting positions.

Using the architect's ceiling plan, I spotted possible antenna positions, and with the side view of the rooms, the ceiling height in different positions in the room.



Ceiling plan

This led to potential ideal ceiling positions, using six APs with 120°/60° antennas in a 2x3 grid, resulting in 10 active radios with nine distinct channels, also fitting the 40-50 seats per AP rule.



Side view

All APs would have their 5 GHz radio active, and two APs would have their 2.4 GHz radios off; the higher receiving aperture of 2.4 GHz antennas would make the potential cell larger to fill the room. With four 2.4 GHz radios active, there would be a channel overlap - this is unfortunate, but is hard to avoid in this case. While the antenna's narrow beam width will help, the client's transmissions would cause co-channel-contention in the one overlapping channel. However, 5 GHz is increasingly the main band, and we can live with a total of nine channels in this room.

I modeled this in Ekahau to confirm my plan, and the results looked good (though modeling slanted floors and ceilings is impossible in Ekahau, I needed to work with tricks - straight floors and APs in different heights). It is essential to understand that these models are only an approximation to see that the antenna model would behave as I think.

The plan was approved by the architect and given to the electricians, who pulled the cable, and carpenters, who constructed the ceiling. I contacted the electricians about the details of the installation regarding the antenna below and the AP above the ceiling.

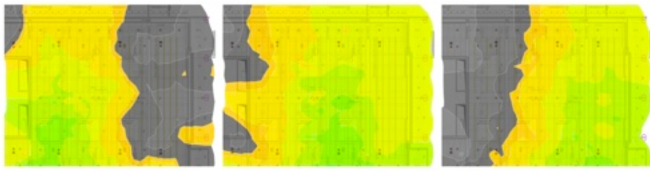
IV. Validation & Conclusion

APs were installed, and a validation survey proved the small cells. Transmit power was adjusted for clear cell distinction. I configured 40 MHz channels in the 5 GHz band, as nothing was leaking in from the outside, giving the room a total of 300 MHz of bandwidth. During a lecture, I sat inside and took measurements, proving high speeds and low channel utilization, making this room renovation successful.

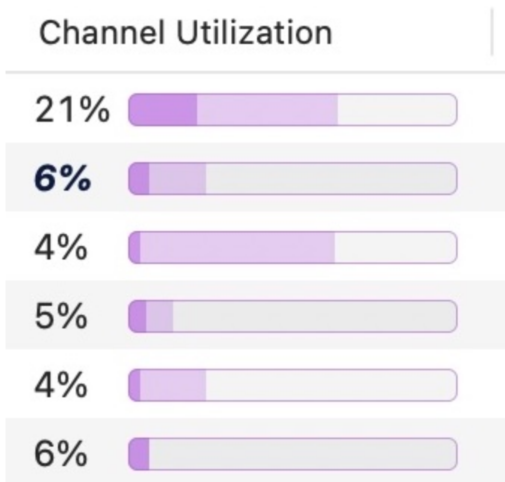
Studying for CWDP and getting to know the tools and antennas I work with has helped me navigate designs with architects a lot.

Installed AP, only antenna visible

Renovated hall with 6 nearly invisible APs



Survey detail - Signal strength in back/middle/front AP on one side



5 GHz channel util. during a lecture