Advanced High-Resolution Controls for Dimmable LED Lighting for Offices

Specification & Procurement Support Materials

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Acknowledgment

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Appendix E: Generic Zoning Diagrams for Lighting Control Systems

Introduction

- When designing an advanced lighting control system, one major consideration is the desired granularity. This affects:
  - **Occupancy zones** based on occupancy sensor coverage and operation
  - **Daylight zones** based on photosensor coverage and operation
  - **Other possible fixture groupings** based on functional reasons (for example, fixtures grouped over a specific desk or workstation)
- A specifier may desire low- or high-granularity based on these considerations. The highest degree of granularity would involve the use of integral sensors and controllers in every single fixture.

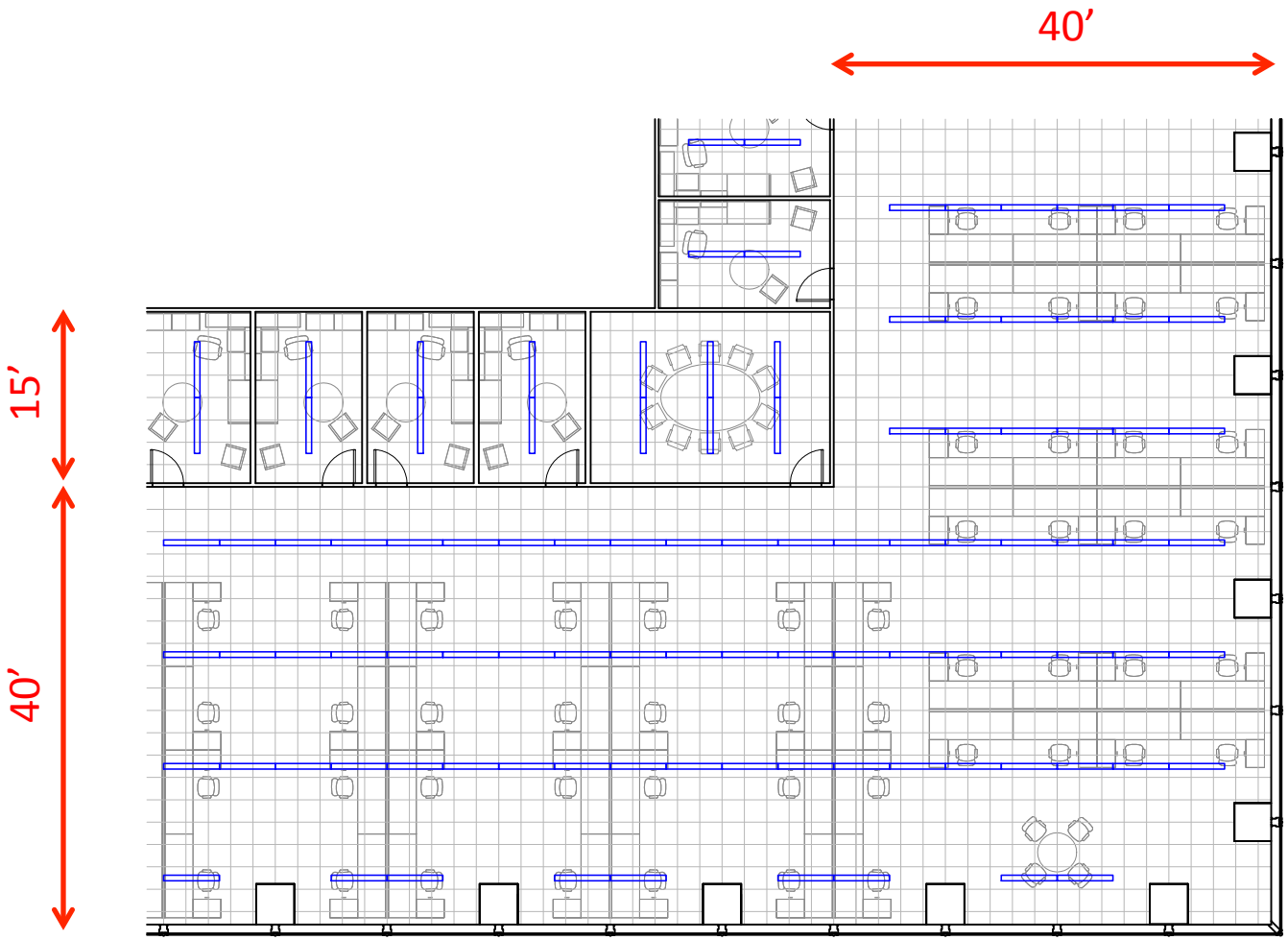
Introduction

- Most advanced lighting control systems rely on individually-addressable fluorescent ballasts, LED drivers or on-board controllers. This allows the specifier to group fixtures based on desired zoning. However, it's also possible to use one ballast, driver or on-board controller to control a group of fixtures if individual addressability isn't required. However, this would reduce options for future rezoning.

- Some lighting control systems allow the specifier to configure the desired degree of granularity in the system's software and may even allow for zones to "overlap", while others are more rigid in their operation. The following slides contain graphic depictions of some methods used by systems currently available in the market.

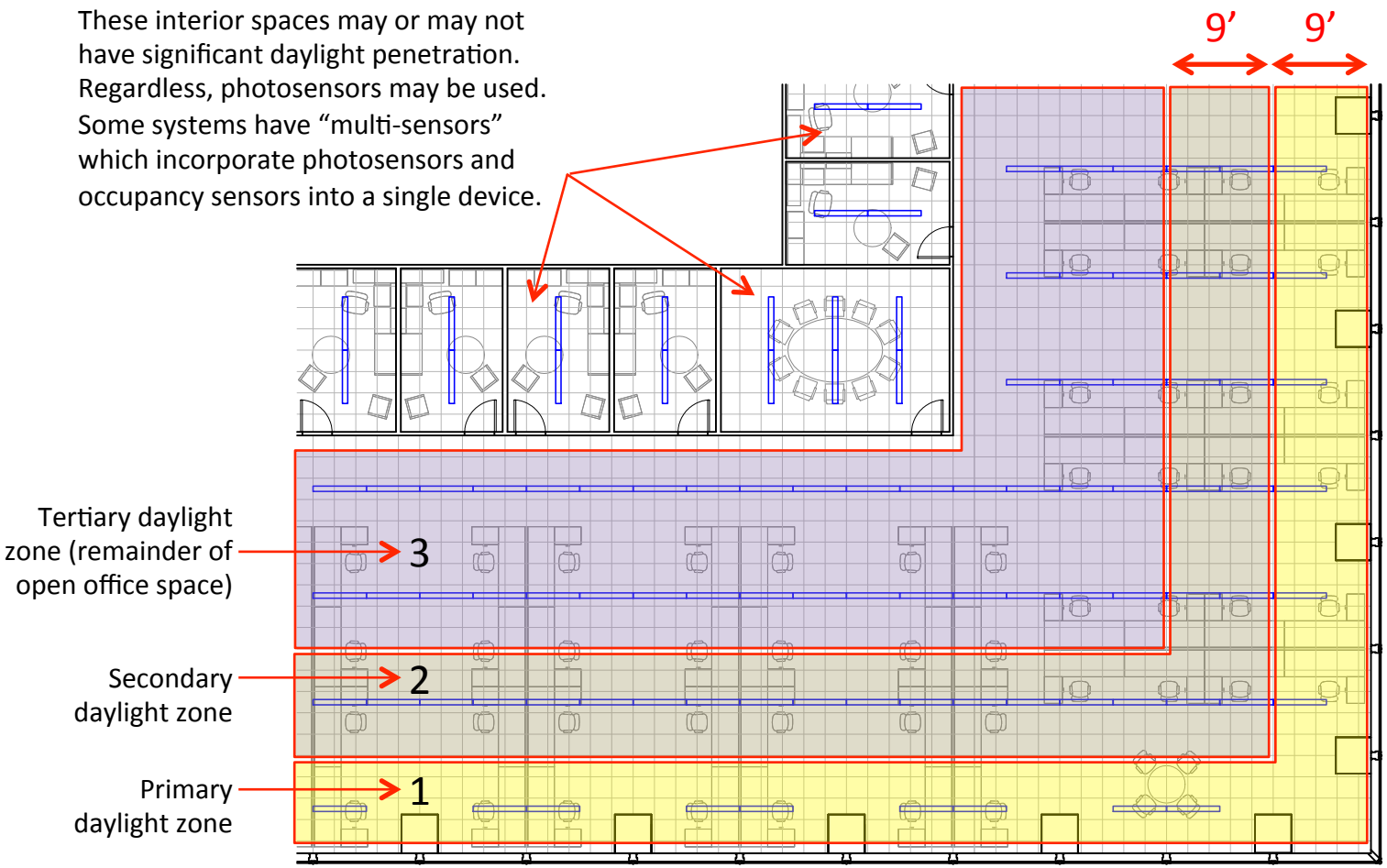
Granularity in offices with continuous rows of fixtures

Open office floor plan with continuous pendant fixture rows



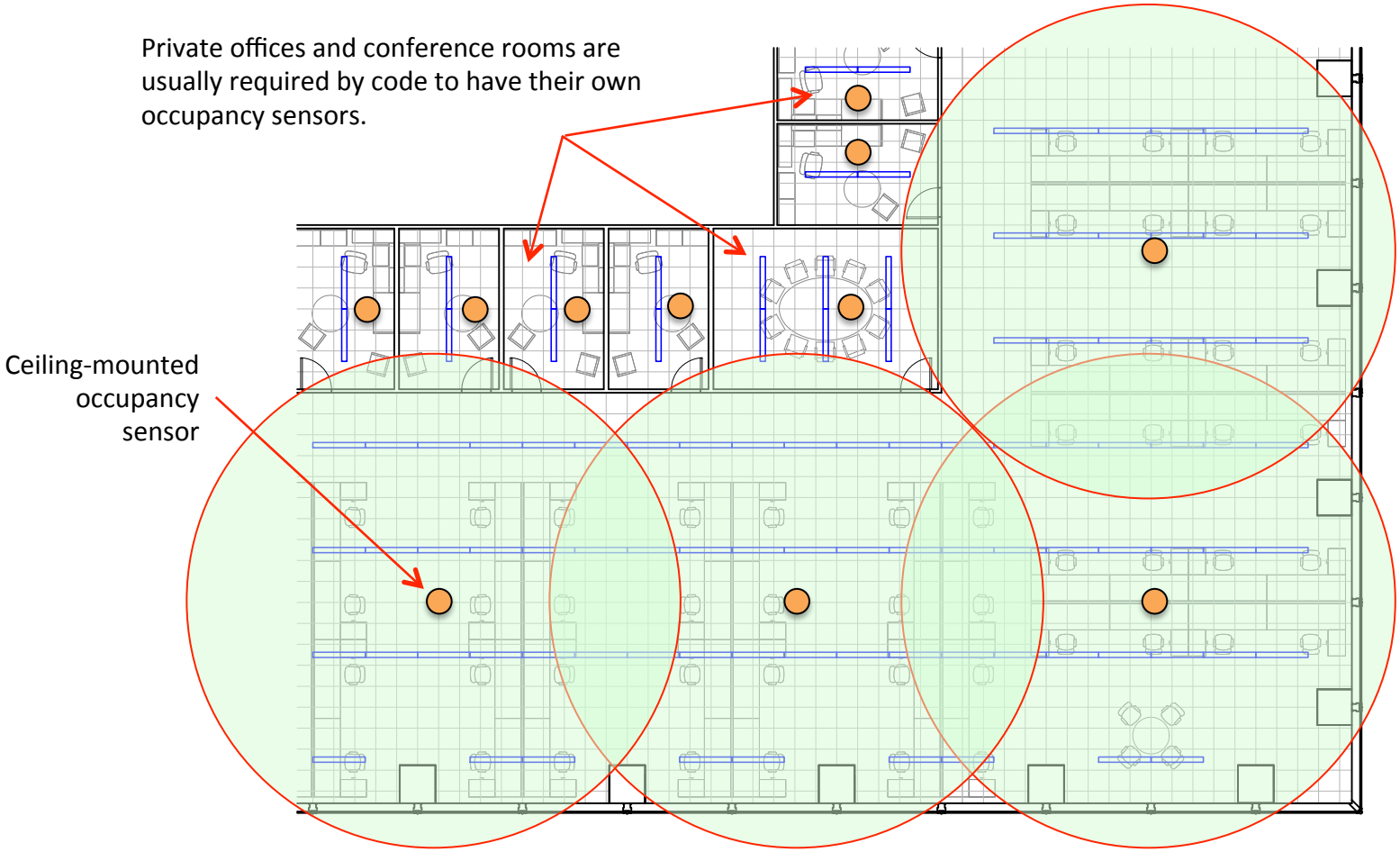
This is an example office space with open office areas at the perimeter, and private offices and conference rooms adjacent to the core. In this example, pendant fixtures are mounted in continuous rows. The ceiling height is 9’-0” and the exterior is a full-height window wall.

Daylight zones



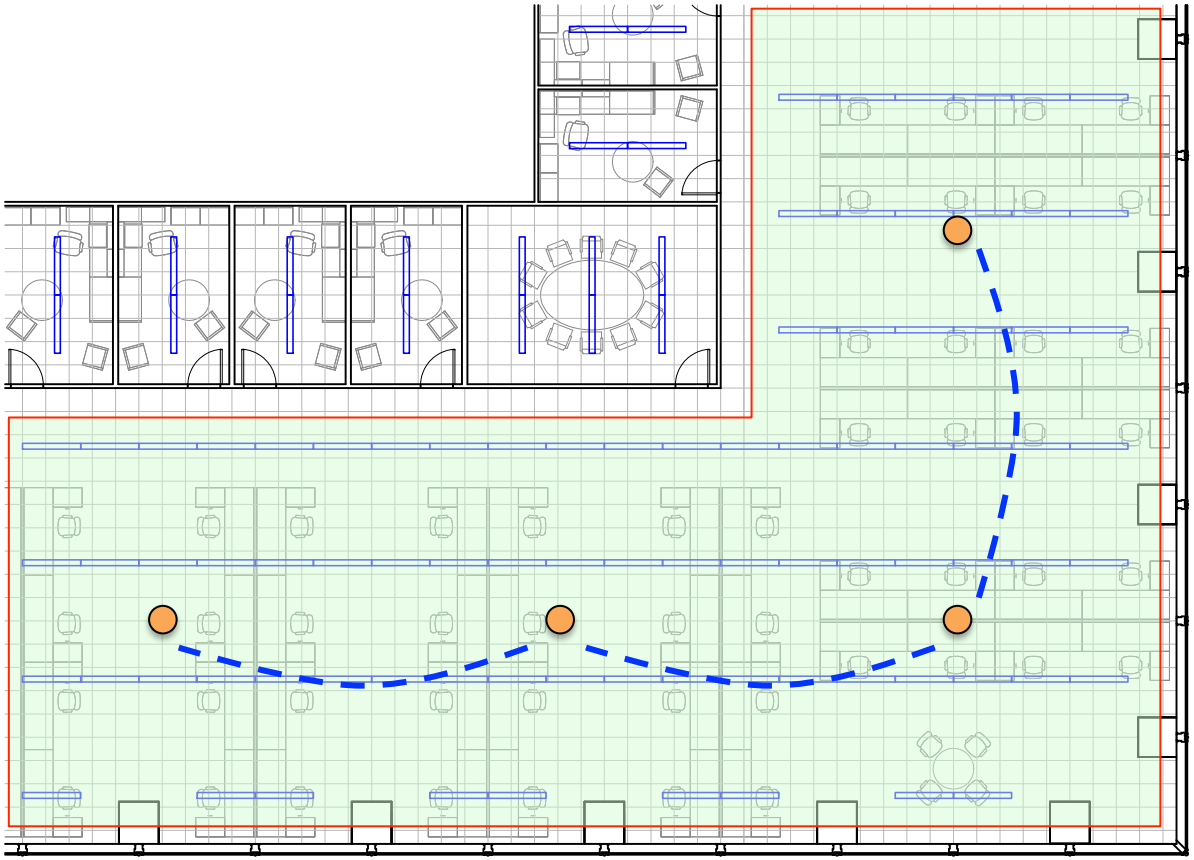
Daylight zones (as designated by numbers in the above example) are based on penetration of daylight into the interior. This example shows a succession of primary, secondary and tertiary daylight zones. Some codes (such as California Title 24) require all fixtures located in primary and secondary daylight zones to be **automatically** controlled. In California Title 24, the width of the primary and secondary zones is equal to the window head height as shown in the example above.

Occupancy sensor coverage in open office space (2,000 ft^2, radius=25')



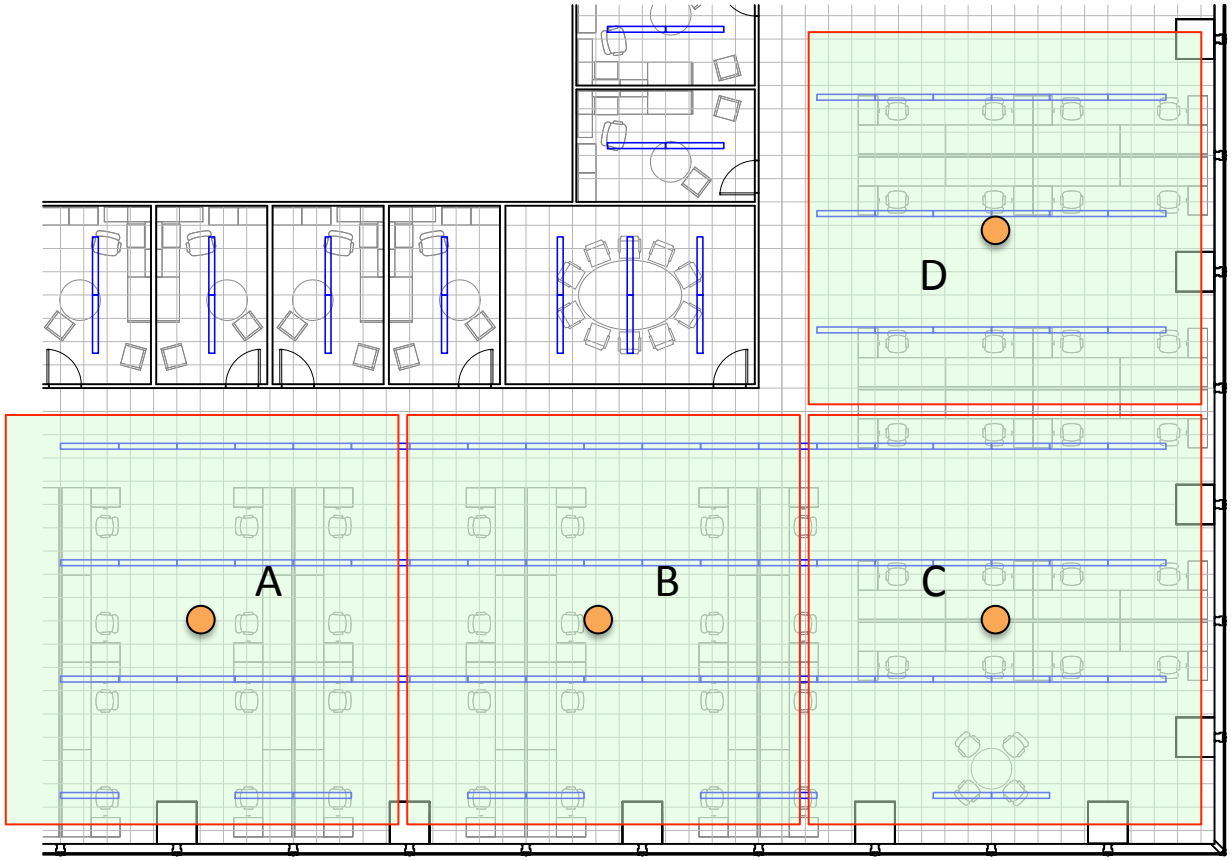
The green circles represent the coverage pattern of typical ceiling-mounted occupancy sensors with 2,000 ft^2 coverage in open office areas.

Occupancy sensors used in parallel operation in open office areas



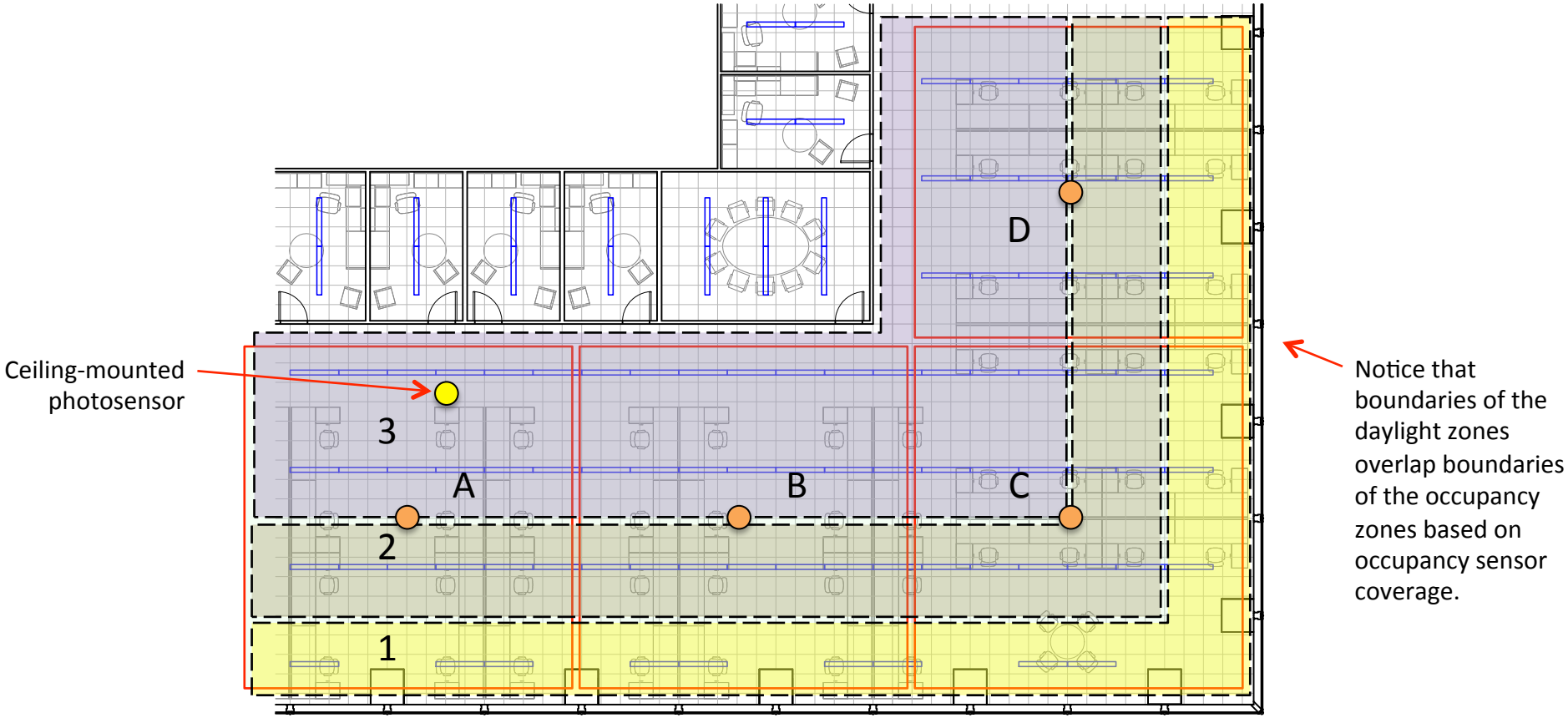
Just as with standalone analog devices, occupancy sensors in digital control systems can also be used “in parallel” (even if they’re not wired together). Essentially this means that the entire space would be one large occupancy zone. In that case, movement detected by any occupancy sensor would keep all of the lights on throughout the entire open office space. This approach would result in the least amount of energy savings.

Low granularity – occupancy zones based on occupancy sensors with 2,000 ft^2 coverage



Establishing occupancy zones (as designated by letters in the above example) based on the coverage of each occupancy sensor allows groups of lights to be separately controlled. Once there is a distinct occupancy zone for each occupancy sensor, there's a greater chance of reducing energy use – since lights in a specific zone can dim or turn off once that zone is vacant.

Overlap of daylight zones with low granularity occupancy zones (using occupancy sensors with 2,000 ft^2 coverage) – unrestricted mapping of fixtures to photosensors

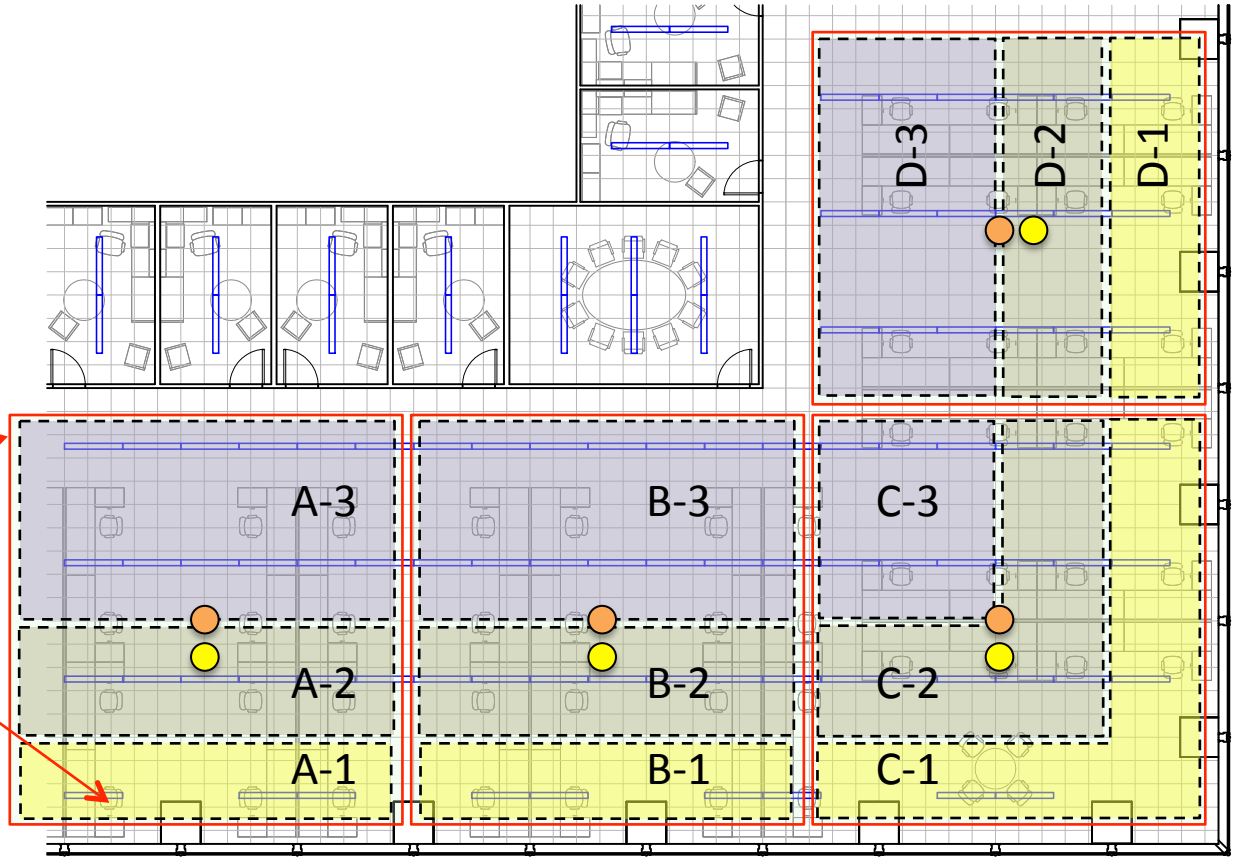


When these daylight zones are overlaid onto the occupancy zones, they overlap (they are not aligned). Some lighting control systems allow **<u>any</u>** fixture to be mapped to **<u>any</u>** photosensor – regardless of which control zone they're in. If such a system is used, then as shown above daylight zones **<u>do not need to align</u>** with occupancy zones. Additionally, some systems can work with as little as one photosensor for an entire open office area, reducing equipment and labor costs.

Separation of daylight zones for systems that **do not** allow unrestricted mapping of fixtures to photosensors

Solid red lines indicate occupancy zones

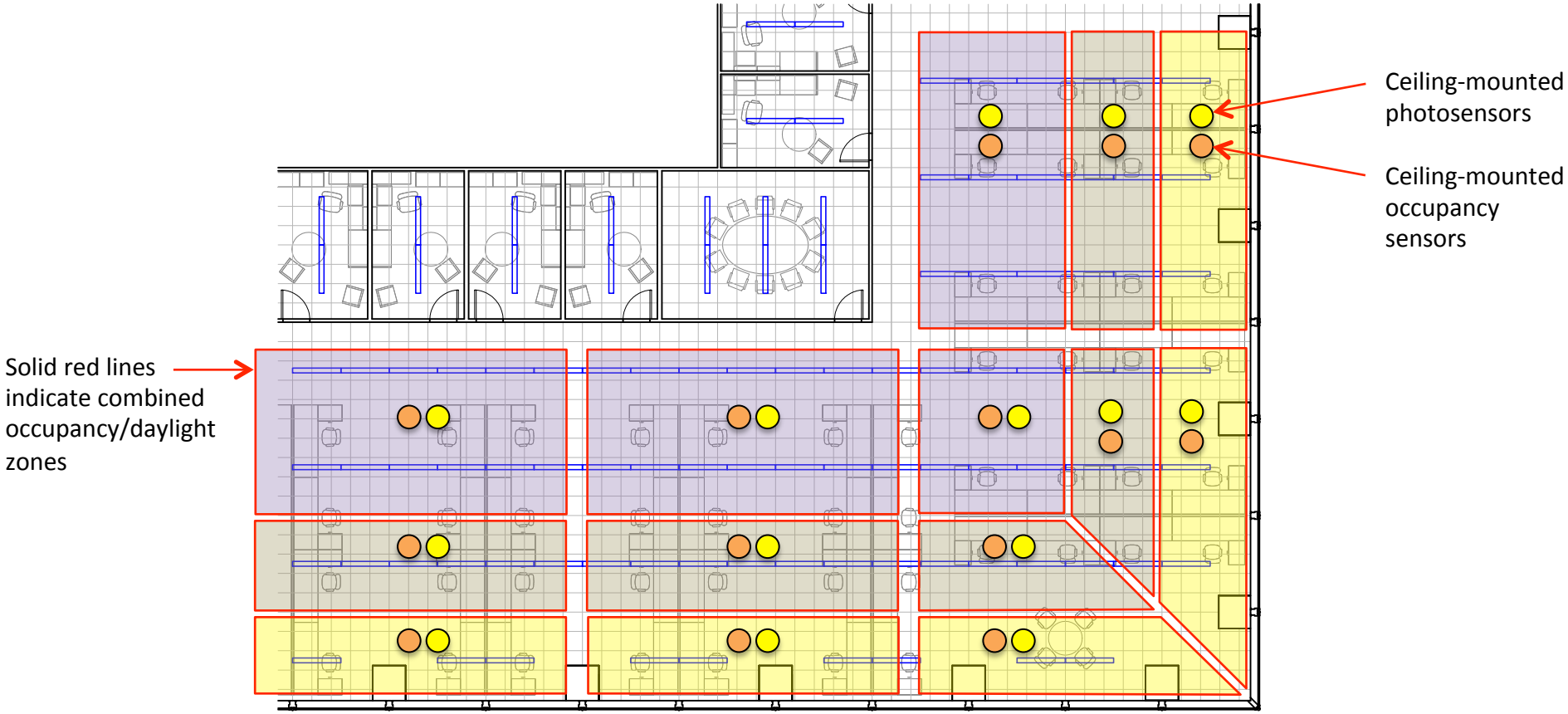
Dashed black lines indicate daylight subzones



If a lighting control system doesn't allow unrestricted mapping of any fixture to any photosensor, then the daylight zones must be split as shown.

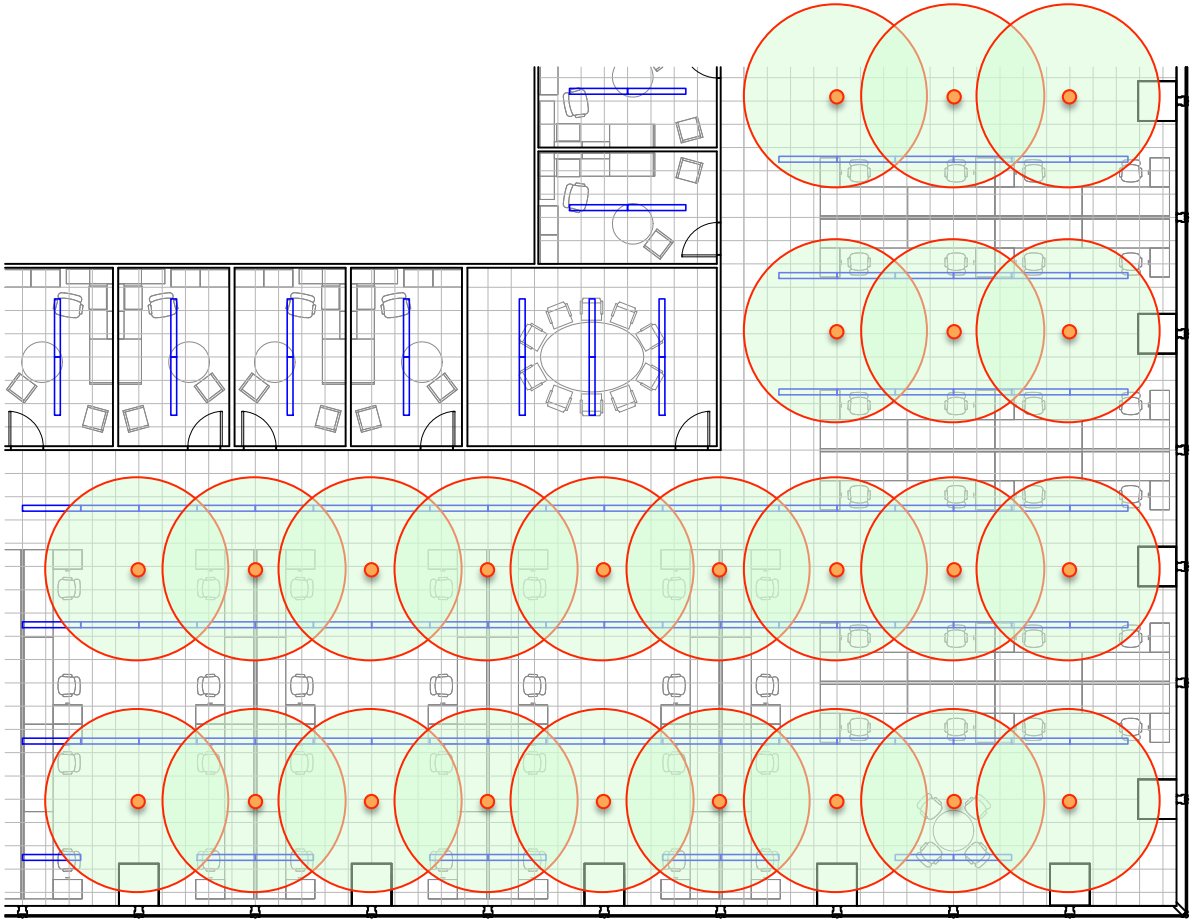
Some systems allow for "differential dimming" of fixtures within an occupancy zone – groups of fixtures can be dimmed to different levels based on the input from one photosensor (as shown above). However, each occupancy zone usually requires its own photosensor as well as occupancy sensor.

Zoning for systems where occupancy zones must exactly match daylight zones



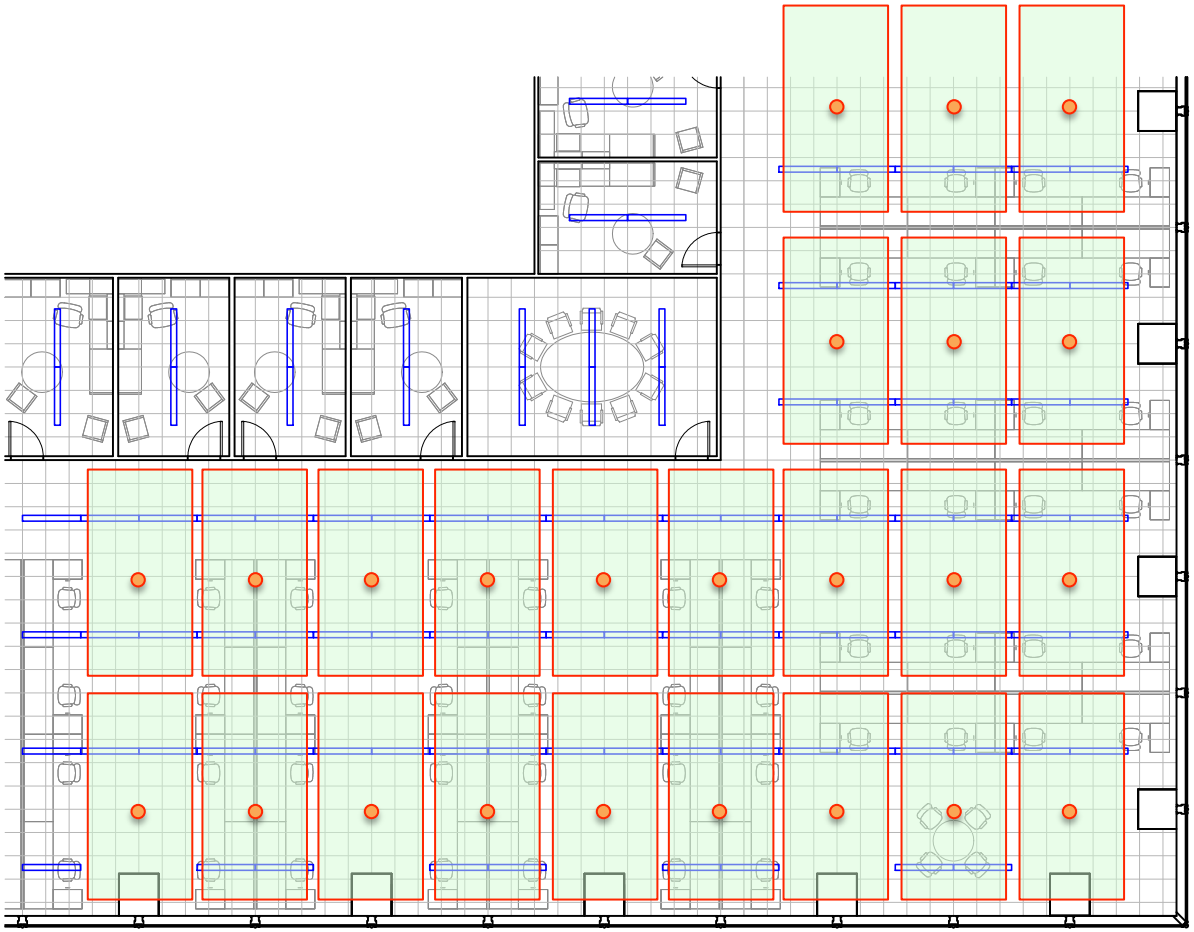
Certain systems require that fixtures responding to a photosensor **exactly** correspond to those in a distinct occupancy zone based on an occupancy sensor. If so, then zones for daylighting would be exactly the same as for occupancy (as shown above). Each zone would require its own occupancy sensor **and** photosensor, potentially increasing the cost of the system.

Occupancy sensor coverage (200 ft^2, radius=8')



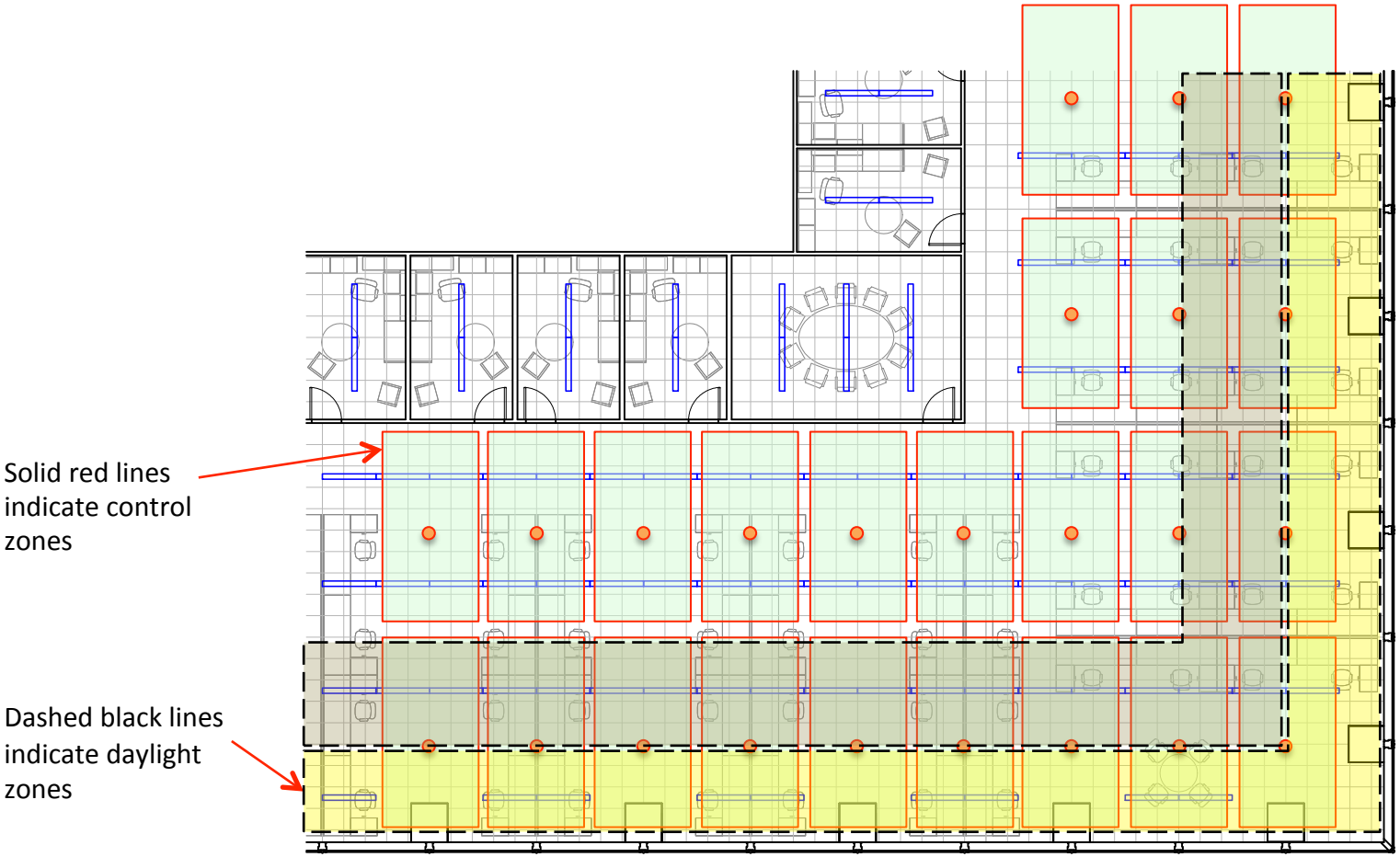
Certain occupancy sensors, such as those designed for use in individual fixtures, have a much smaller area of coverage. If these sensors are mounted separately (as shown), they can control small groups of fixtures. (In some systems, these sensors are combined with transceivers that communicate with a wireless gateway via RF transmission, then back to a server.)

High granularity – occupancy zones based on occupancy sensors with 200 ft^2 coverage



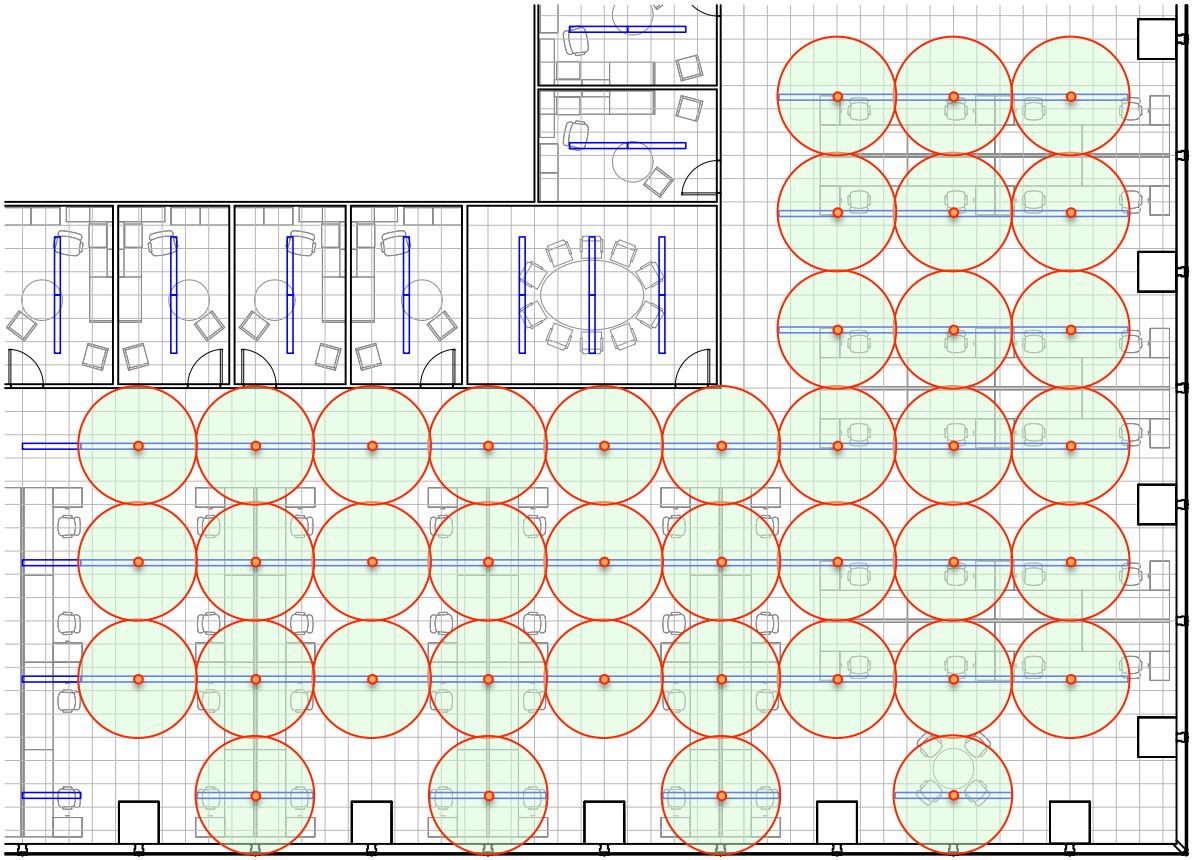
The benefit of having small occupancy zones is that there's a better chance that lights in certain zones will dim or turn off upon vacancy – as compared to those in larger occupancy zones where occupancy sensors have much greater areas of coverage. This will also result in a greater number of zones in the system's software. However, this is purely "administrative" and shouldn't have any significant impact on the operation of the system or the complexity for the owner.

Overlap of daylight zones with high granularity occupancy zones (using occupancy sensors with 200 ft^2 coverage)



Notice that in this example daylight zones do not coincide with the occupancy zones. When using a system that **<u>doesn't</u>** allow unrestricted mapping of fixtures to photosensors, it may be necessary to shift the occupancy and/or daylight zones (if possible). It may be worth considering the highest degree of granularity – using a system with integral occupancy sensors and photosensors in every fixture.

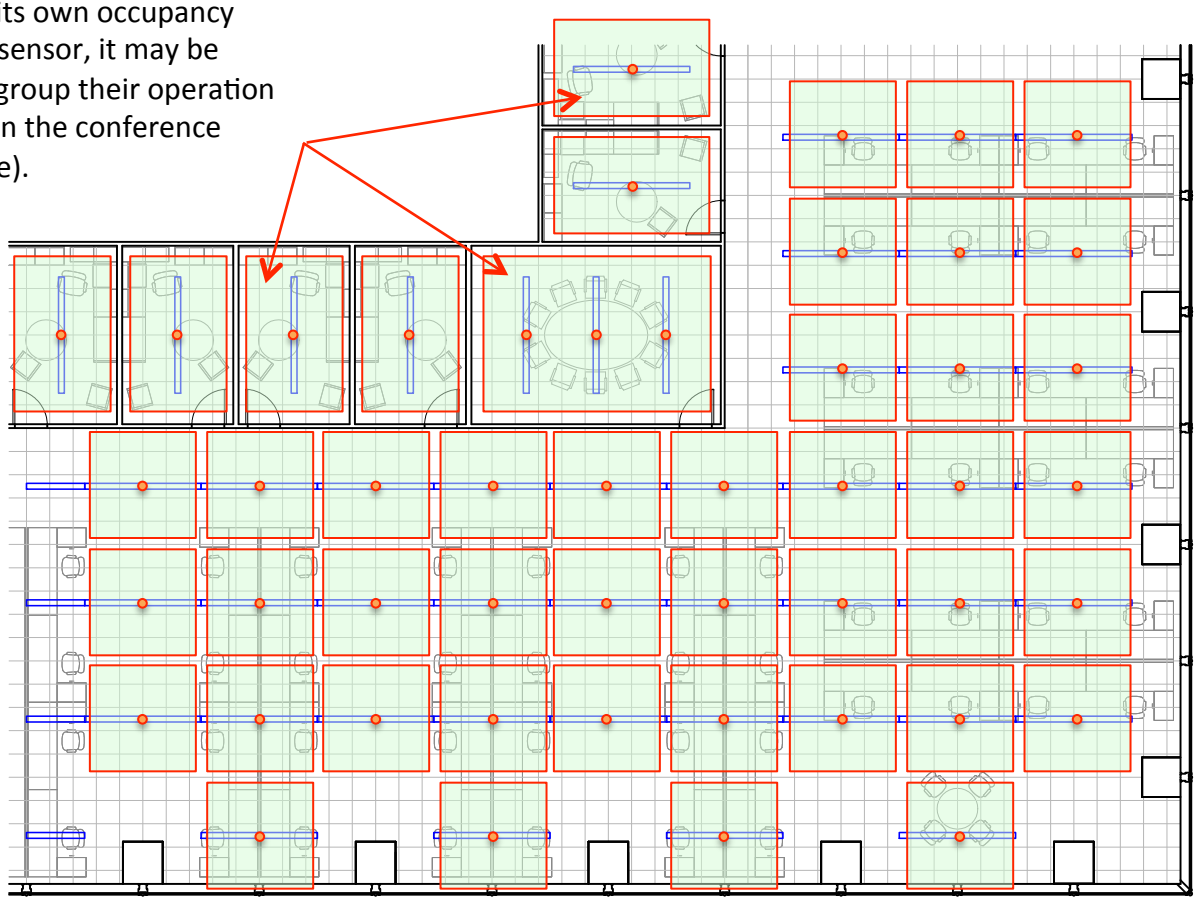
Fixture-integrated occupancy sensors (highest granularity)



Since the quantity of occupancy zones is typically unlimited in the system software, it's possible to use fixture-integrated sensors – every fixture has its own occupancy sensor and photosensor. Then each fixture can respond to daylight availability and occupancy based on its location on the plan.

Occupancy zones using fixture-integrated occupancy sensors (highest granularity)

Even though every fixture in each of these spaces has its own occupancy sensor and photosensor, it may be advantageous to group their operation and behavior (as in the conference room, for example).



Using fixture-integrated photosensors and occupancy sensors results in the greatest amount of hardware. However, as shown in the conference room above, it may still be preferable to use one photosensor and one occupancy sensor to control all fixtures within certain spaces. Alternatively, some systems that rely on fixture-integrated sensors allow for the creation of “groups” even though every fixture still has it own sensor – for open or enclosed spaces.

Occupancy zones using fixture-integrated multi-sensors (highest granularity)

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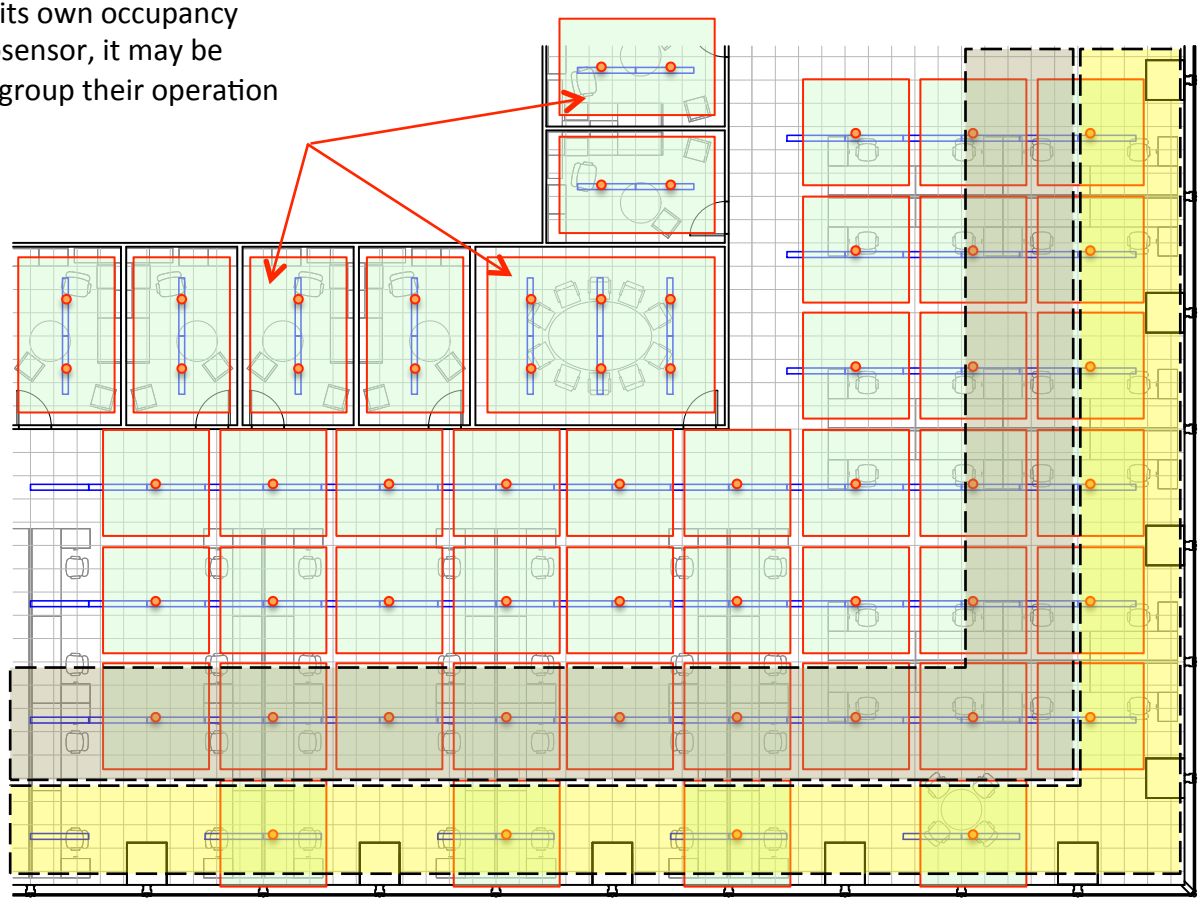


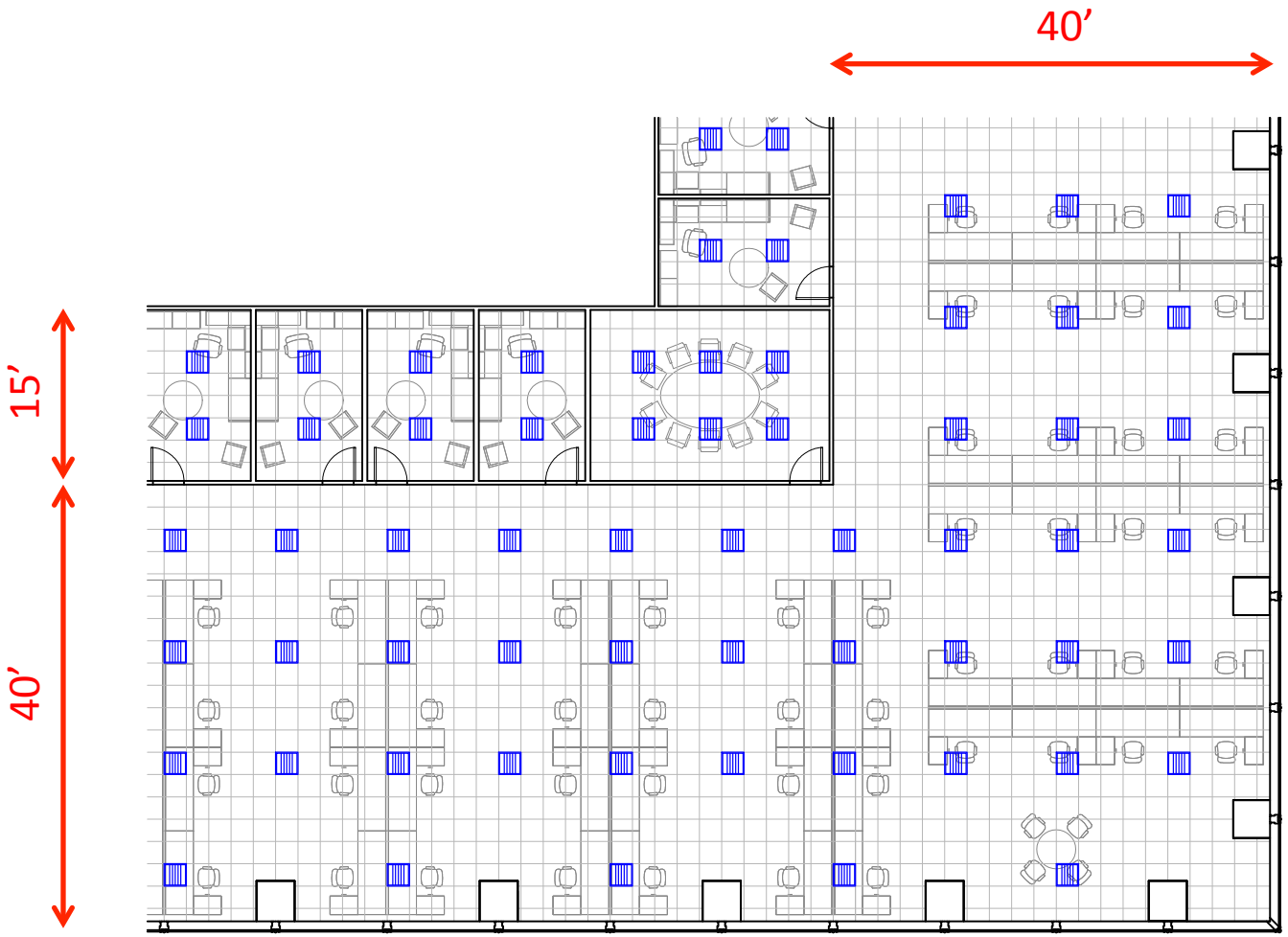
If the fixtures contain both an occupancy sensor as well as photosensor (sometimes combined into a single unit called a "multi-sensor"), then it's likely that each fixture can be appropriately programmed to respond to available daylight as well as occupancy.

Questions to ask about zoning when specifying a lighting control system

- Do code provisions specify or limit the size or shape of daylight or occupancy zones? For example:
  - Occupancy (control) zones must be limited to a maximum of 5,000 ft^2? 1,000 ft^2? ____ ft^2?
  - Daylight zones: width must equal window head height for primary and secondary daylight zones?
- Control of fixtures in daylight zones. For example:
  - Provisions must be made for manual control in primary daylight zones only?
  - All lights in primary as well as secondary daylight zones must be automatically controlled?
- Does the owner have specific needs for controlling groups of fixtures? For example:
  - Fixtures over each open desk group must be controlled separately?
  - Fixtures in each department must be controlled separately from those in other departments?
  - Fixtures lighting circulation areas must be controlled separately from those lighting desks or other work spaces? (This may help to provide "wayfinding" after hours, and/or to reduce energy use.)
- Are DR (demand response) provisions required? For example:
  - Provisions must be made to automatically dim or turn off fixtures during a DR "event". However, the owner needs to control which zones can be dimmed more … or less … or not at all.

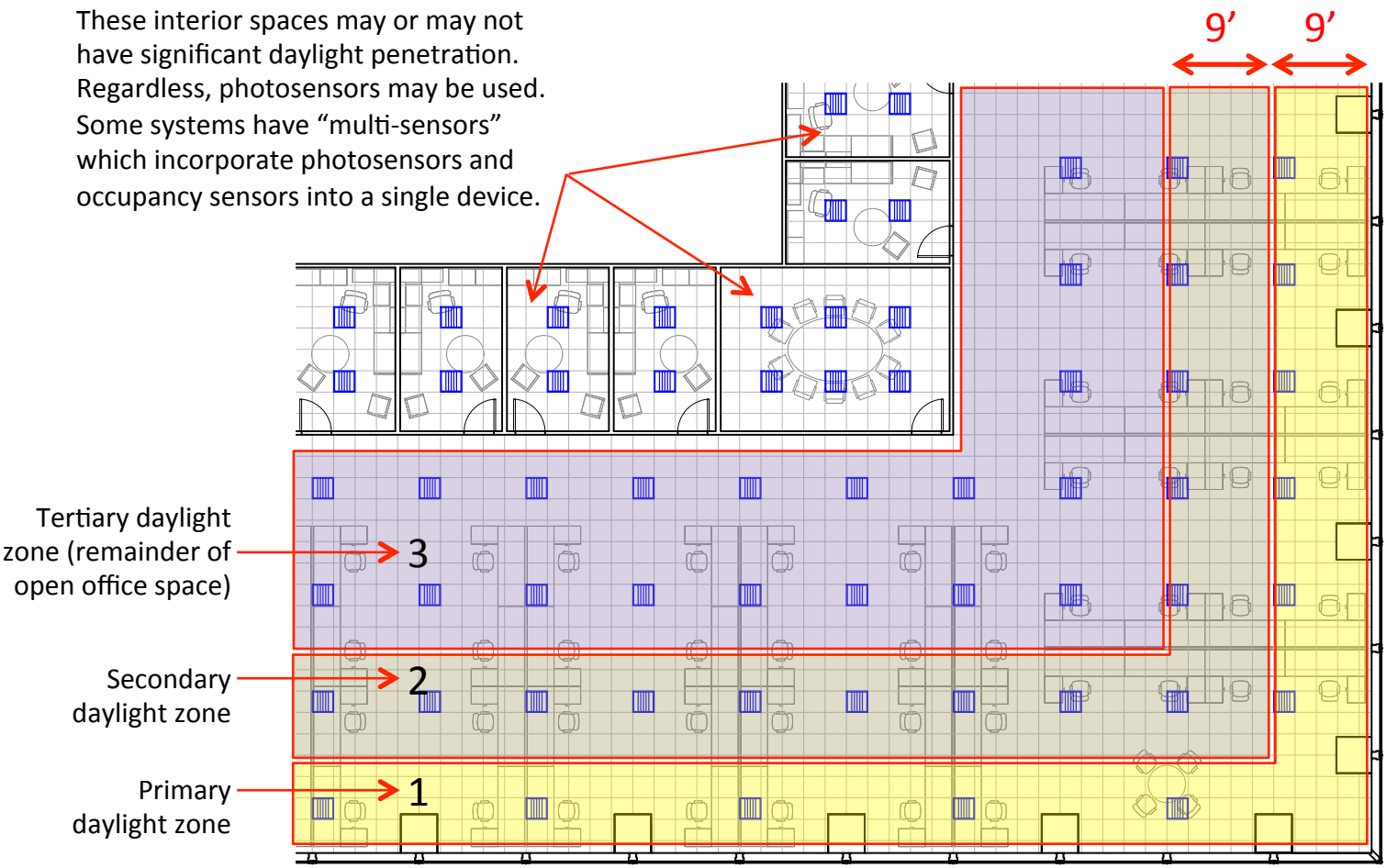
Granularity in offices with individual recessed fixtures

Open office floor plan with recessed troffers



This is an example office space with open office areas at the perimeter, and private offices and conference rooms adjacent to the core. In this example, individual recessed fixtures are used. The ceiling height is 9’-0” and the exterior is a full-height window wall.

Daylight zones



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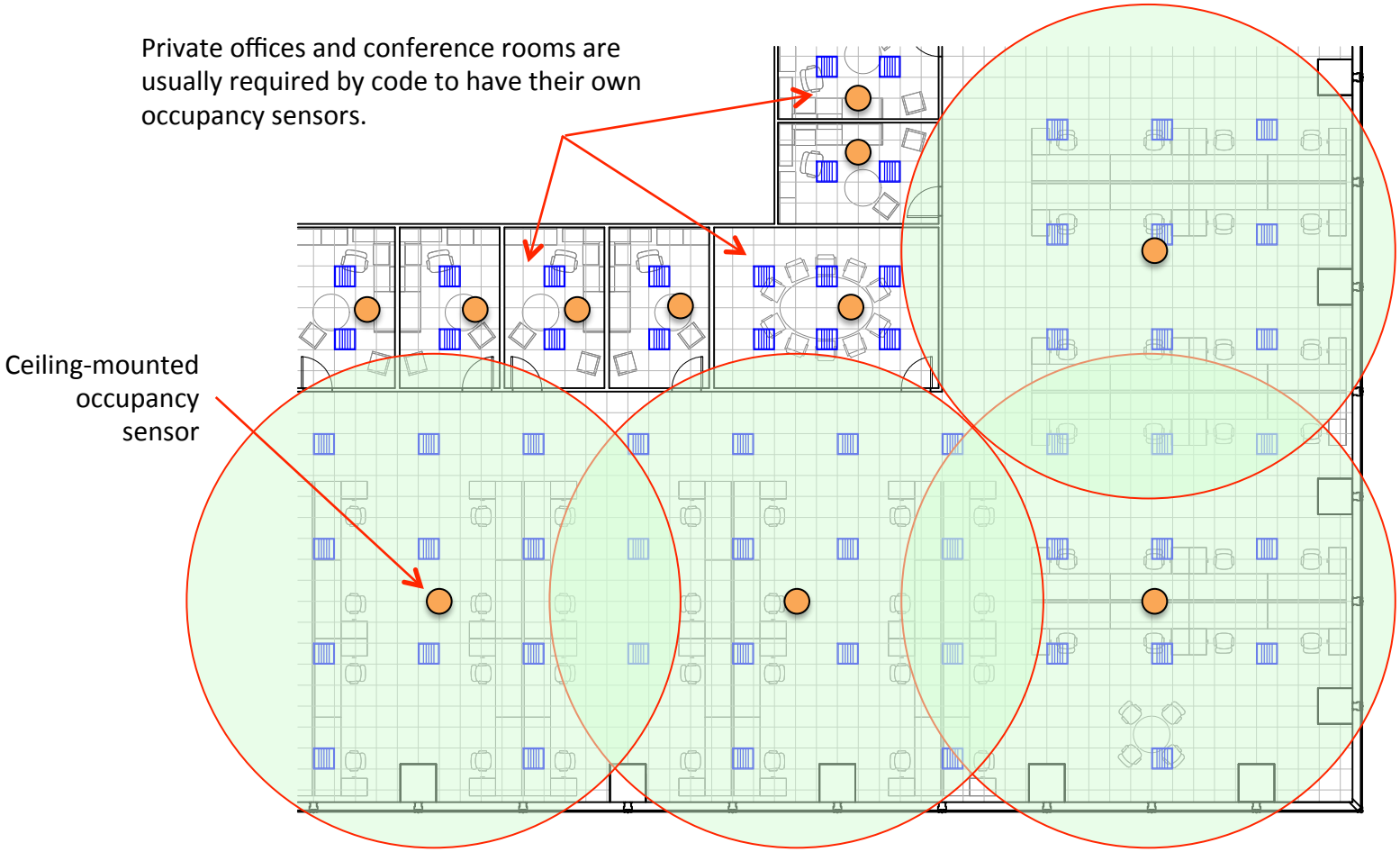
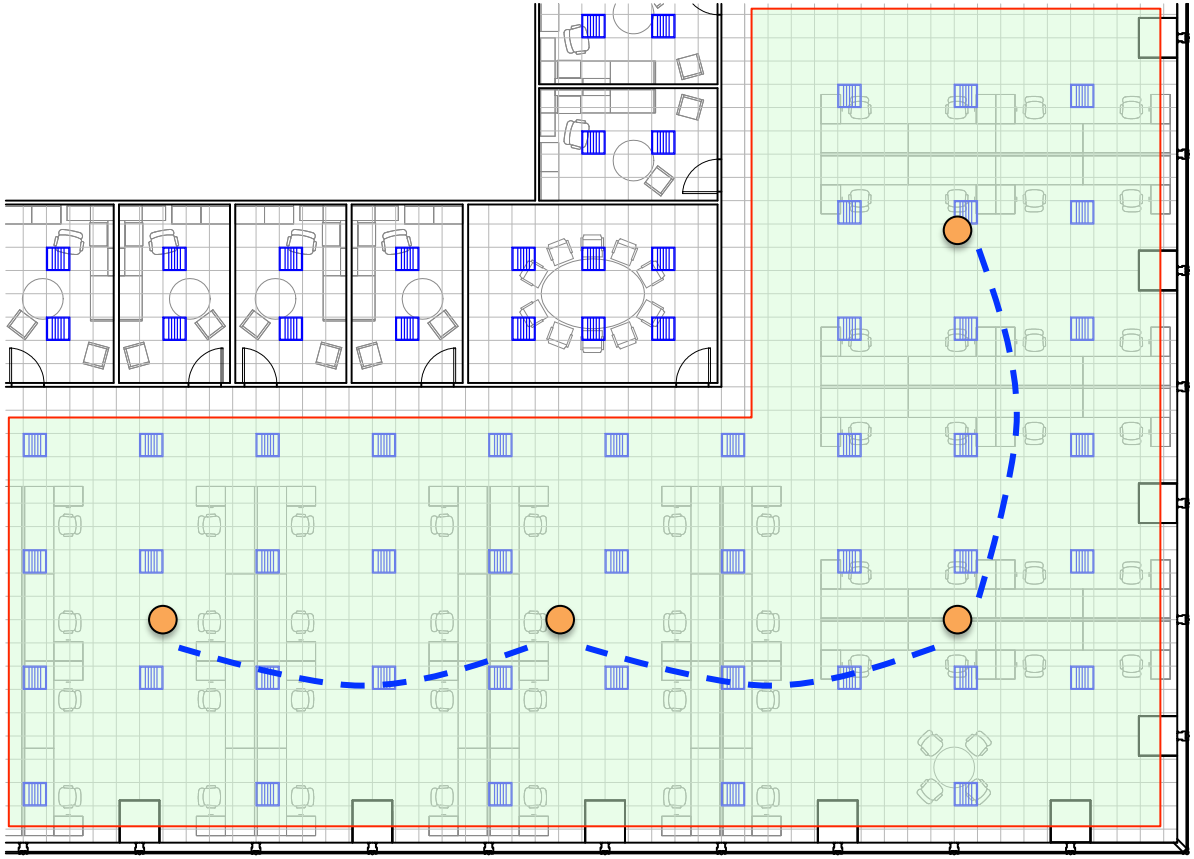
Occupancy sensor coverage in open office space (2,000 ft^2, radius=25')



The green circles represent the coverage pattern of typical ceiling-mounted occupancy sensors with 2,000 ft^2 coverage in open office areas.

Occupancy sensors used in parallel operation in open office areas



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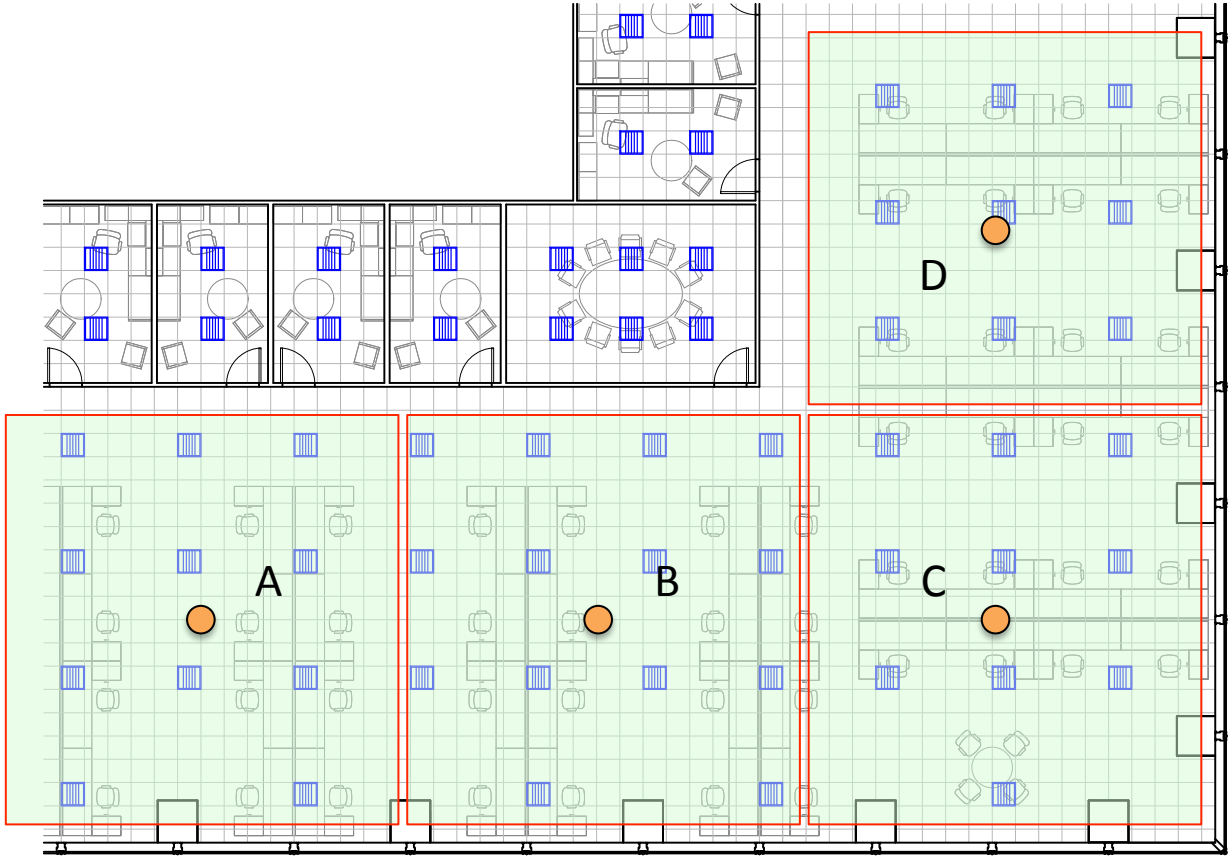
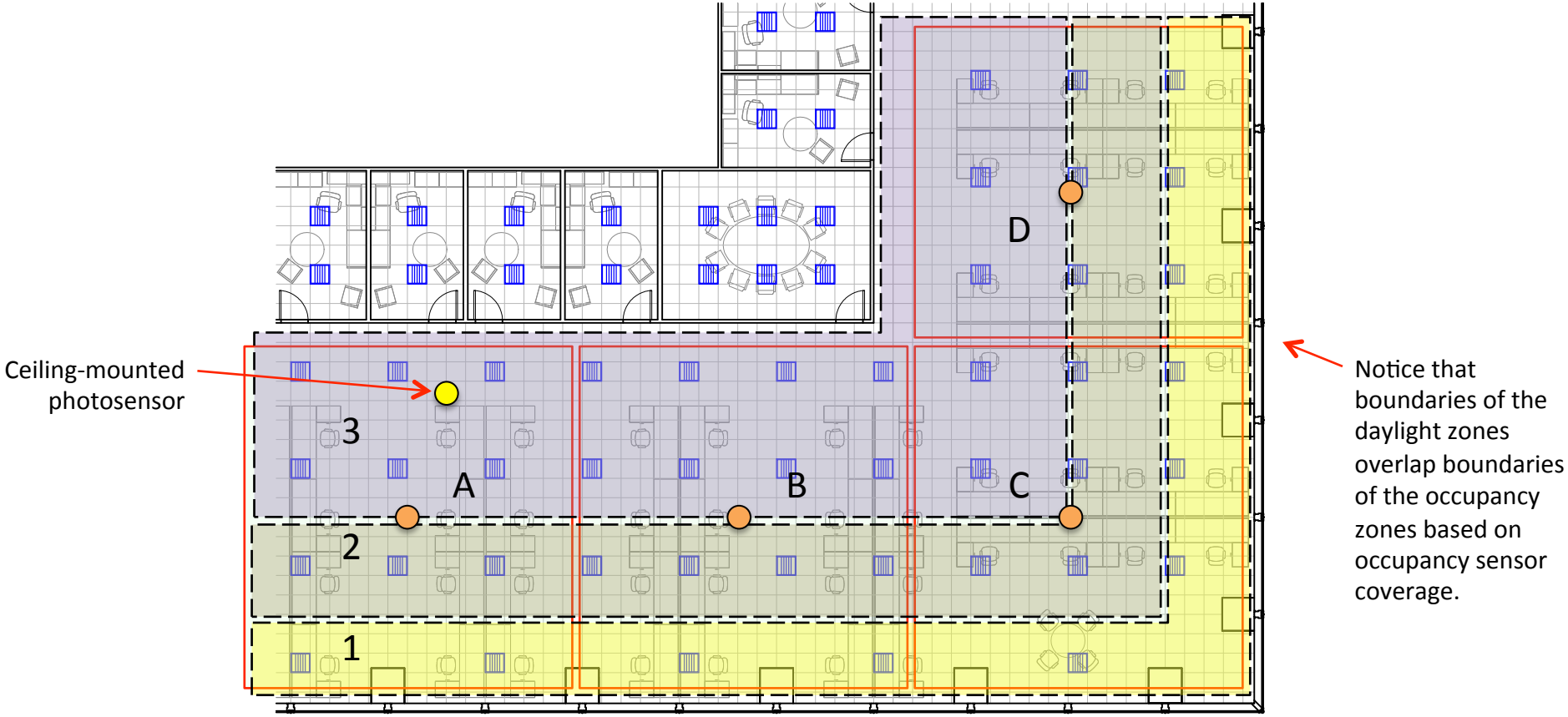
Low granularity – occupancy zones based on occupancy sensors with 2,000 ft^2 coverage



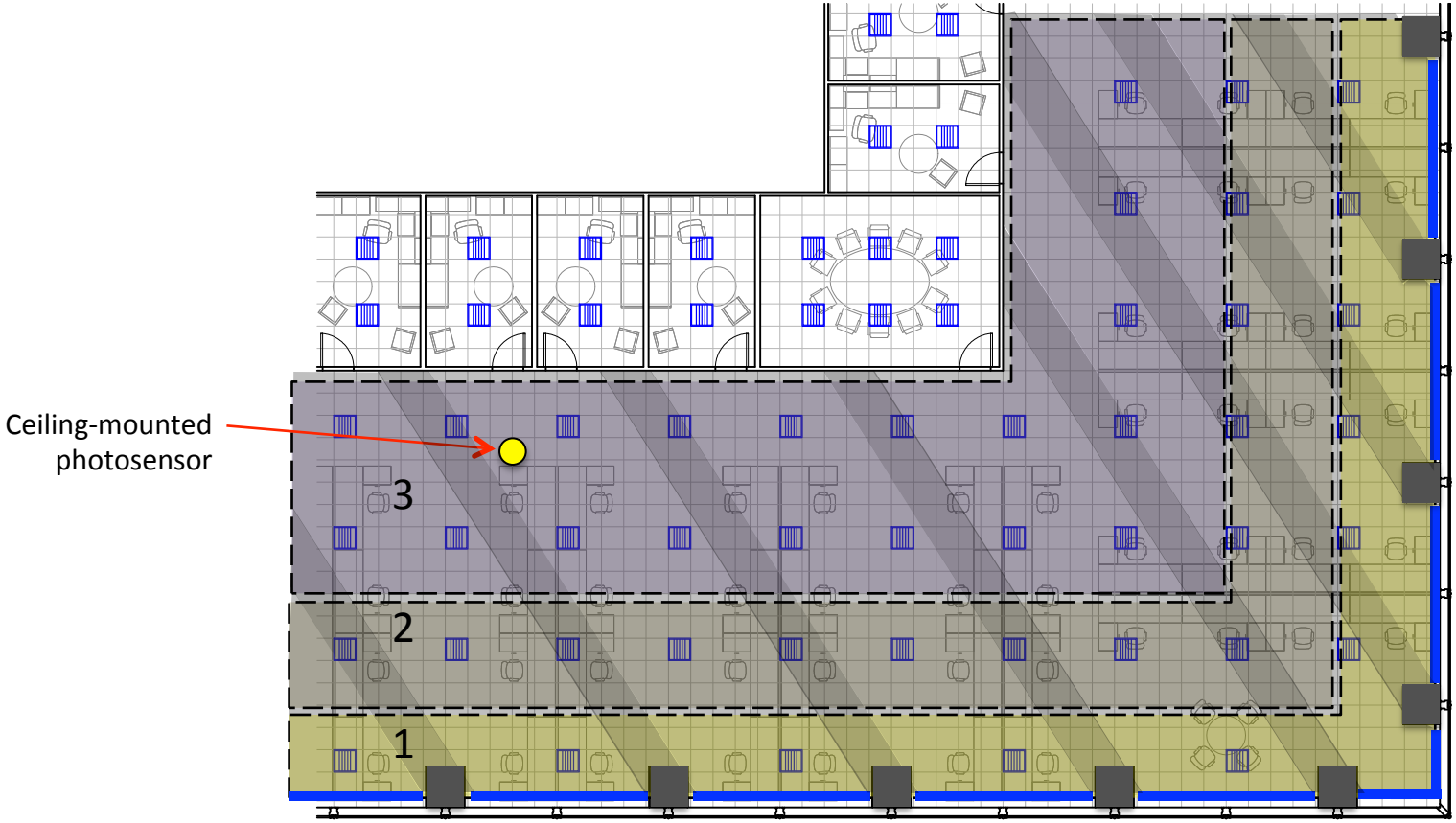
Establishing occupancy zones (as designated by letters in the above example) based on the coverage of each occupancy sensor allows groups of lights to be separately controlled. Once there is a distinct occupancy zone for each occupancy sensor, there's a greater chance of reducing energy use – since lights in a specific zone will dim or turn off once that zone is vacant.

Overlap of daylight zones with low granularity occupancy zones (using occupancy sensors with 2,000 ft^2 coverage) – unrestricted mapping of fixtures to photosensors



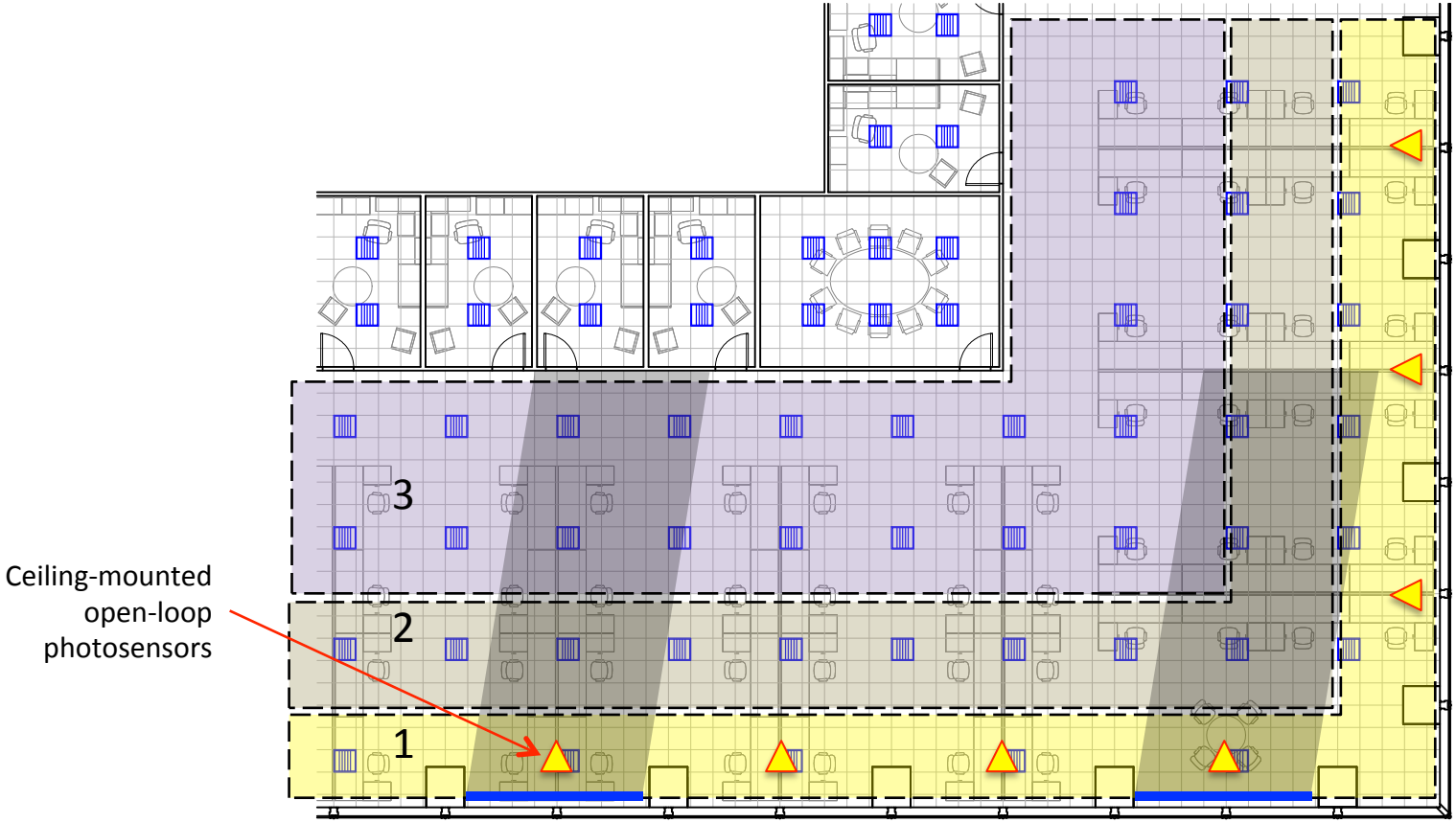
When these daylight zones are overlaid onto the occupancy zones, they overlap (they are not aligned). Some lighting control systems allow **<u>any</u>** fixture to be mapped to **<u>any</u>** photosensor – regardless of which control zone they're in. If such a system is used, then daylight zones **<u>do not need to align</u>** with control zones (as shown above). Additionally, some systems can work with as little as one photosensor for an entire open office area, reducing equipment and labor costs.

Using photosensors to automatically adjust electric lights in response to shading systems



A shading system may be installed without individual “user override” control. In that case, it’s reasonable to expect that all fixtures within a specific “daylight zone” should dim to the same level for uniform lighting. However, it may be desirable to split each zone as shown into separate subzones based on the predominant exposure of the façade. For example, even with the same shades, fixtures near the east façade may need to be dimmed differently than those near the south façade.

Using open-loop photosensors to accommodate differences in façade shading

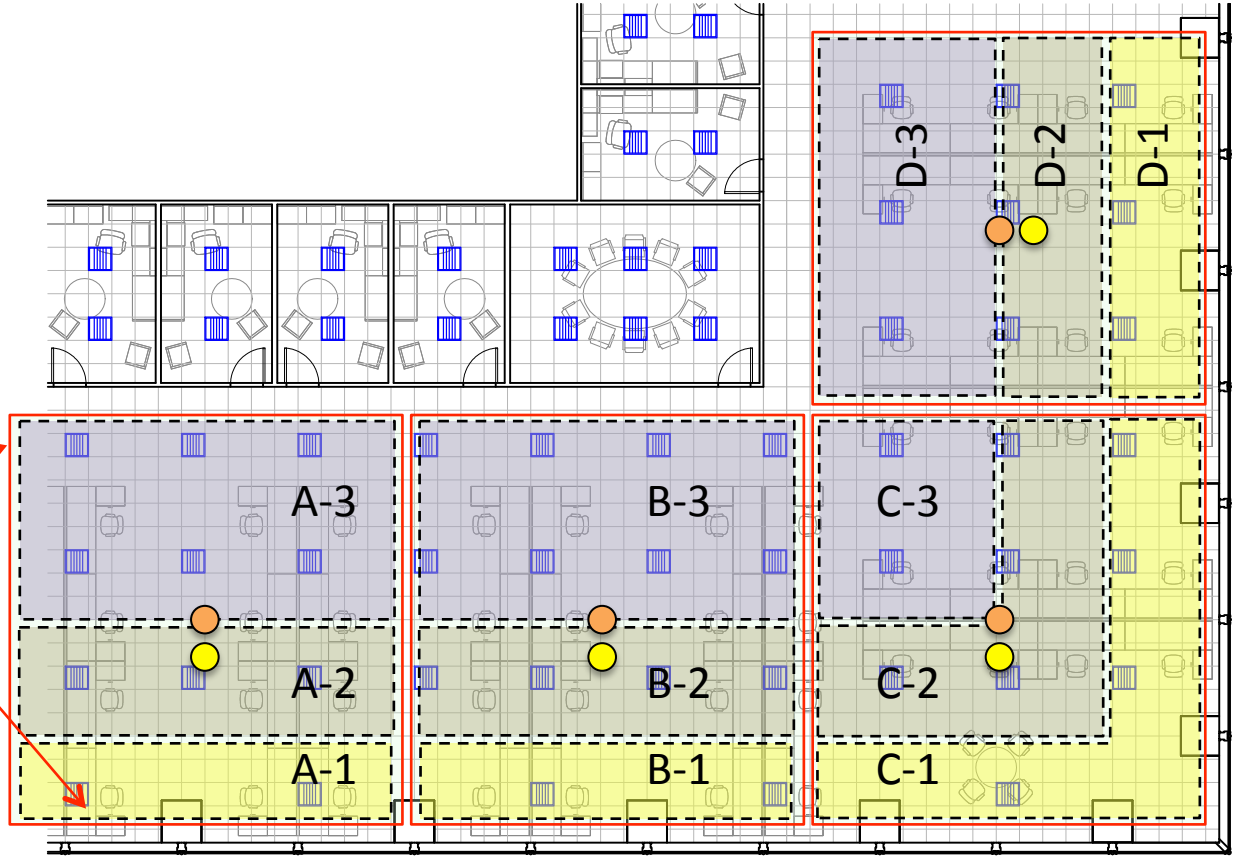


Many shading systems allow each section to be separately controlled – either manually and/or automatically. If so, then a logical strategy would be to use one "open-loop" photosensor corresponding to each shade. If a system is used that allows for unrestricted mapping of fixtures to photosensors, then the owner can decide which photosensor controls which fixture. In some systems, signals from more than one photosensor can be programmed to appropriately dim each specific fixture.

Separation of daylight zones for systems that **do not** allow unrestricted mapping of fixtures to photosensors

Solid red lines indicate occupancy zones

Dashed black lines indicate daylight subzones



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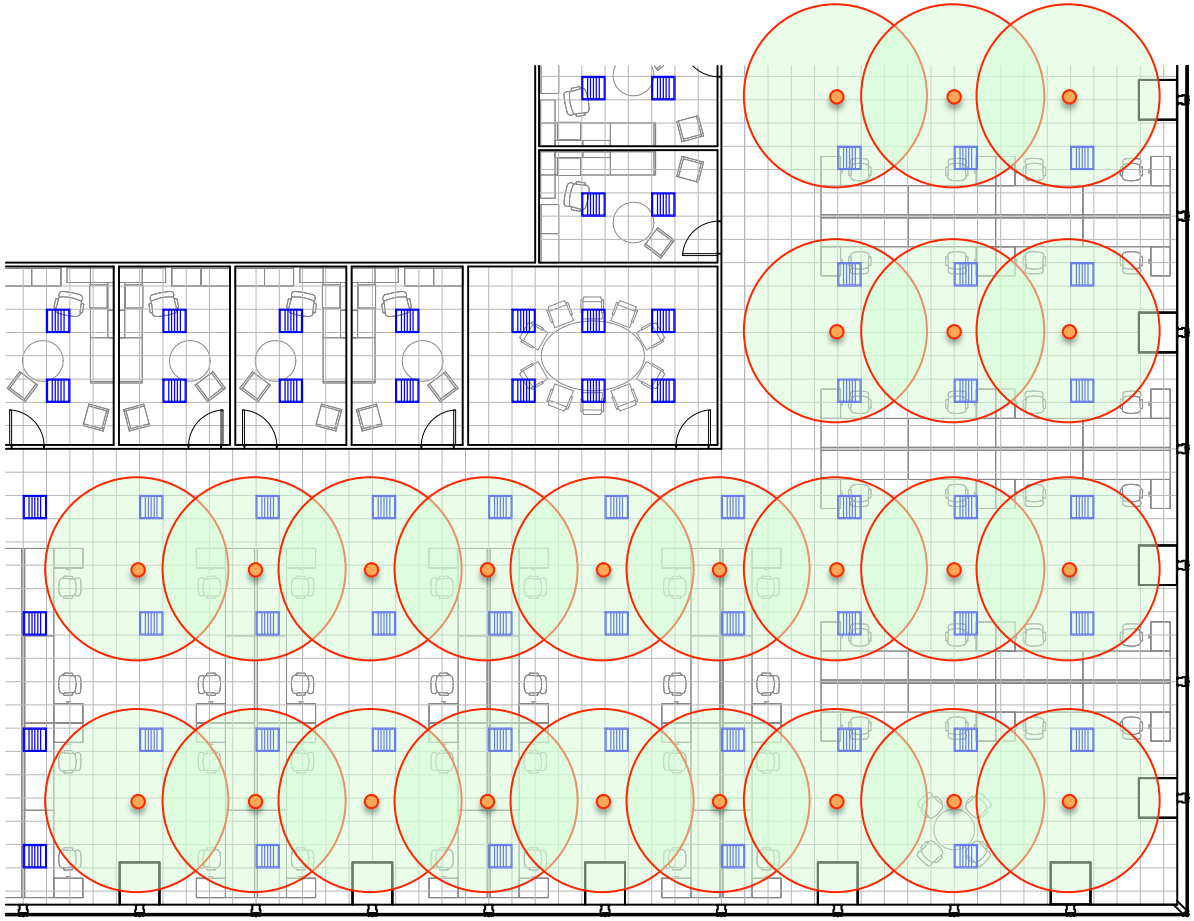
Occupancy sensor coverage (200 ft^2, radius=8')



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High granularity – occupancy zones based on occupancy sensors with 200 ft^2 coverage

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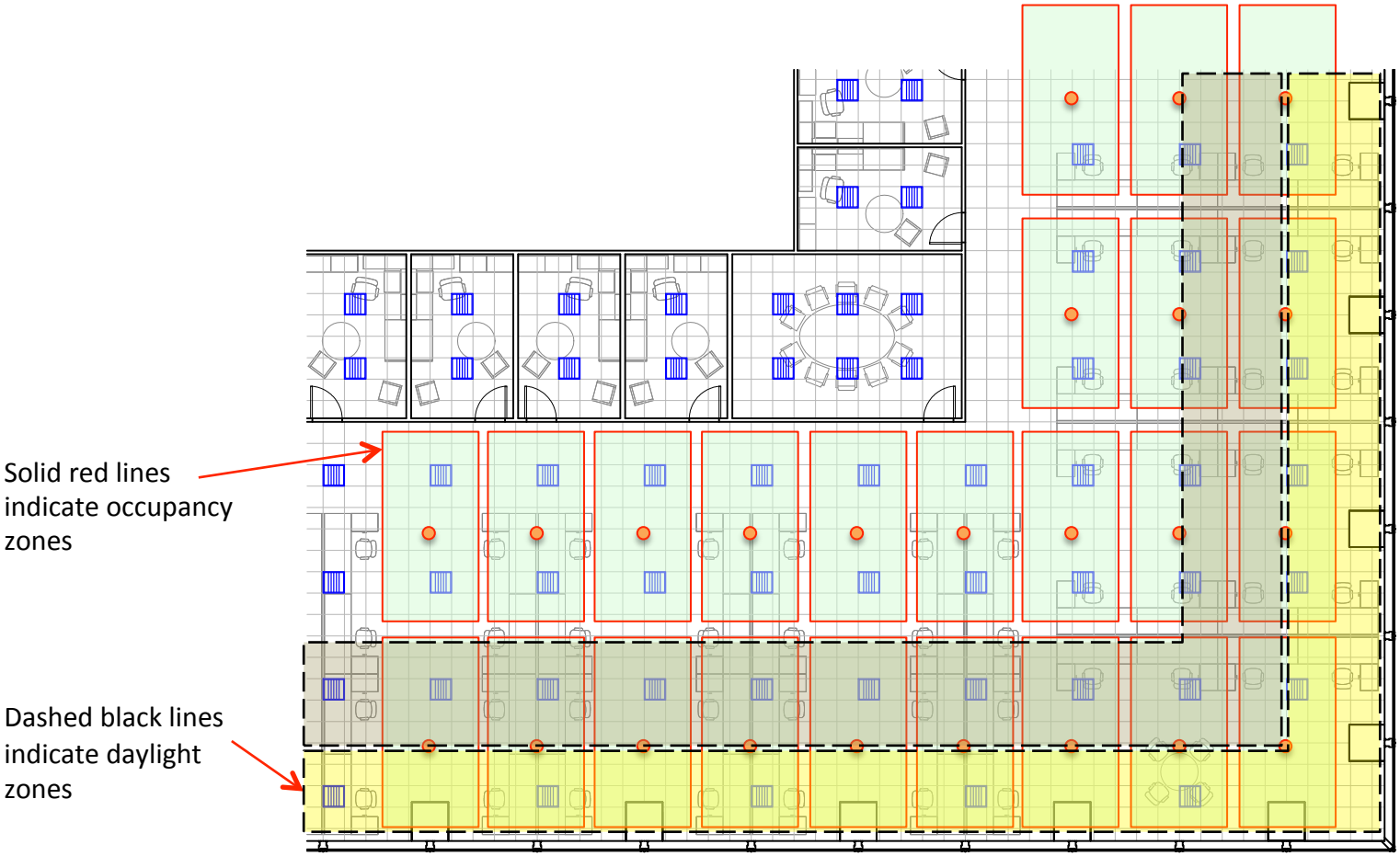
Overlap of daylight zones with high granularity occupancy zones (using occupancy sensors with 200 ft^2 coverage)



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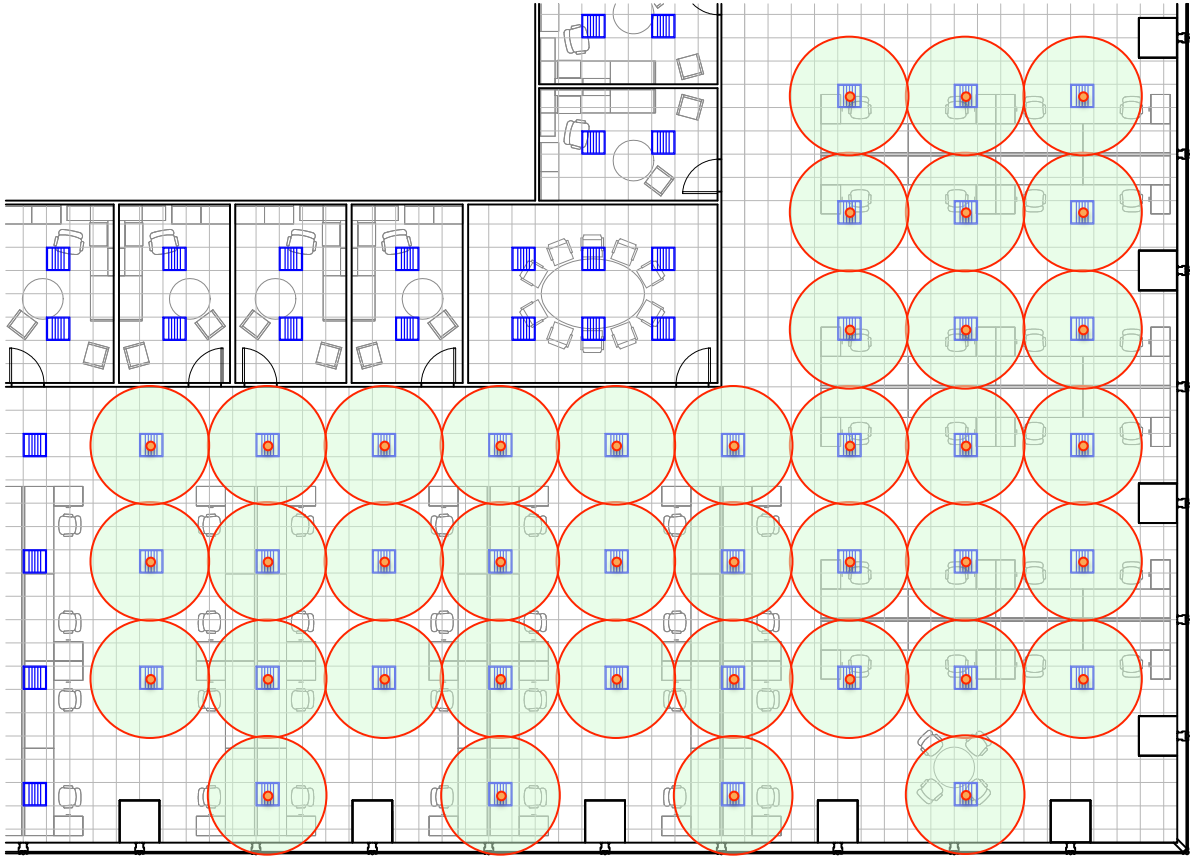
Fixture-integrated occupancy sensors (highest granularity)



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Occupancy zones using fixture-integrated occupancy sensors (highest granularity)

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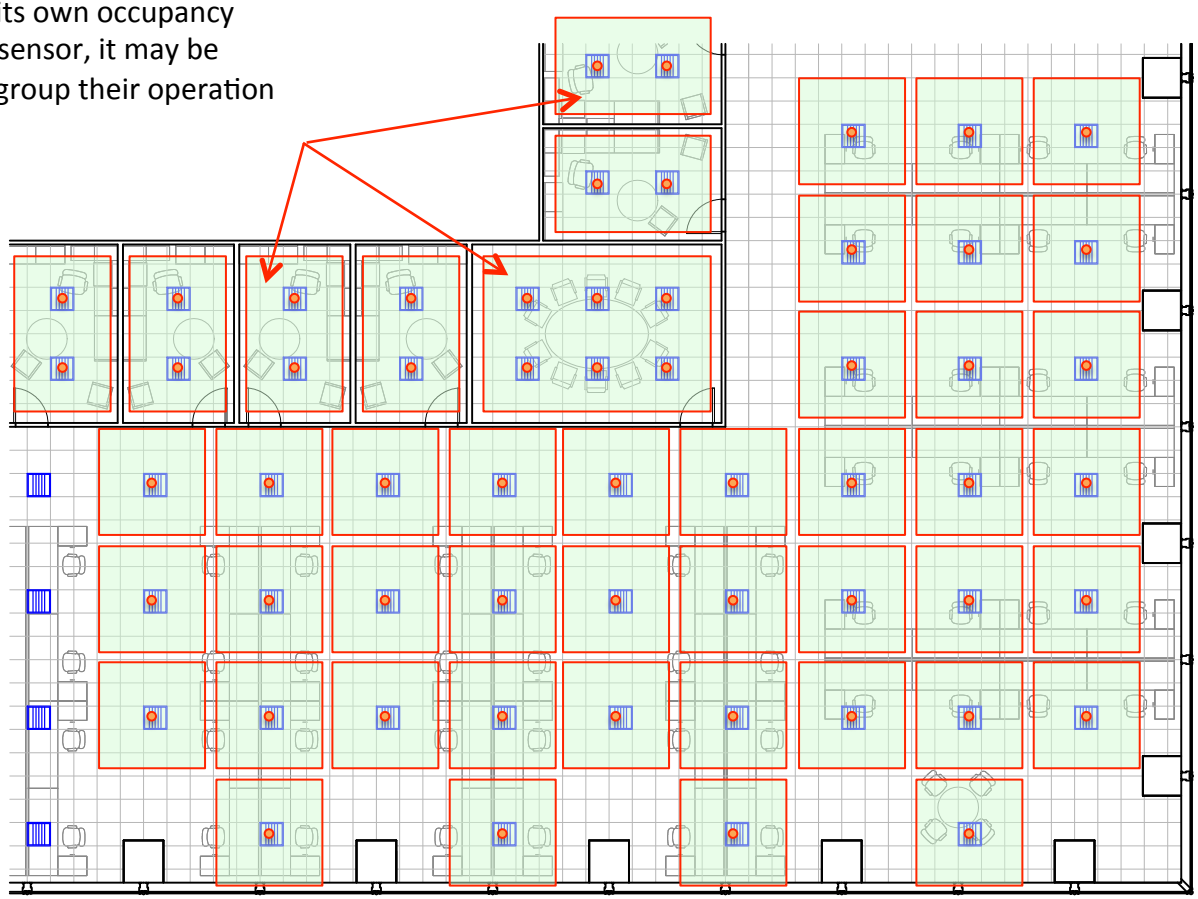

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Occupancy zones using fixture-integrated multi-sensors (highest granularity)

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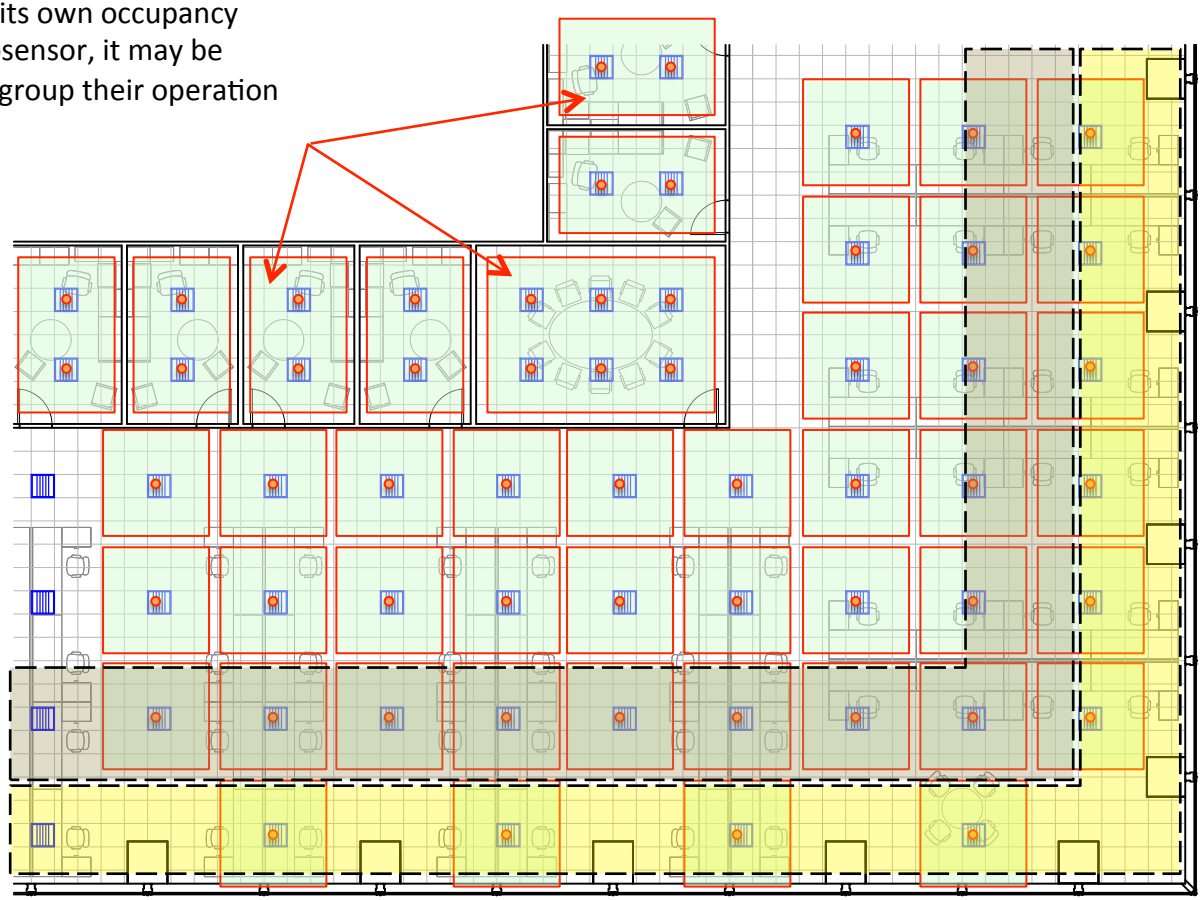

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