Using Graphs: Visibility Culling

(slides based on those of David Luebke)

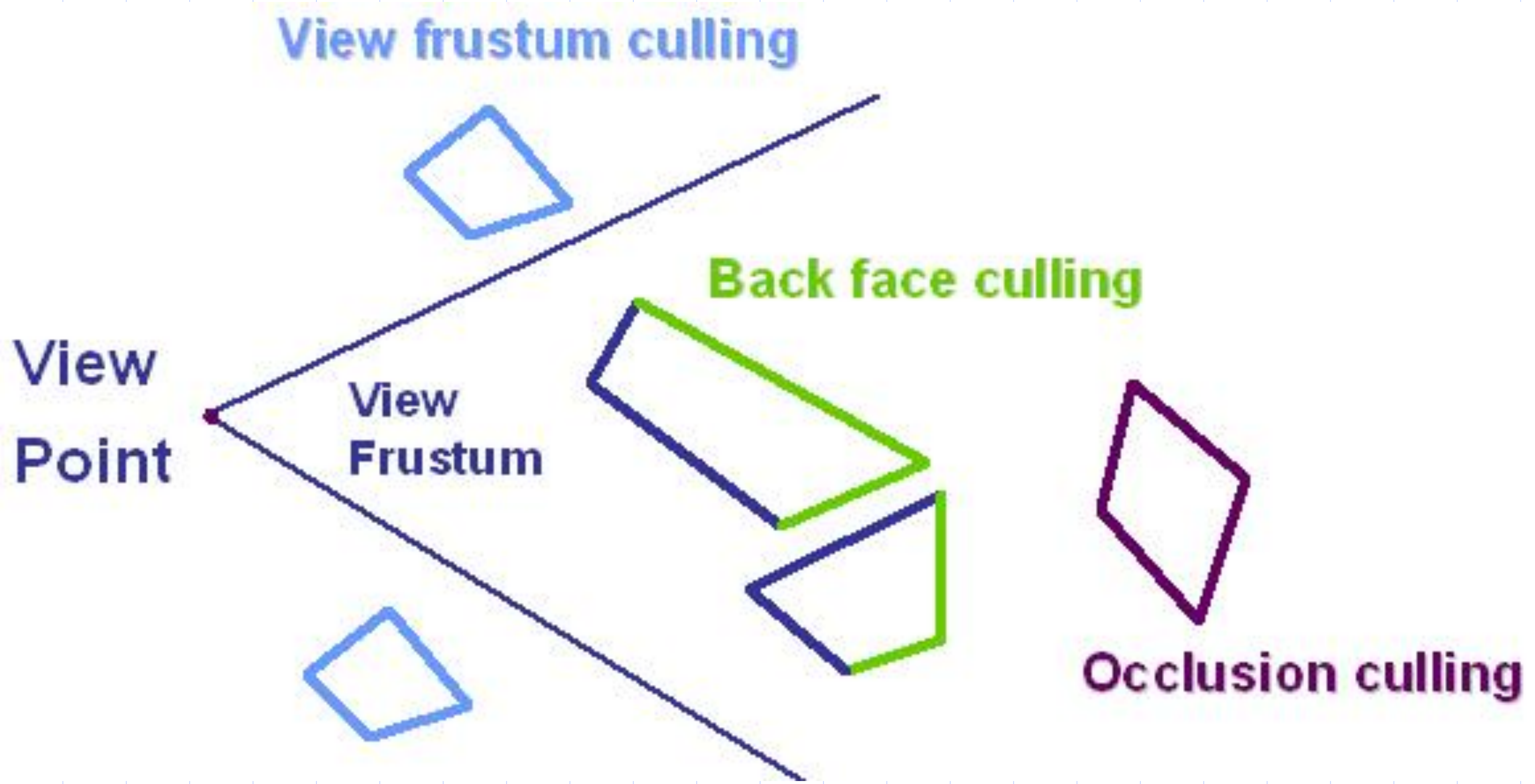
Motivation

- When rendering/displaying objects on a computer screen, we do not need to draw objects that are not visible
- Thus, visibility culling = cull away non-visible objects
- The graphics-card (z-buffer) does this but *after* transformation; we want to do it *before* it even reaches the graphics card

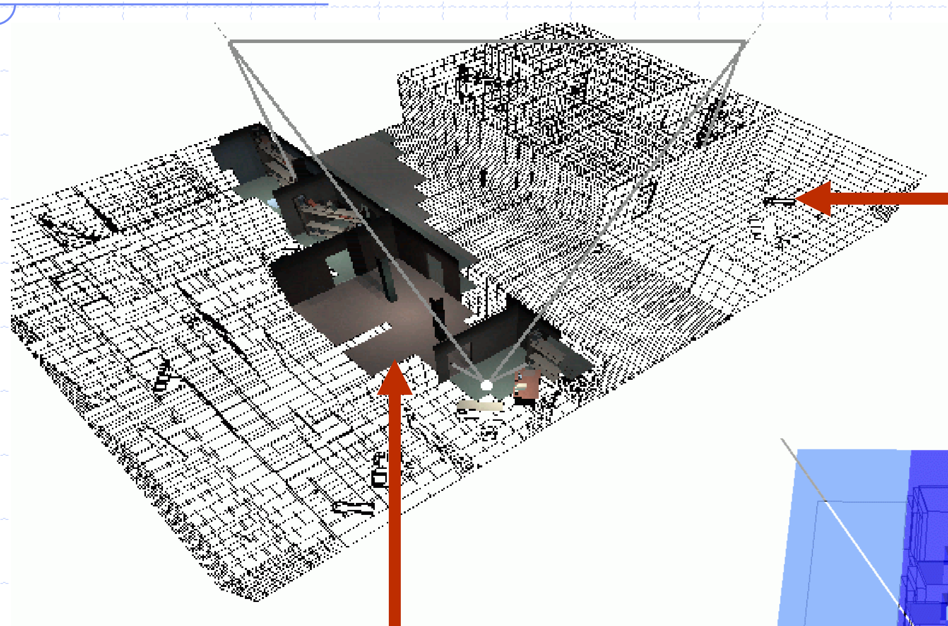
Visibility Culling vs. Level-of-detail Simplification

- Level-of-detail (LOD) simplification is related to visibility culling but is <u>not</u> the same thing
  - LOD "simplifies" the visible object(s)
  - Visibility culling does not change what is rendered/displayed – it just reduces the unnecessary work of rendering non-visible geometry

Types of visibility culling

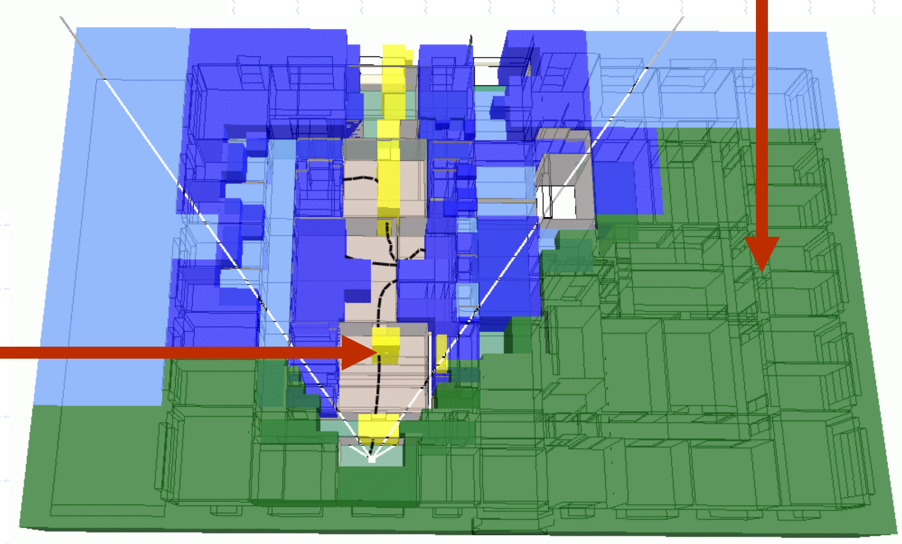


Examples of visibility culling

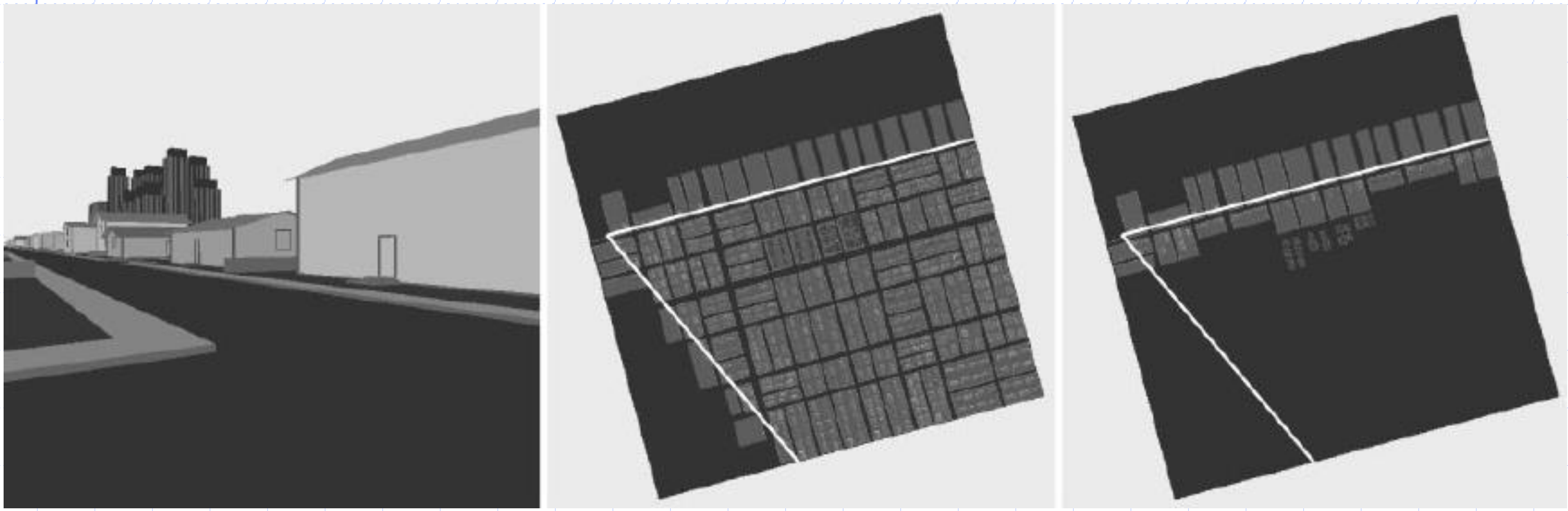


not-visible

(potentially) visible



Examples of visibility culling



Visibility Culling

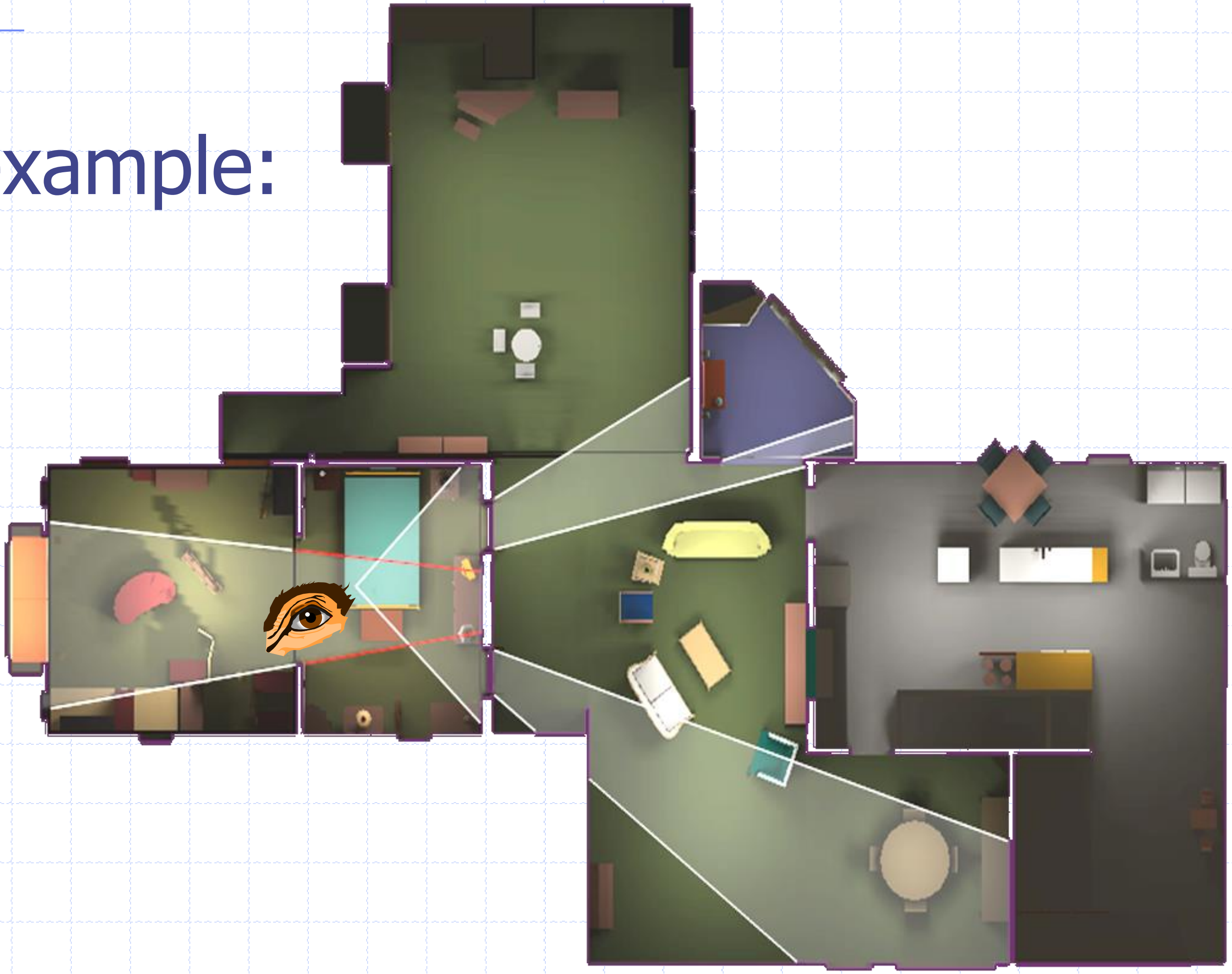
- Let’s focus on architectural models…

Portal Culling

- Goal: walk through architectural models (buildings, cities, catacombs)
- These divide naturally into *cells*
  - Rooms, alcoves, corridors…
- Transparent *portals* connect cells
  - Doorways, entrances, windows…
- Notice: cells only see other cells through portals

Cells & Portals

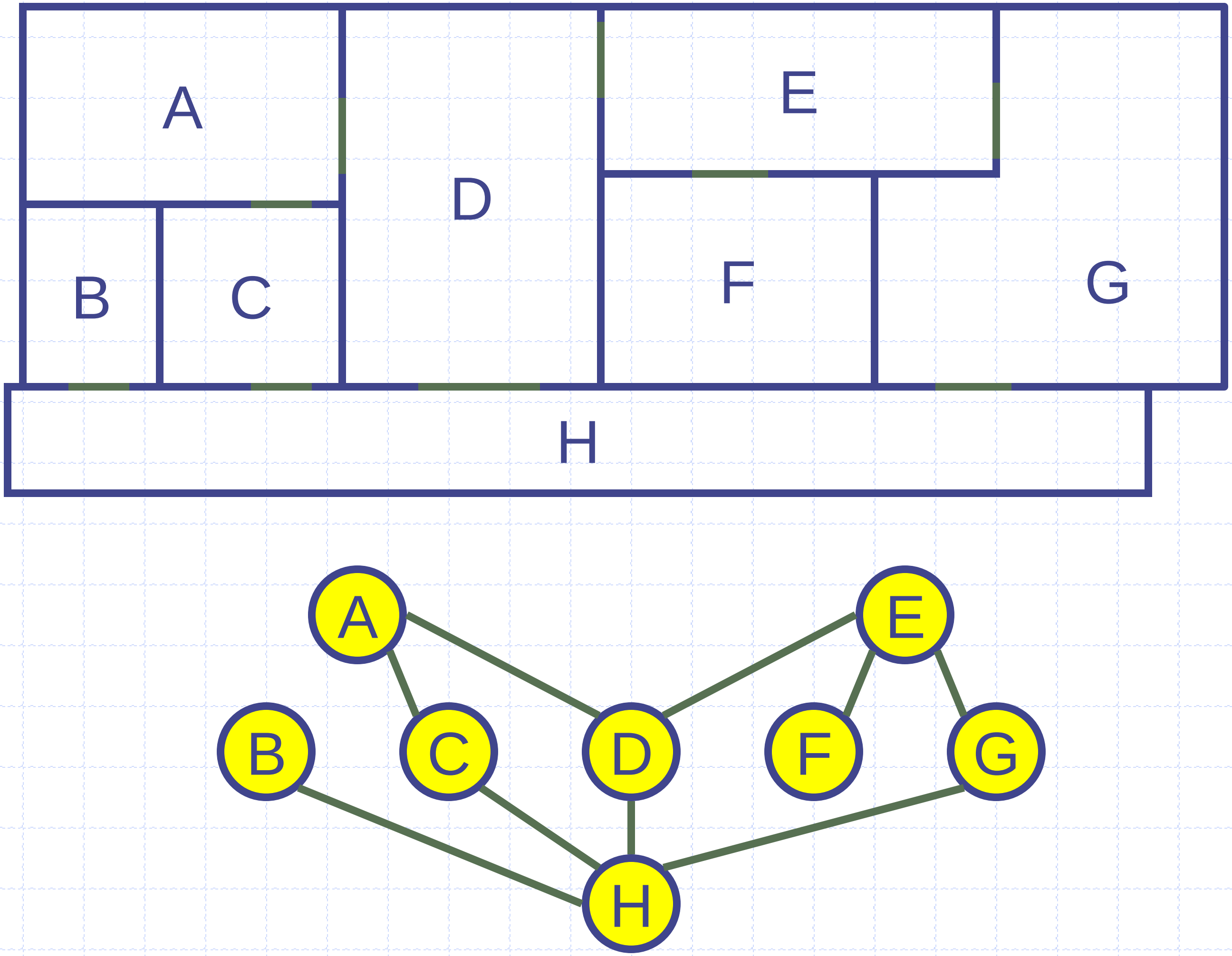
- An example:



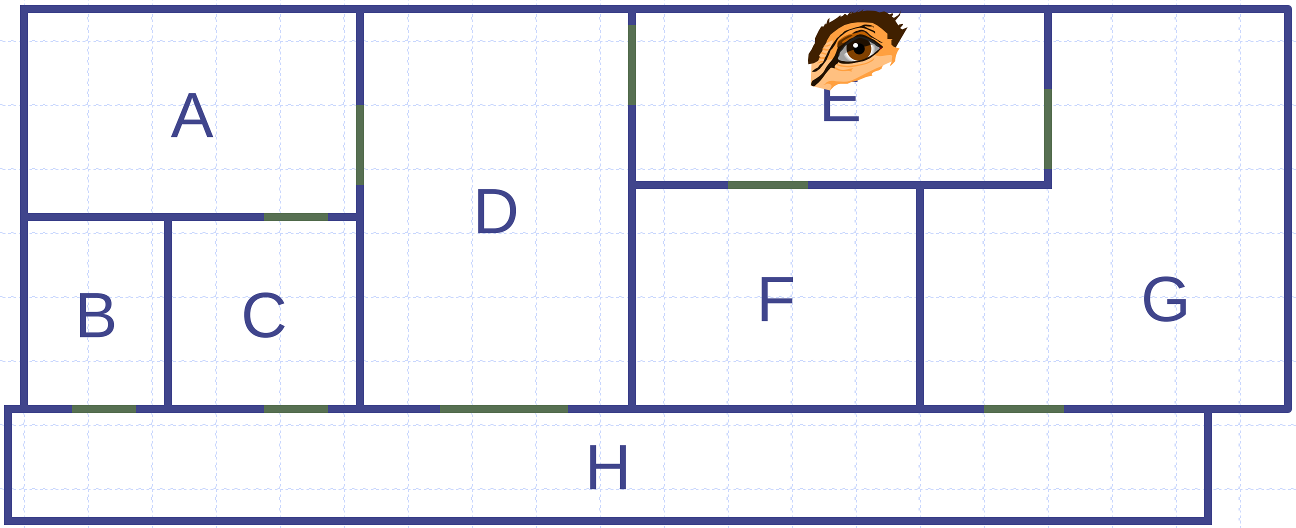
Cells & Portals

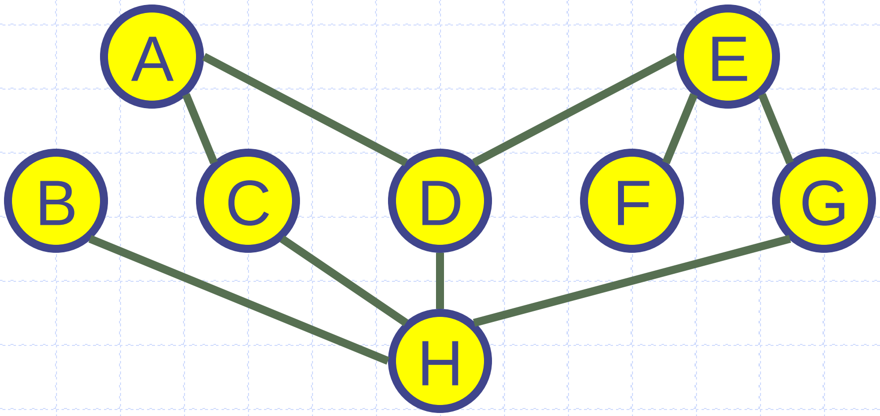
- Visibility Culling Idea:
  - Create an *adjacency graph* of cells
  - Starting with cell containing eyepoint, traverse graph, rendering visible cells
  - A cell is only visible if it can be seen through a sequence of portals
    - So cell visibility reduces to testing portal sequences for a *line of sight…*

Cells & Portals

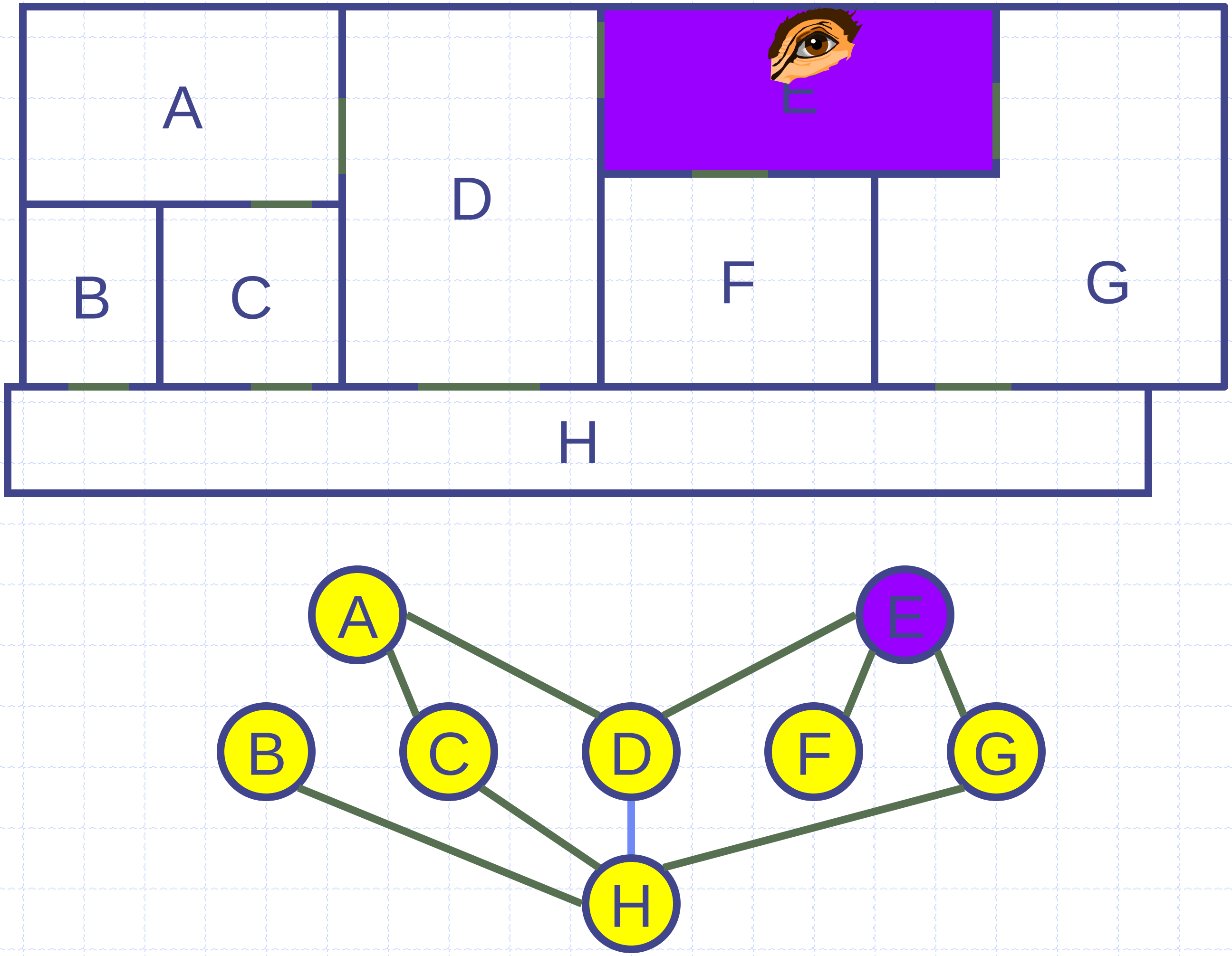


Cells & Portals

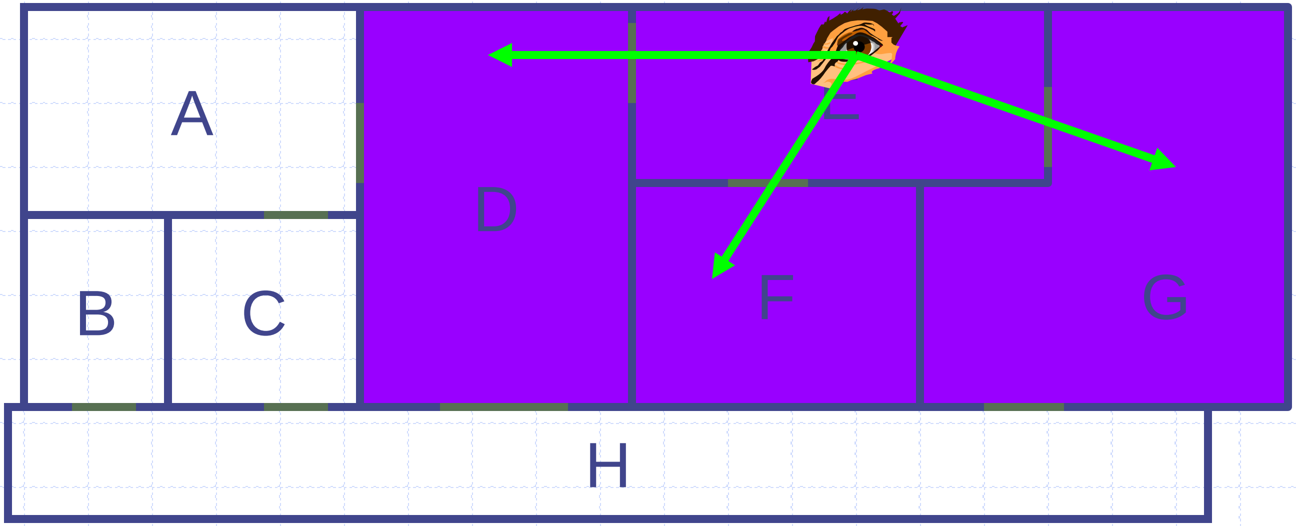


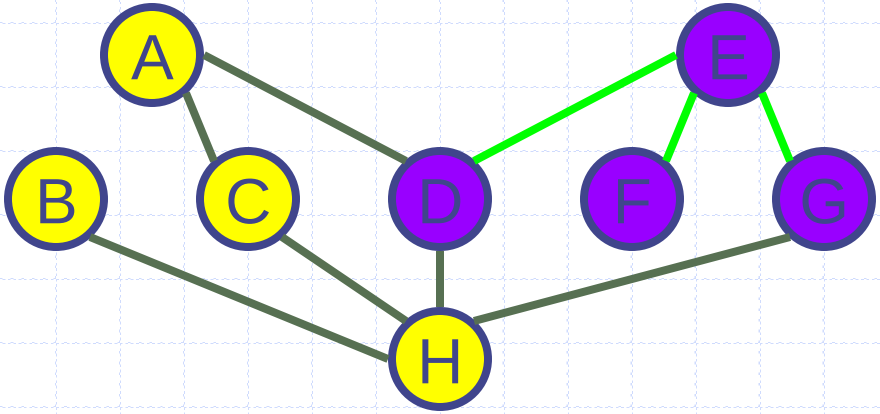


Cells & Portals

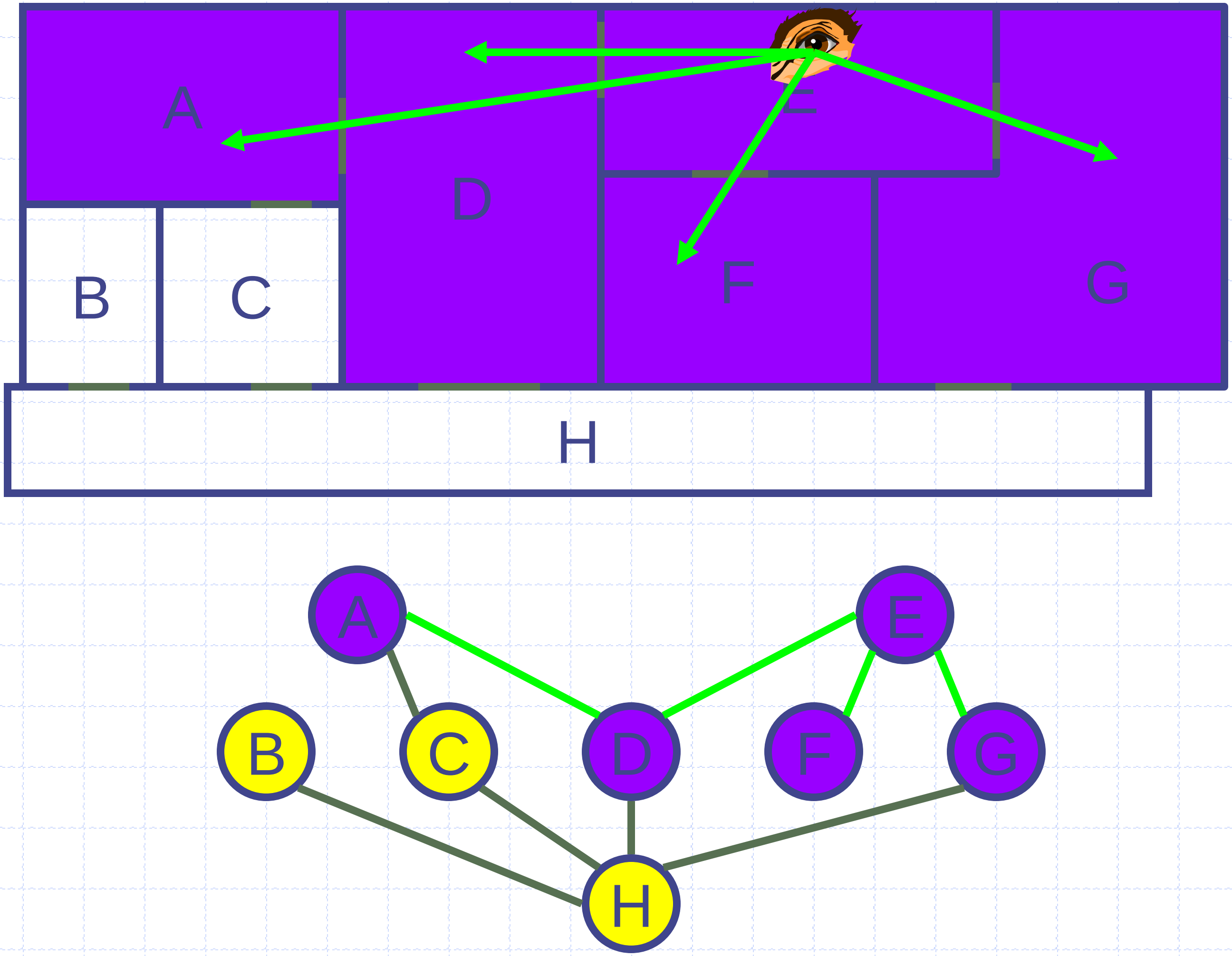


Cells & Portals

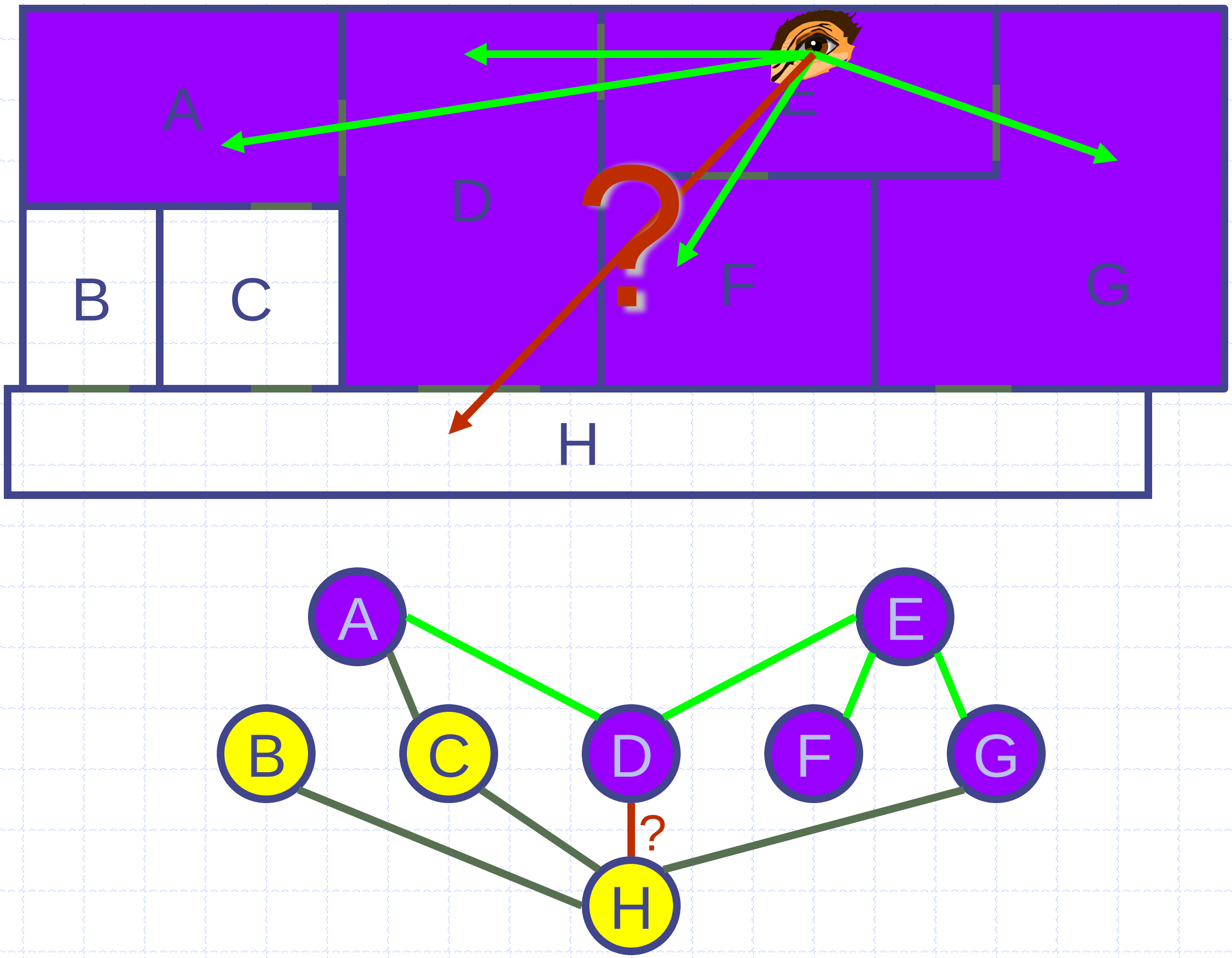




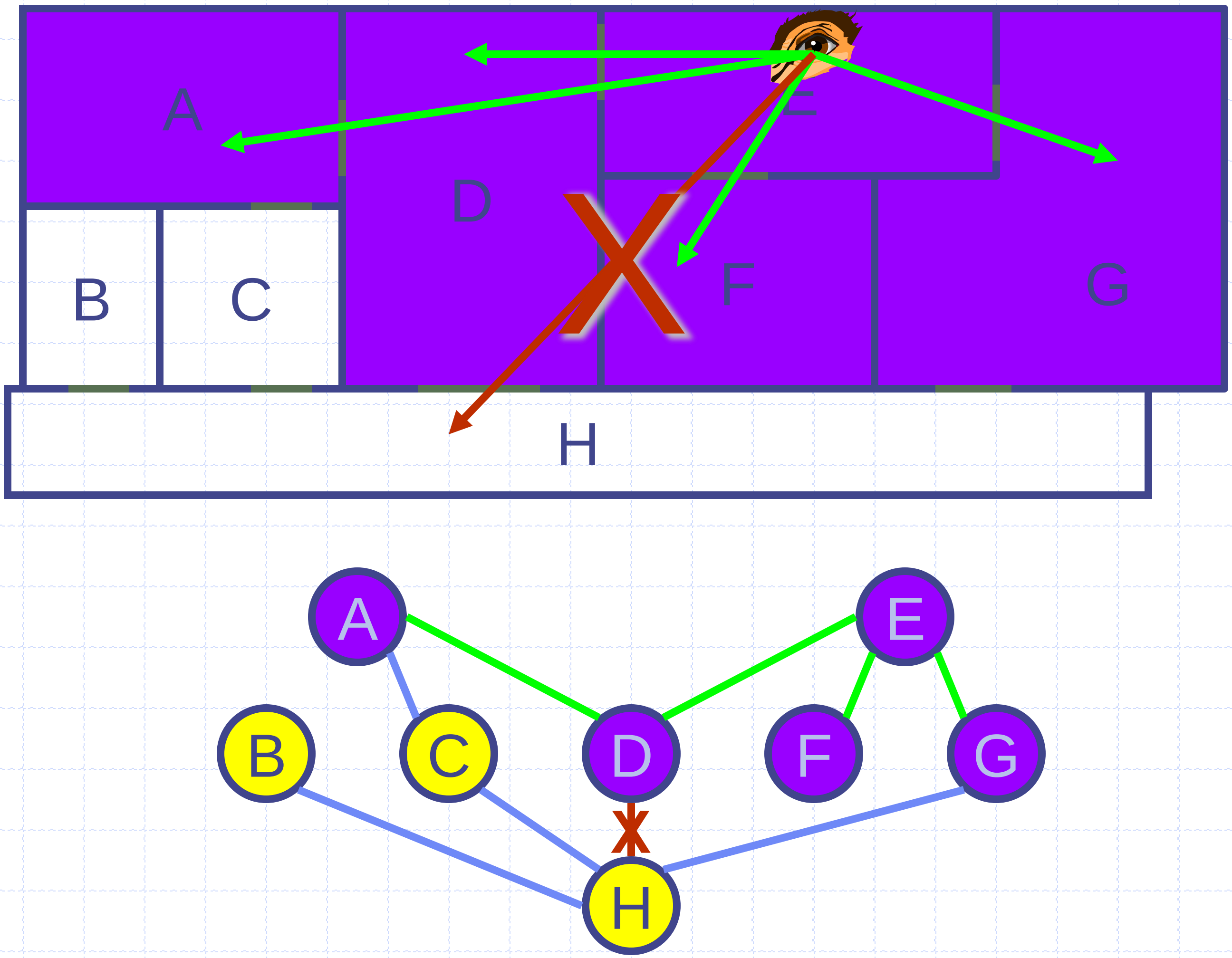
Cells & Portals



Cells & Portals

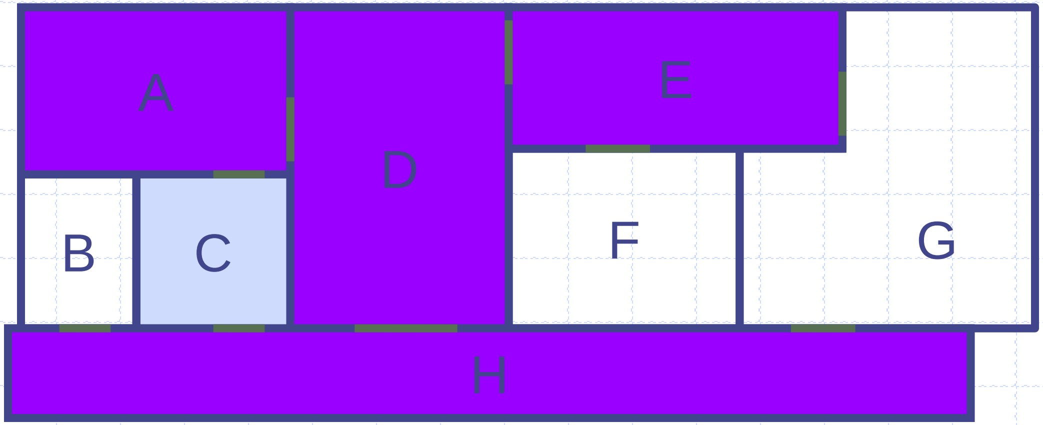


Cells & Portals



Cells & Portals

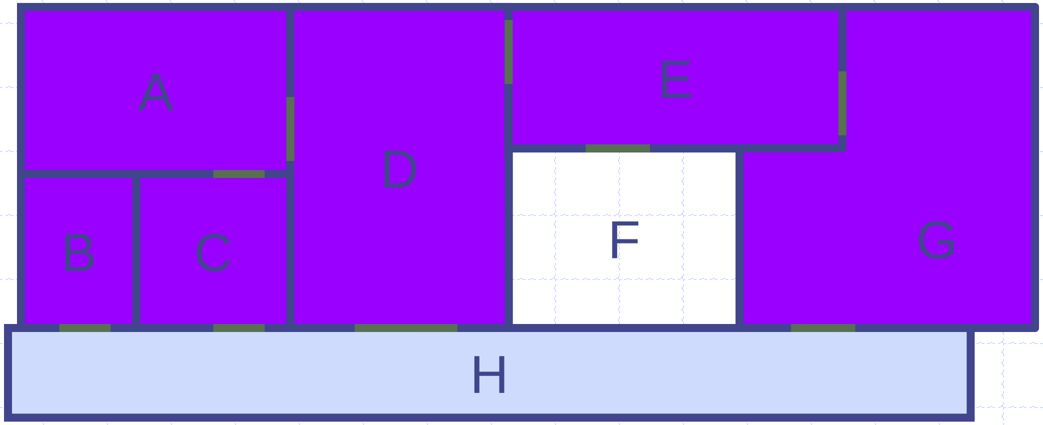
- *View-independent* solution: find all cells a particular cell could *possibly* see; e.g. what can C see?



C can *only* see A, D, E, and H

Cells & Portals

- *View-independent* solution: find all cells a particular cell could *possibly* see; e.g. what can H not see?

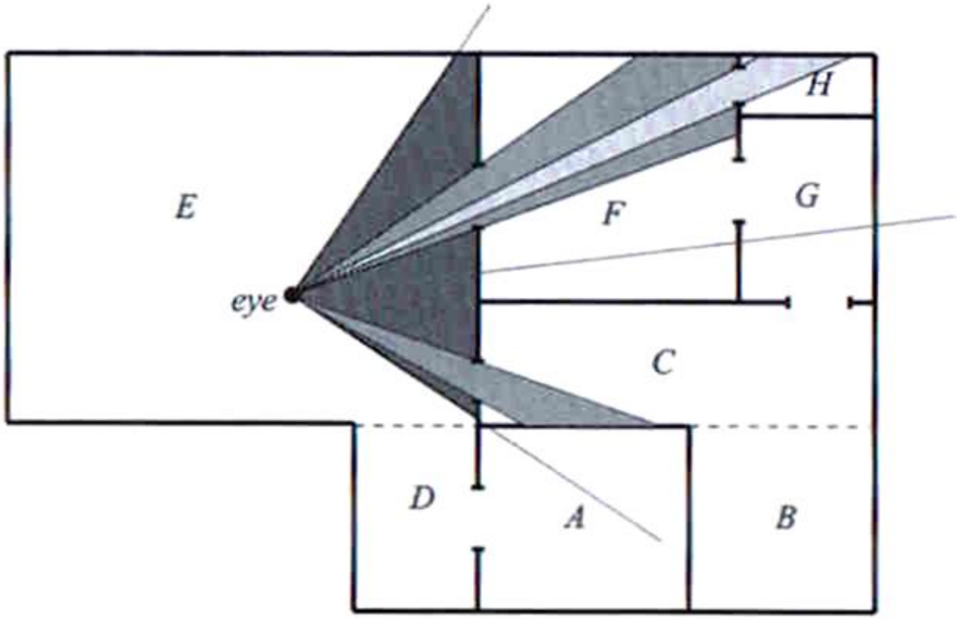


H will *never* see F

Cells and Portals

- How can we detect the cells that are visible from any given viewpoint?
- Idea:
  - Set the view box (P) as the entire screen
  - Compare the portal (B) to the neighbor cell (C) against the current view box P
    - If B outside P – the neighbor cell C cannot be seen
    - Otherwise – the neighbor cell C is visible
      - New view box P = intersection of P and the portal B
      - For each neighbor of C, depth first traverse the adjacency graph of C and recurse

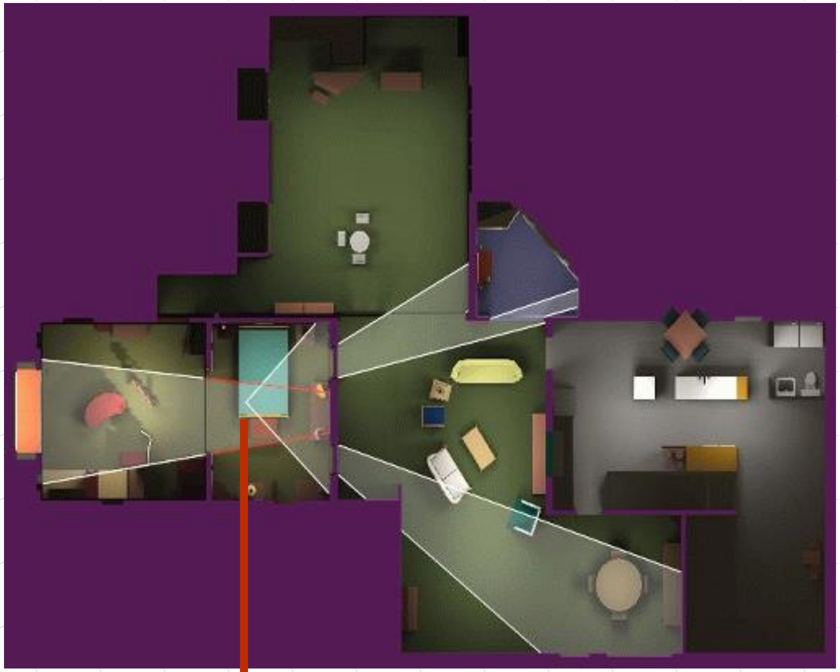
Example I

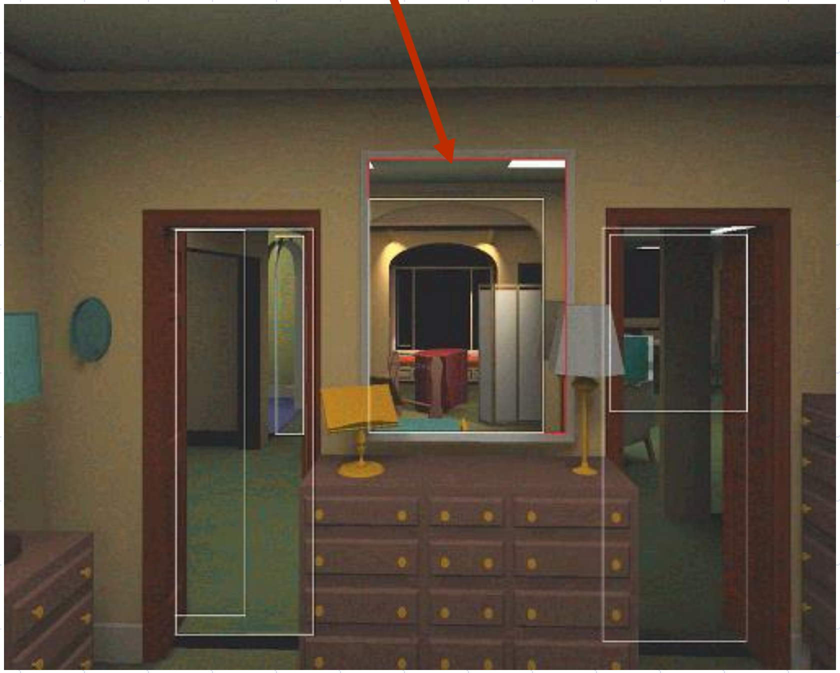


1. From eye, can see to C and to F
2. From C, can see nothing more
3. From F, can see H
4. From H, can see nothing more

Example II

A mirror – still works (cool!)



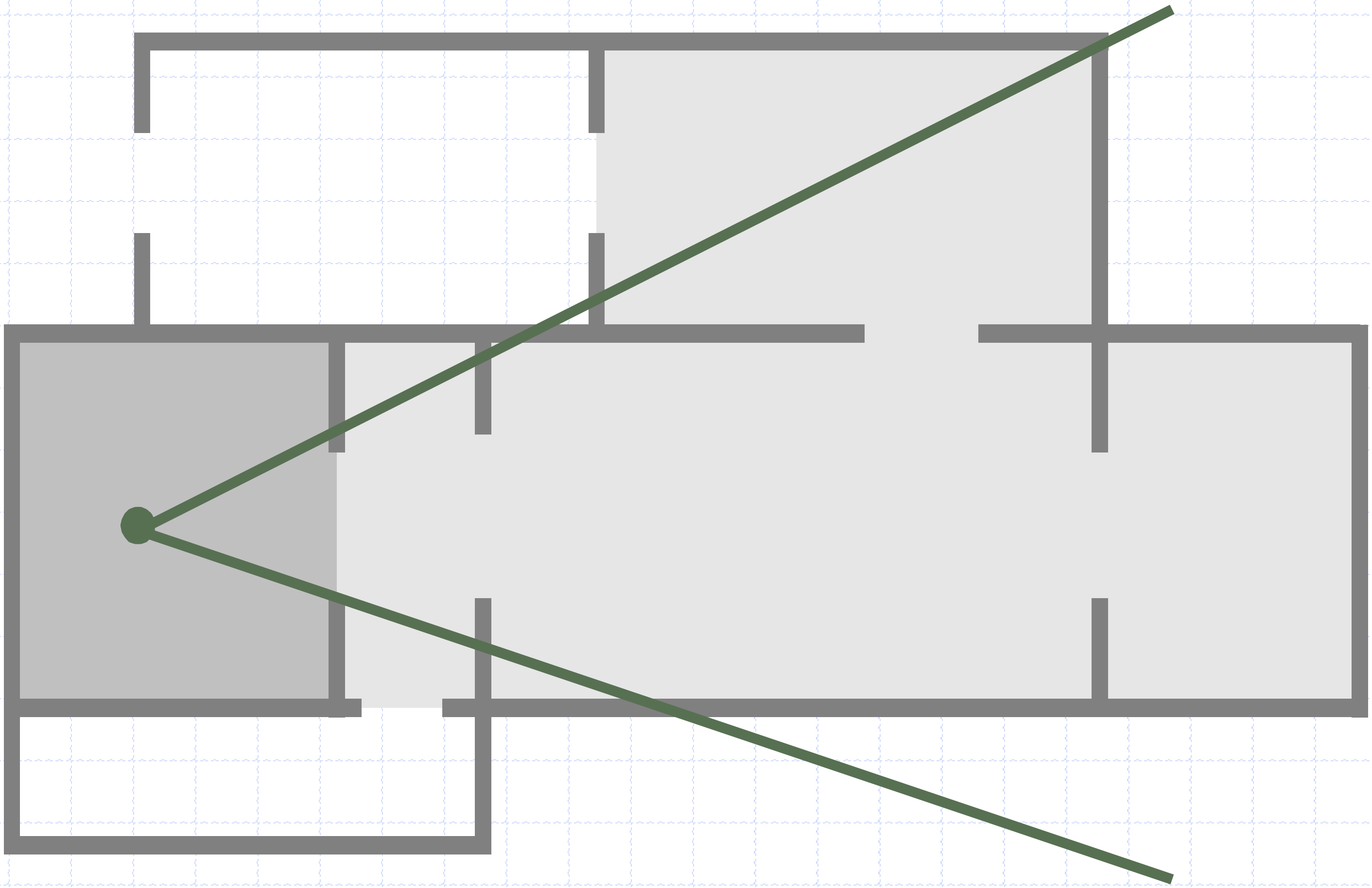


eye

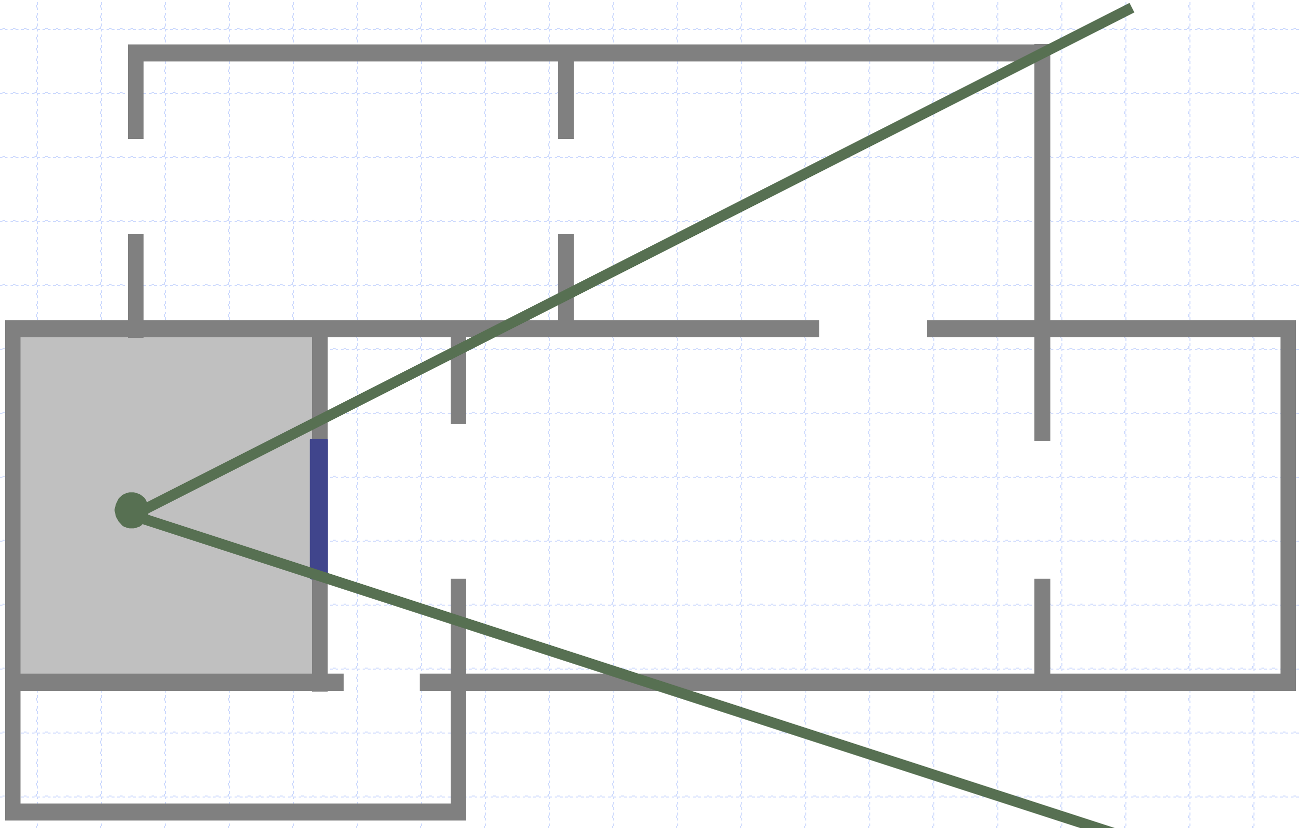
Extension: Portal Images

- How can you reduce the number of rendered cells to at most 2?
- Answer: replace cells with images… ☺

Cells and Portal Culling

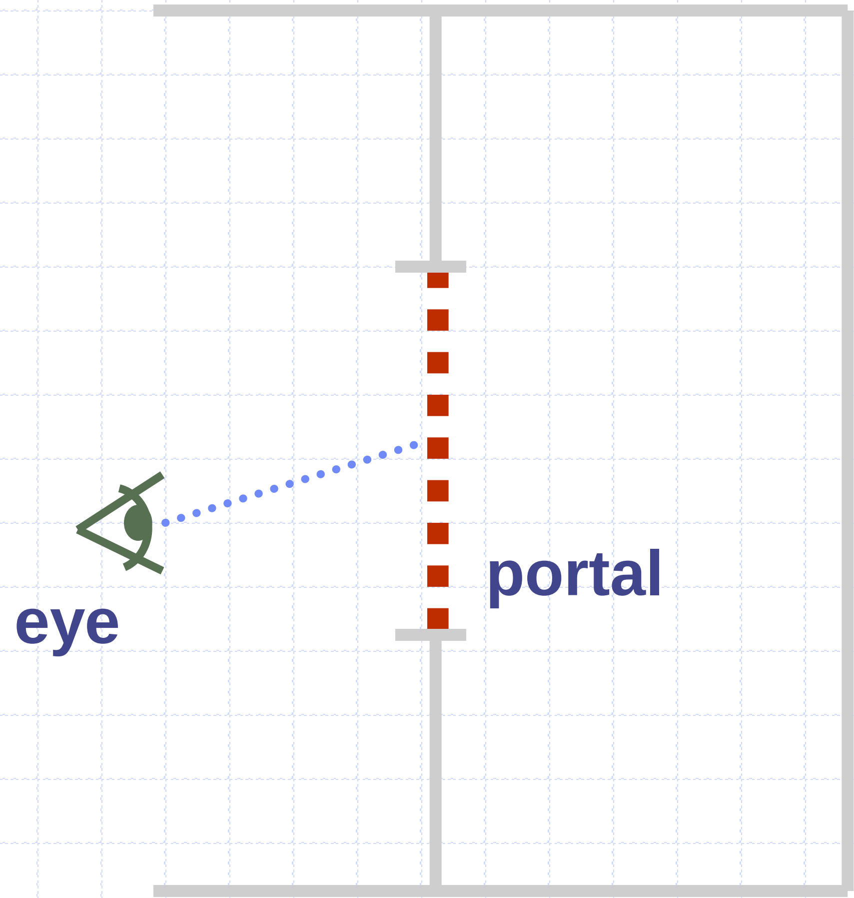


Portal Image Culling



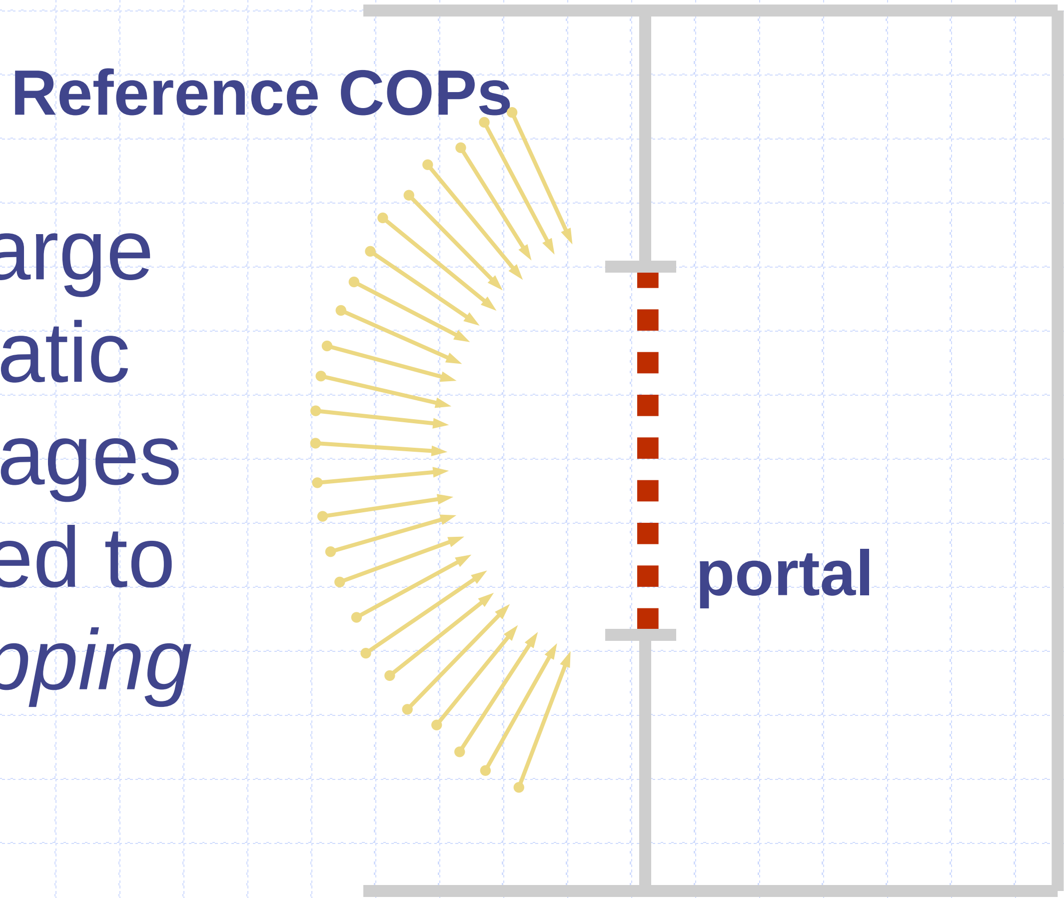
Creating Portal Images

- Ideal portal image would be one sampled from exactly the current eye position



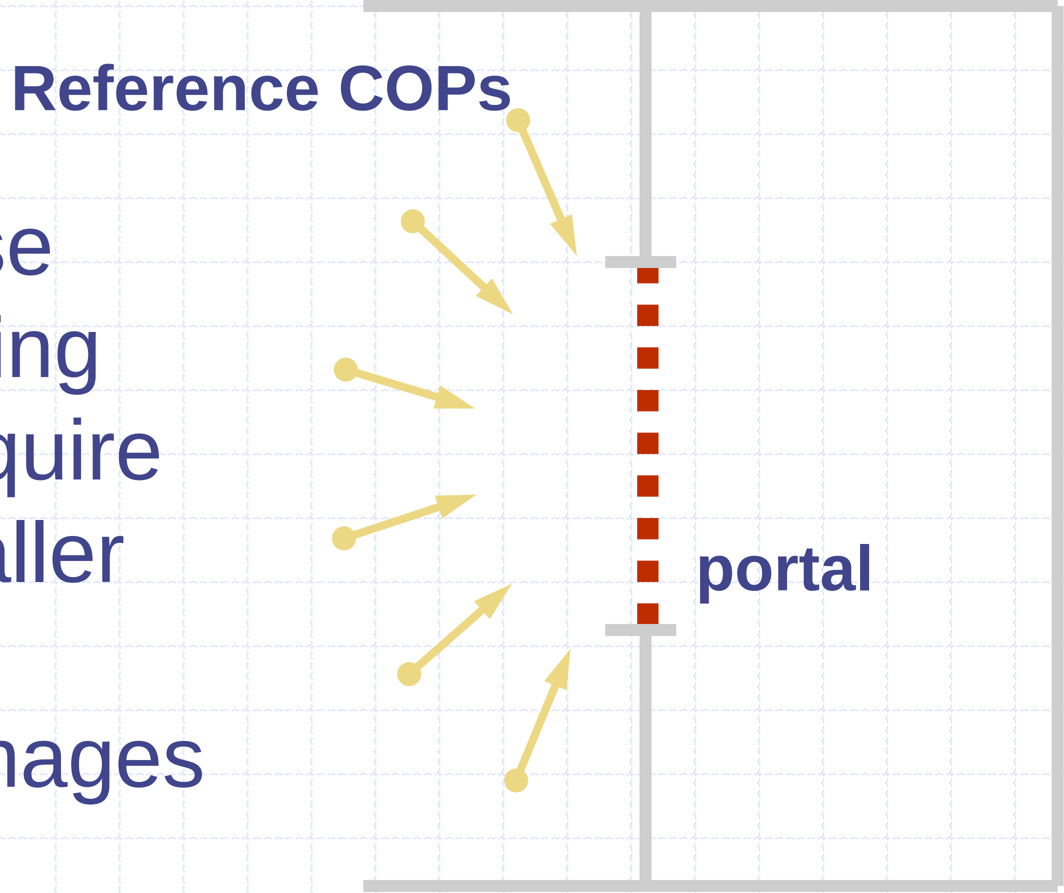
Creating Portal Images

Option 1: a large number of static reference images (~120) needed to eliminate *popping*



Creating Portal Images

Option 2: use image warping and thus require a much smaller number of reference images



Example: Comparison

Color Figure A: Visibility Errors. This image shows a single reference image being warped (from a total of six sampled across the portal). The viewpoint is at the worst location for this reference image. Observe the black areas where we have no information.

Color Figure B: Two Reference Images. An image from the same viewpoint as A, but we are warping the two nearest reference images (from a total of six) to render the desired image. The large areas that were invisible from one are visible from the second.

Color Figure C: Layered Depth Image. The LDI for the portal captures almost all of the visible detail. In addition, it takes up less storage and can be rendered faster than two full reference images. Furthermore, in the architectural domain, we can construct high-quality LDIs by using reference images sampled along a semicircle in front of each portal.

Color Figure D: Geometry. An image from the same viewpoint as A, but rendered using the model geometry for purposes of comparison with figures A, B and C. The main difference is some detail through the left doorway. Apparently these were some features that were visible from only certain viewing angles.