Advanced Pathfinding

Technical Game Development II

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References: Buckland, Chapter 5, 8
Millington, Chapter 4

A* Pathfinding Search

- Covered in IMGD 3000
- Review below if needed

References: Buckland, Chapter 5 (pp. 241-247)
Millington, Section 4.3

Practical Path Planning

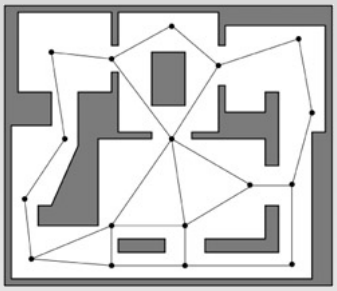
- Just raw A* not enough
- Also need:
  - navigation graphs
    - points of visibility (POV)
    - navmesh
  - path smoothing
  - compute-time optimizations
  - hierarchical pathfinding
  - special case methods

Navigation Graph Construction

- Tile (cell) based
  - very common, esp. if env't already designed in squares or hexagons
  - node center of cell; edgest to adjacent cells
  - each cell already labeled with material (mud, etc.)
  - *downside:*
    - modest 100x100 cell map
    - 10,000 nodes and 78,000 edges
    - can burden CPU and memory, especially if multiple AI's calling in

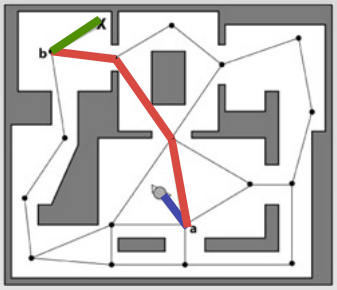
*Rest of lecture is a **survey** about how to do better...*

Point of Visibility (POV) Navigation Graph



- Place graph nodes (usually by hand) at important points in env't
- Such that each node has line of sight to at least one other node

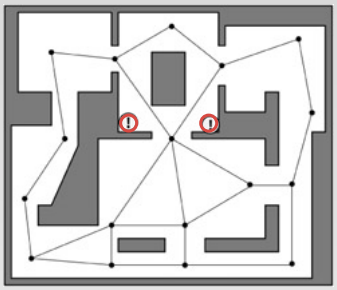
POV Navigation



- find closest *visible* node (a) to current location
- find closest *visible* node (b) to target location
- search for least cost path from (a) to (b)
- move to (a)
- follow path to (b)
- move to target location

note "backtracking"

Blind Spots in POV



- No POV point is visible from red spots!
- Easy to fix manually in small graphs
- A problem in larger graphs

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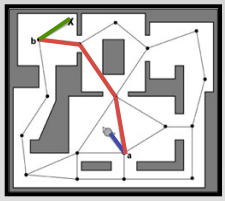
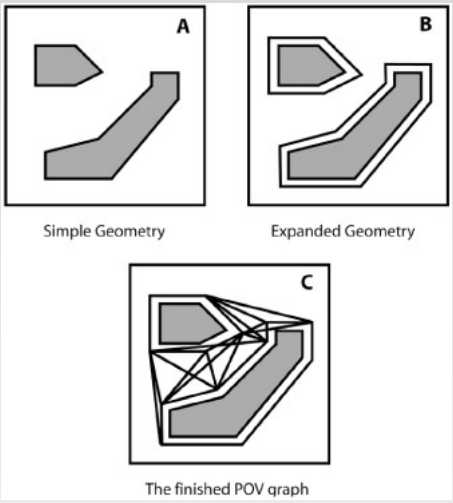
POV Navigation



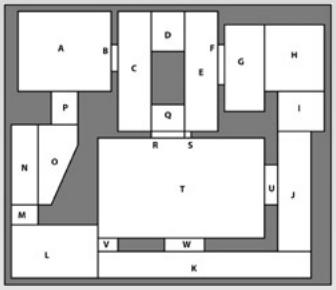
- Obvious how to build and expand
- ***Downsides***
  - can take a lot of developer time, especially if design is rapidly evolving
  - problematic if random or user generated maps
  - can have "blind spots"
  - can have "jerky" paths
- ***Solutions***
  - automatically generate POV graphs
  - make finer grained graphs
  - path smoothing

Automatic POV by Expanded Geometry

1. expand geometry by amount proportional to bounding radius of agents
2. add vertices to graph
3. prune non line of sight points

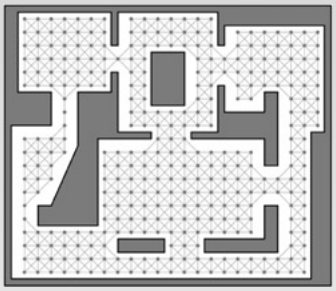


NavMesh



- network of *convex* polygons
- very efficient to search
- can be automatically generated from polygons
- becoming very popular

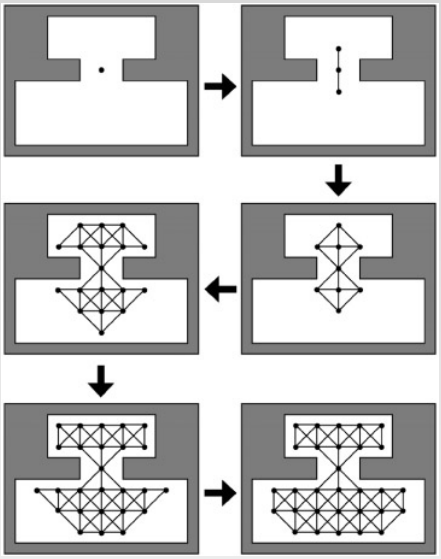
Finely Grained Graphs



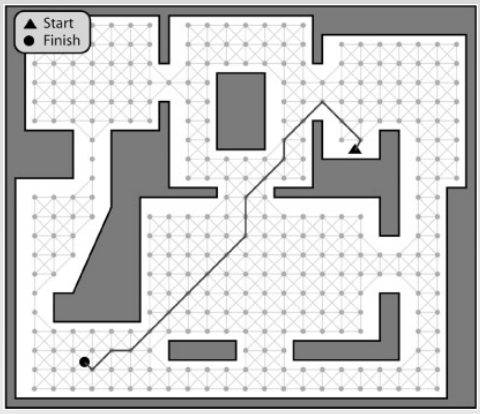
- Improves blind spots and path smoothness
- Typically generate automatically using “flood fill”
- Back to similar performance issues as tiled graphs

Flood Fill

• same algorithm as in “paint” programs

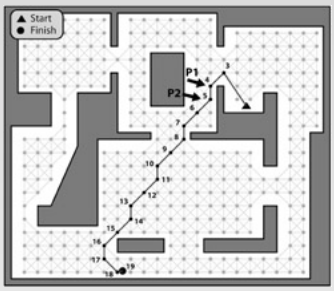


Path Finding in Finely Grained Graph



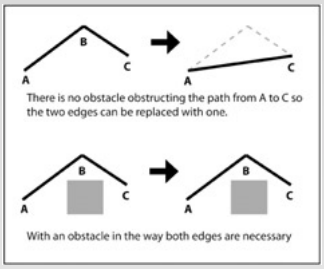
- use A* or Dijkstra depending on whether looking for one or multiple targets

Kinky Paths



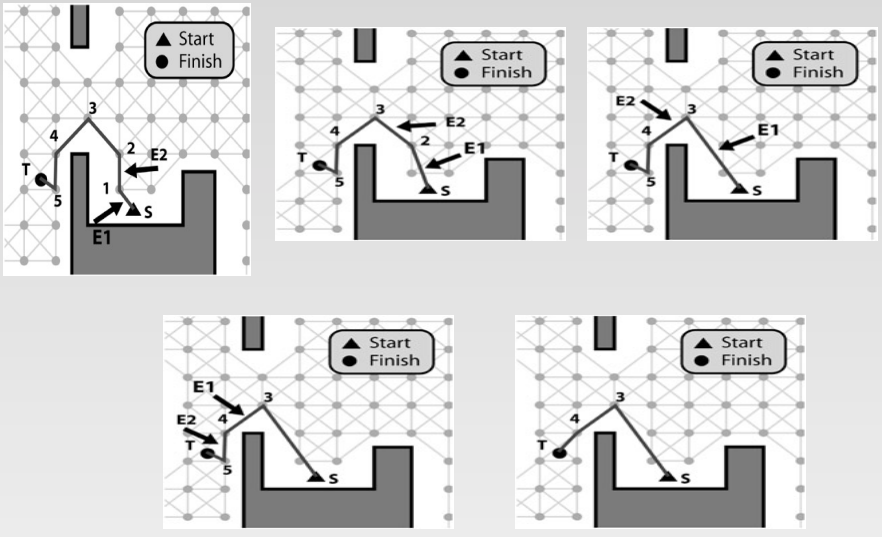
The solution: Path smoothing

Simple Smoothing Algorithm



- Check for "passability" between *adjacent* edges

Smoothing Example



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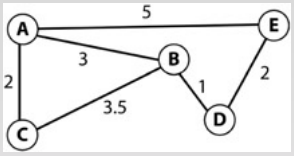
Methods to Reduce CPU Overhead



time/space tradeoff

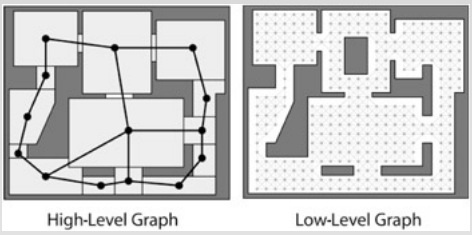
	A	B	C	D	E
A	A	B	C	B	E
B	A	B	C	D	D
C	A	B	C	B	B
D	B	B	B	D	E
E	A	D	D	D	E

shortest path table
(next node)

	A	B	C	D	E
A	0	3	2	4	5
B	3	0	3.5	1	3
C	2	3.5	0	4.5	6.5
D	4	1	4.5	0	2
E	5	3	6.5	2	0

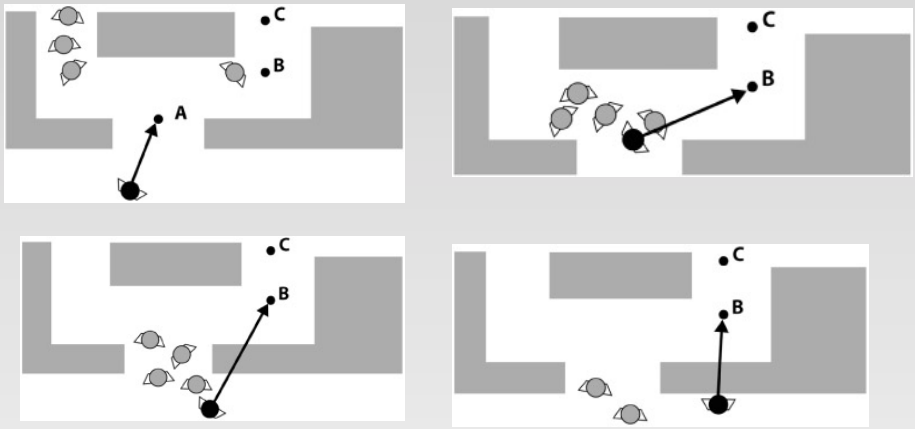
path cost table

Hierarchical Path Planning



- reduces CPU overhead
- typically two levels, but can be more
- first plan in high-level, then refine in low-level

Getting Out of Sticky Situations



- ***bot gets "wedged" against wall***
- ***looks really bad!***

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Getting Out of Sticky Situations

- Heuristic:
  - calculate the distance to bot's current waypoint each update step
  - if this value remains about the same or consistently increases
  - then it's probably wedged
  - backup and replan

Advanced Pathfinding Summary

- You would not necessarily use *all* of these techniques in *one* game
- Only use whatever your game demands and no more