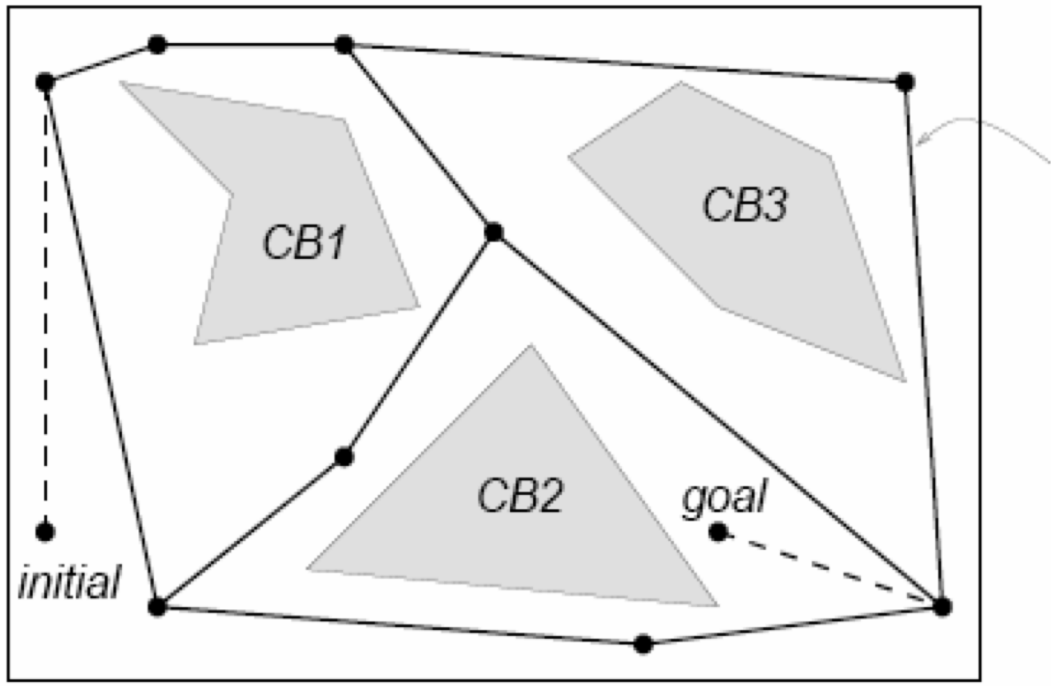
Roadmaps
Visibility Graphs

Alfredo Weitzenfeld

Roadmaps

- A *roadmap* is a class of topological map with nodes representing physical locations and edges representing paths between neighboring locations.
- Robots use roadmaps as people use highway systems.
- If a roadmap exists then a path exists



Roadmap Definition

- A roadmap, RM, is a union of curves such that all start and goal points in Q_{free} can be connected by a path:
  - *Accessibility*: there exists a collision-free path from $q_{start} \in Q_{free}$ to some $q'_{start} \in RM$
  - *Departability*: there exists a collision-free path from some $q'_{goal} \in RM$ to $q_{goal} \in Q_{free}$
  - *Connectivity*: there exists a path in RM between q'_{start} and q'_{goal}

Roadmap Path Planning

- Build the roadmap
  - nodes are points in Q_{free} (or its boundary)
  - two nodes are connected by an edge if there is a free path between them
- Connect start end goal points to the road map at point q'_{start} and q'_{goal}, respectively
- Find a path on the roadmap between

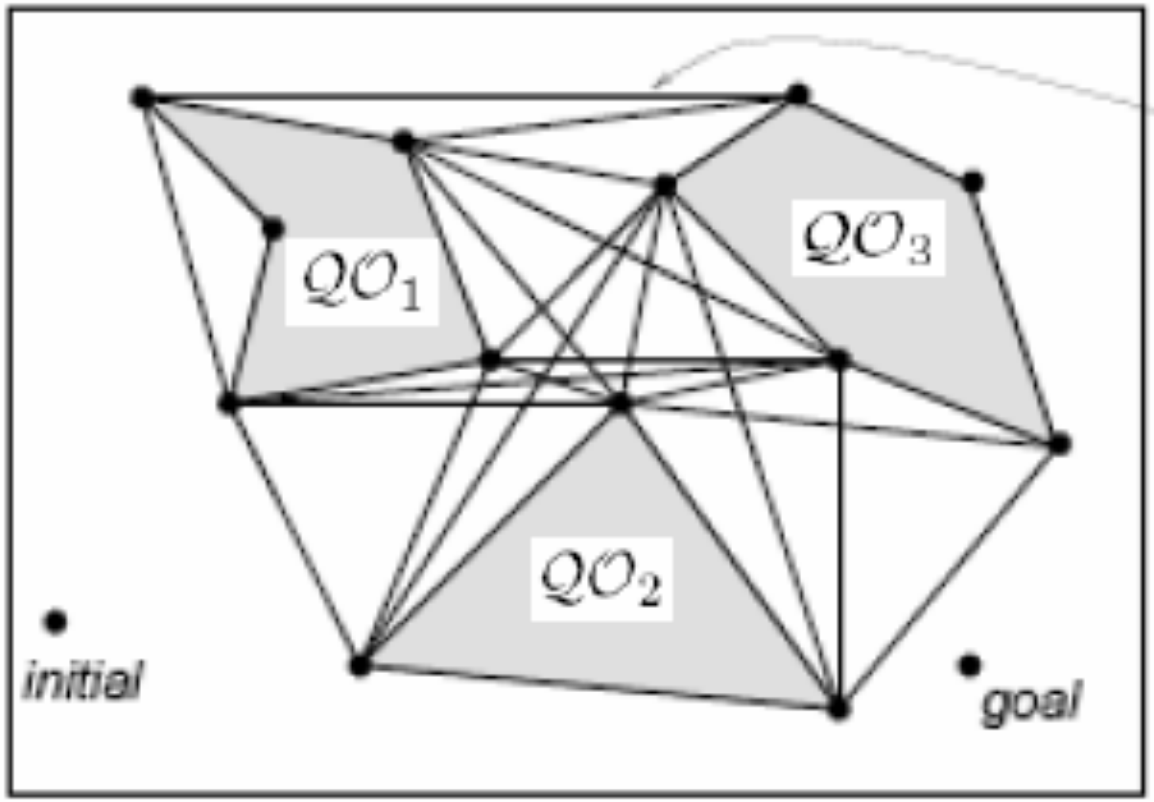
  q'_{start} and q'_{goal}
- The result is a path in Q_{free} from start to goal

Roadmap Types

- Visibility Graphs
- Generalized Voronoi Diagram (GVD)

Visibility Graph

- A visibility graph is formed by connecting all “visible” vertices, the start point and the end point, to each other.

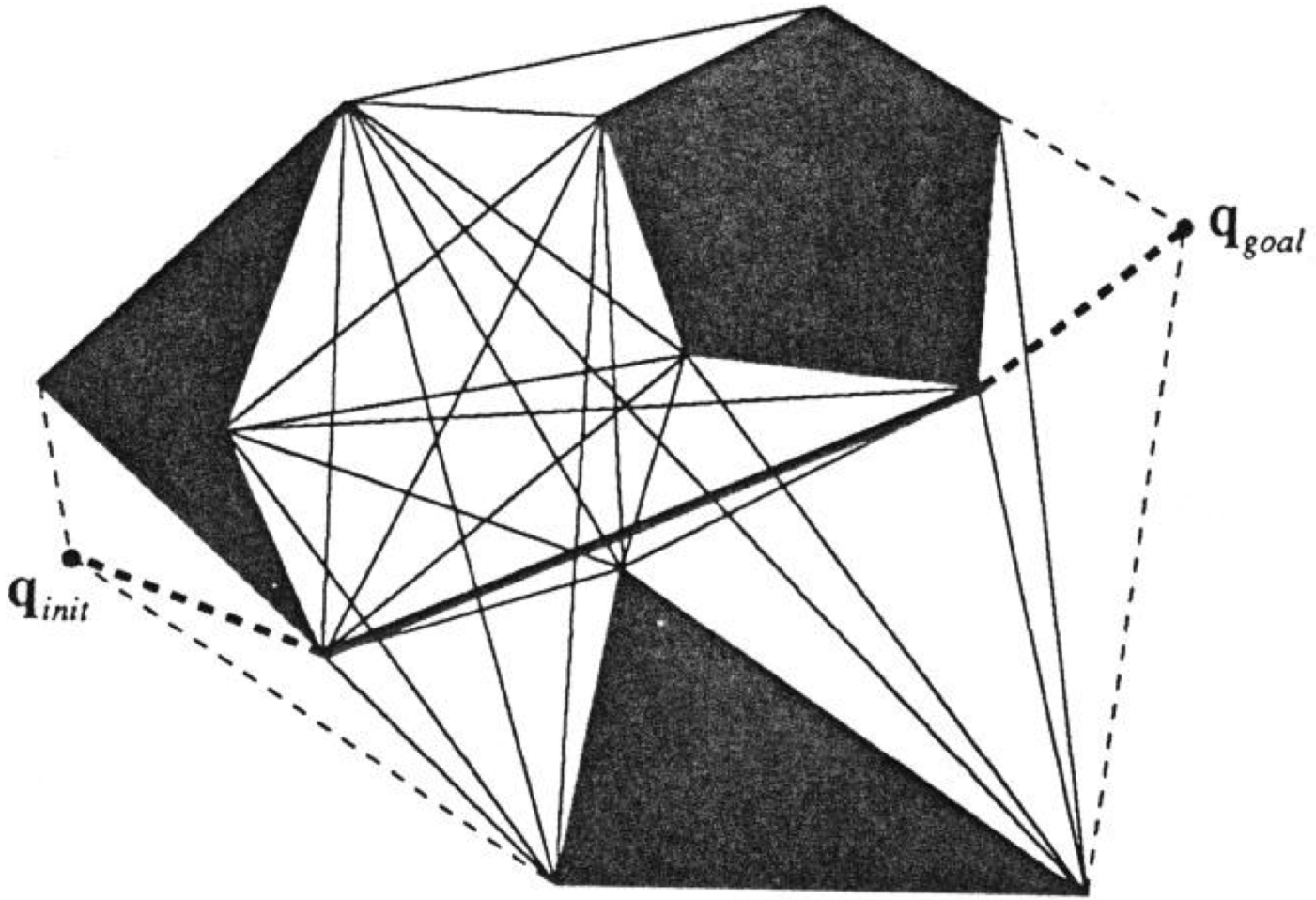


Visibility Graph

- For two points to be “visible” no obstacle can exist between them.
  - Paths exist on the perimeter of obstacles
- Defined for polygonal obstacles
- Nodes correspond to vertices of obstacles
- Nodes are connected if
  - they are already connected by an edge on an obstacle
  - the line segment joining them is in free space
- Not only there is a path on this roadmap, but it is the *shortest path*
- If we include the start and goal nodes, they are automatically connected
- Algorithms for constructing them can be efficient

Visibility Graphs

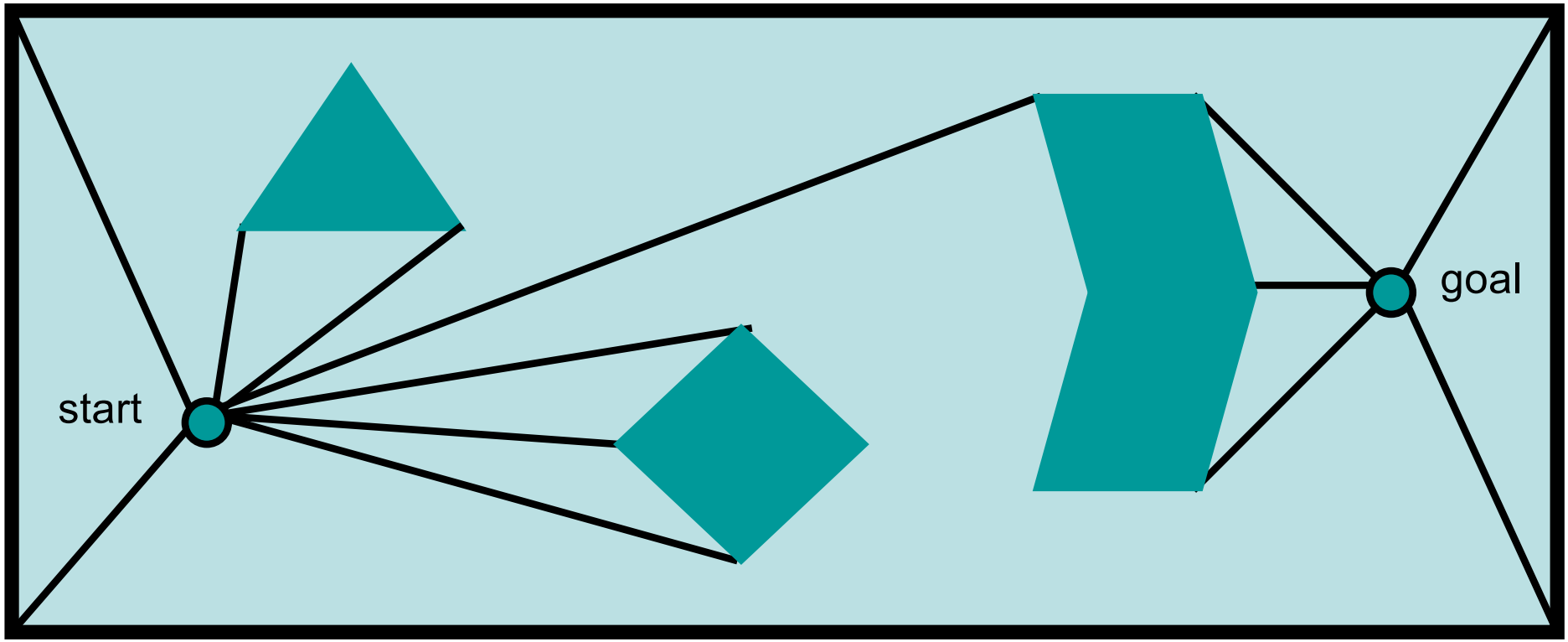
- Thin solid lines delineate edges of the visibility graph for the obstacles represented as filled polygons.
- Thick dotted line represents shortest path between start and goal.



The Visibility Graph: Step 1

- First, draw lines of sight or edges e_{ij} from the start and goal to all "visible" vertices and corners of the world v_i and v_j:

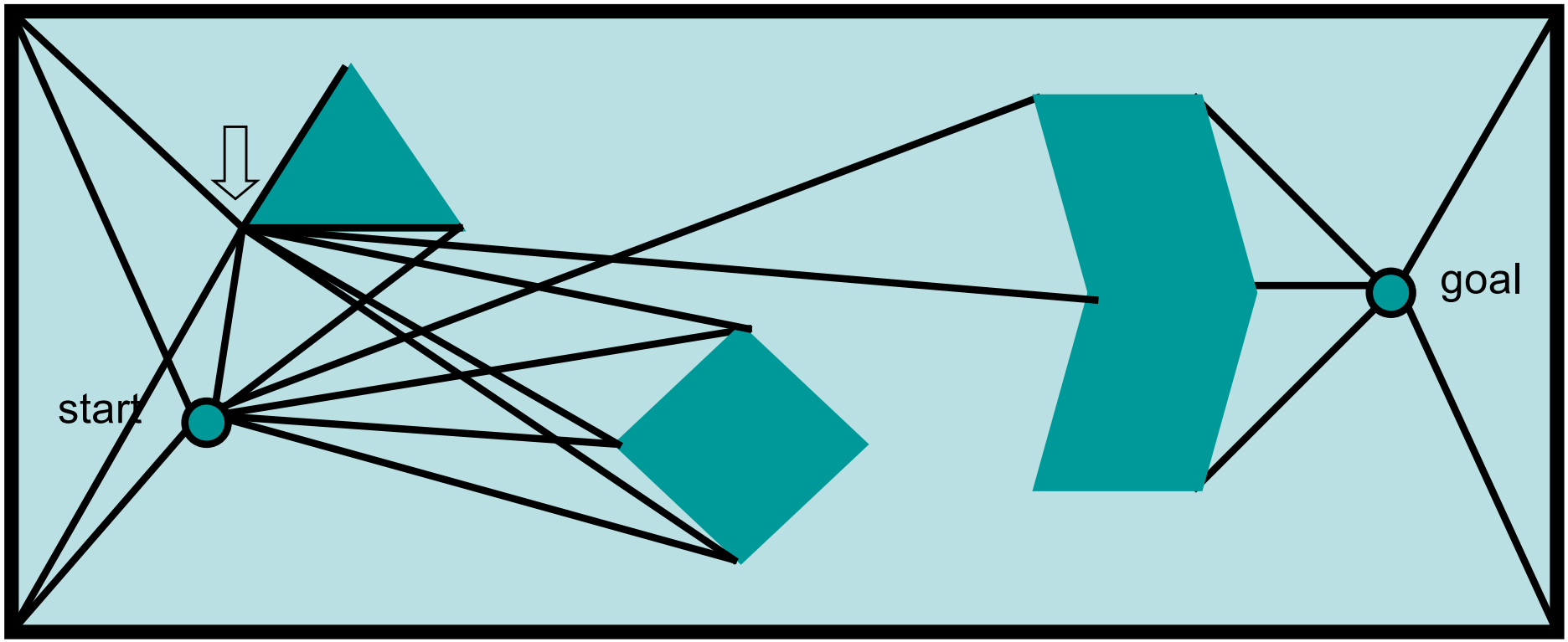
$$e_{ij} \neq 0 \Leftrightarrow sv_i + (1-s)v_j \in cl(Q_{free}) \forall s \in (0,1)$$



The Visibility Graph: Step 2

- Second, draw lines of sight e_{ij} from every vertex v_i and v_j of every obstacle like before. Remember lines along edges are also lines of sight.

$$e_{ij} \neq 0 \Leftrightarrow sv_i + (1-s)v_j \in cl(Q_{free}) \forall s \in (0,1)$$



The Visibility Graph: Step 3

- Second, draw lines of sight e_{ij} from every vertex v_i and v_j of every obstacle like before. Remember lines along edges are also lines of sight.

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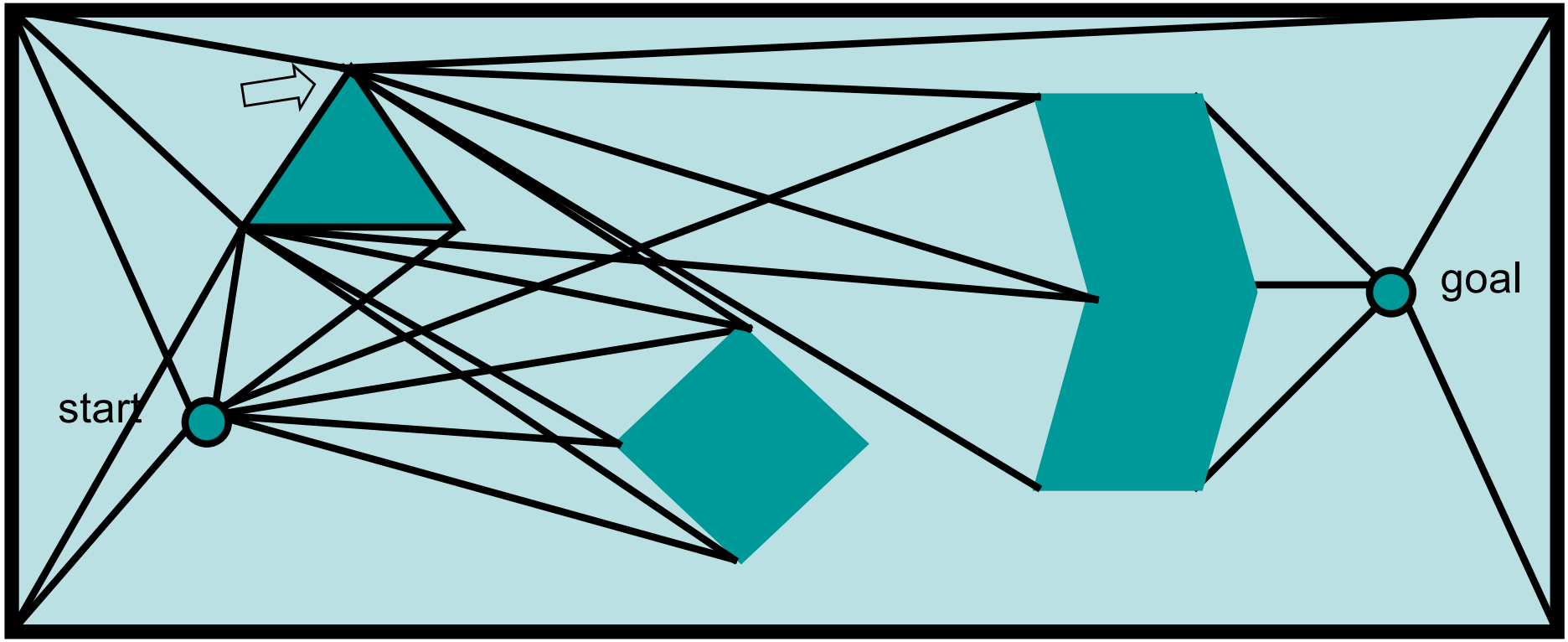

The Visibility Graph: Step 4

- Second, draw lines of sight e_{ij} from every vertex v_i and v_j of every obstacle like before. Remember lines along edges are also lines of sight.

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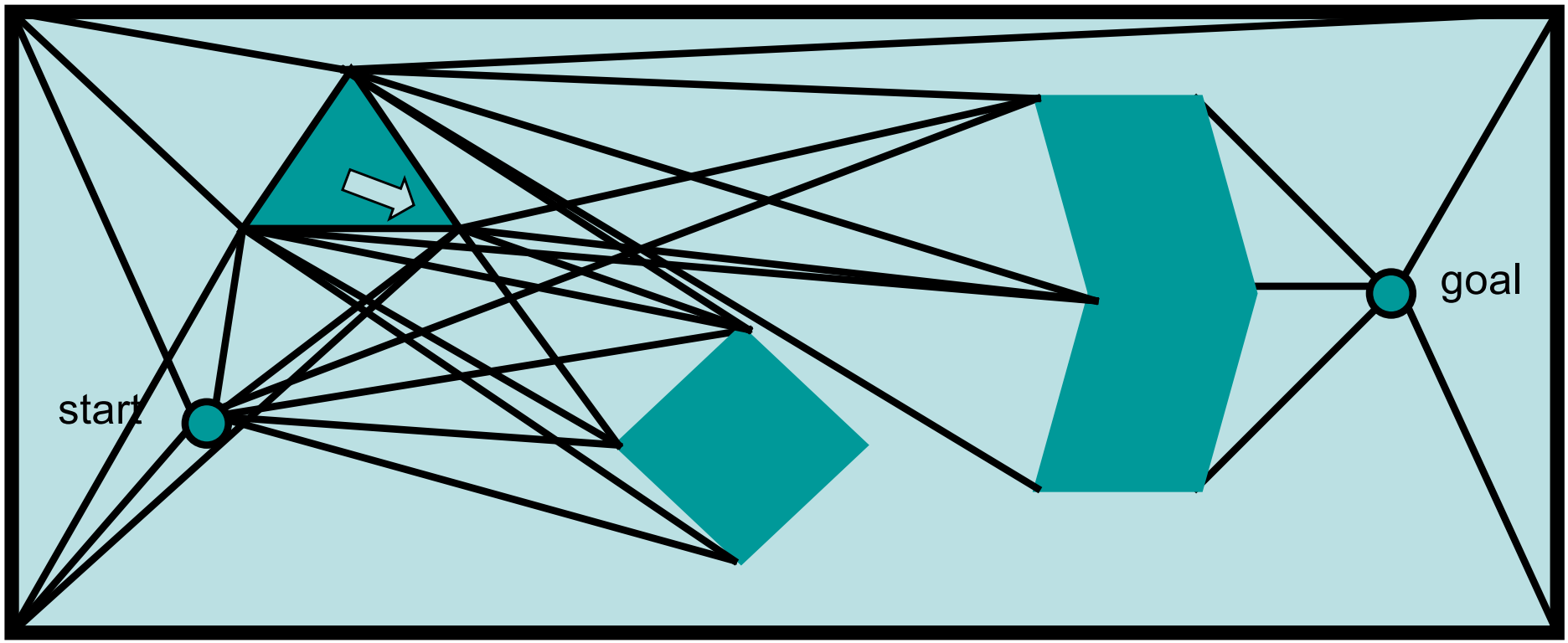
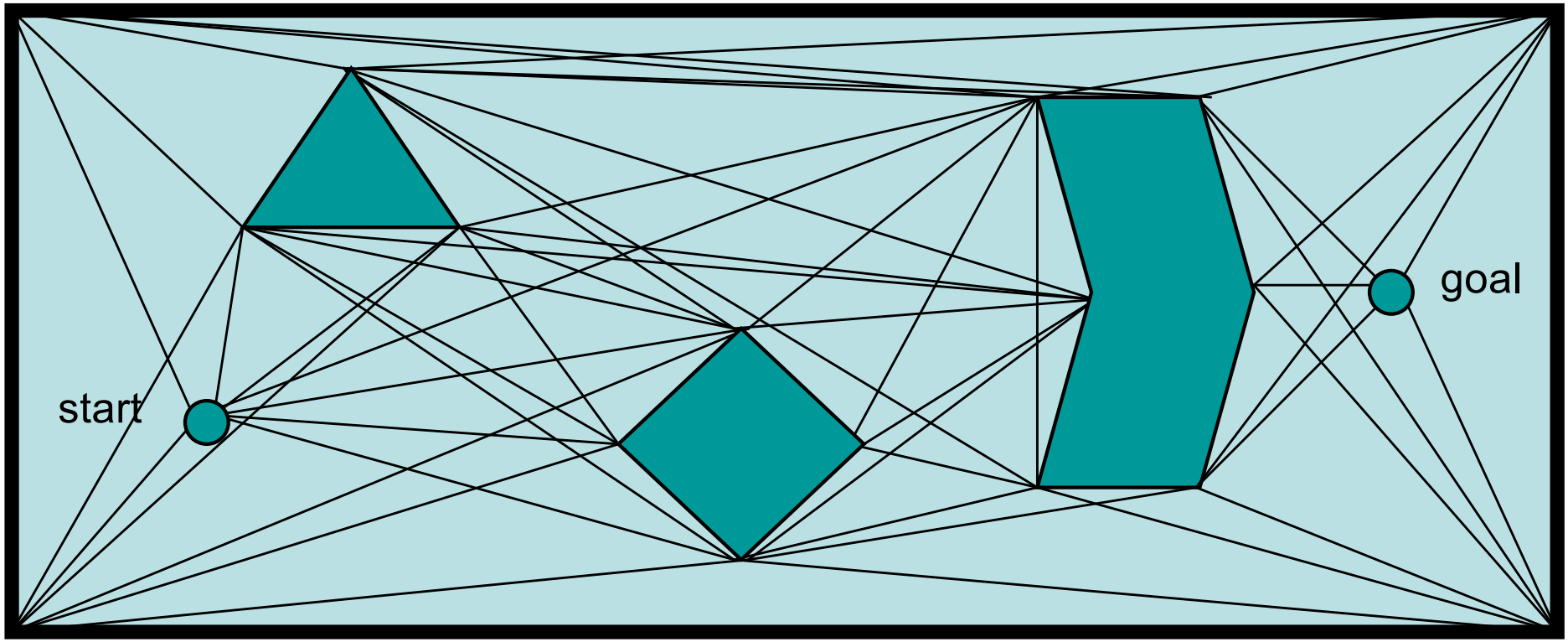


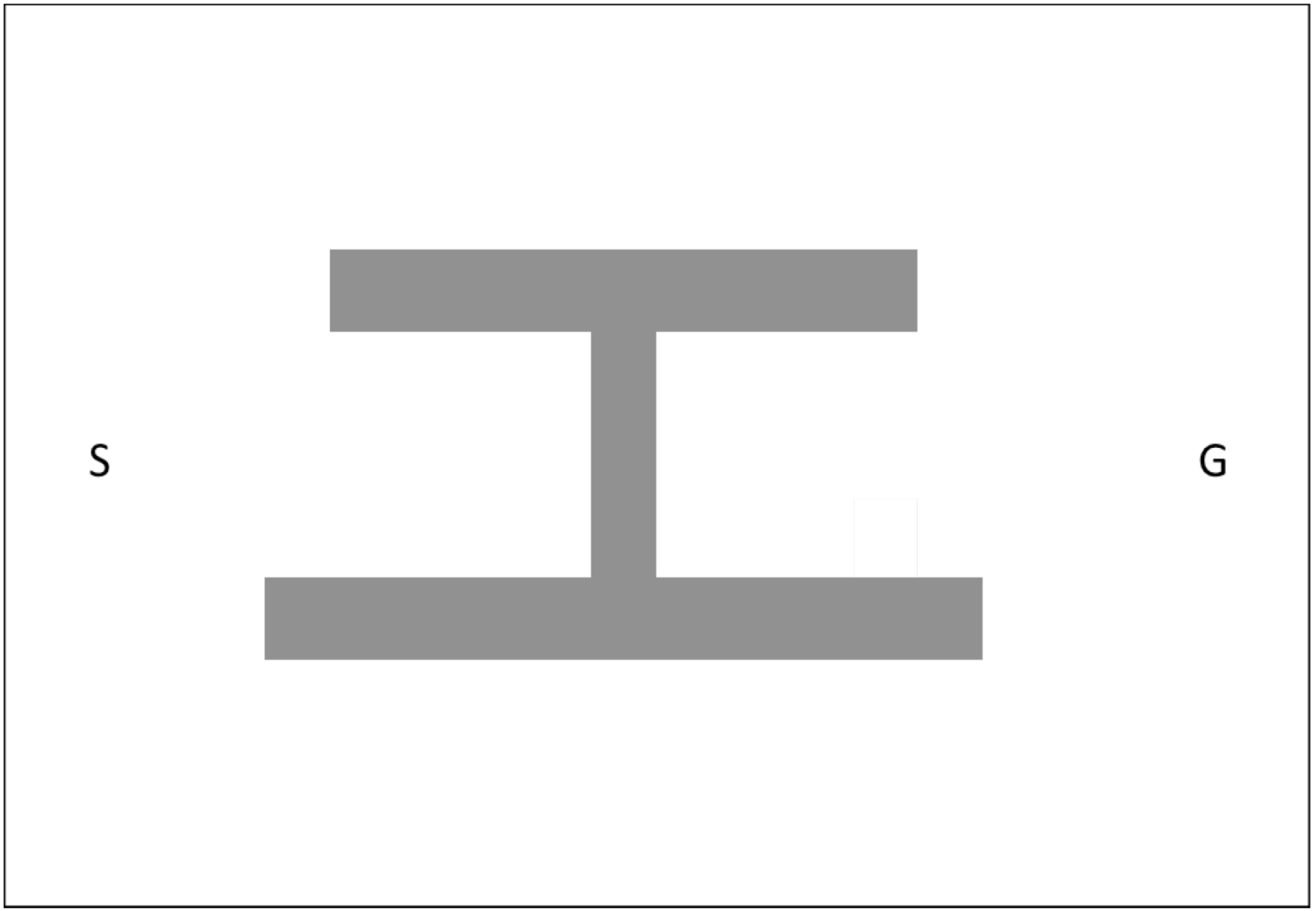
The Visibility Graph: Last Step

- Repeat until you're done.



Roadmaps – Visibility Graph

Apply the Roadmap Visibility Graph algorithm to the scene below where darker elements correspond to obstacles and surrounding rectangle represents a wall. Show the complete visibility graph including start and goal. Show the final shortest path from start to goal using the visibility graph.



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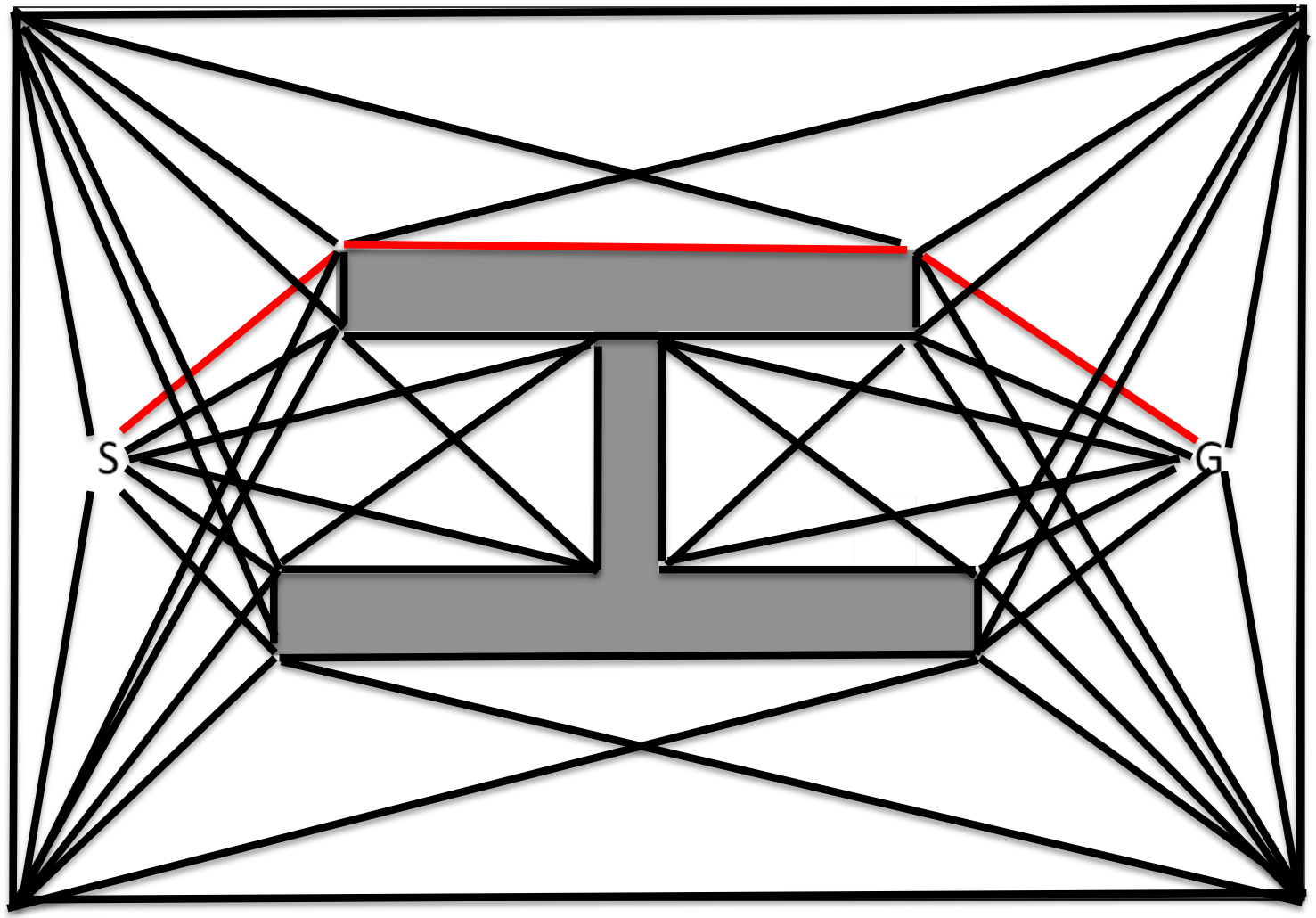

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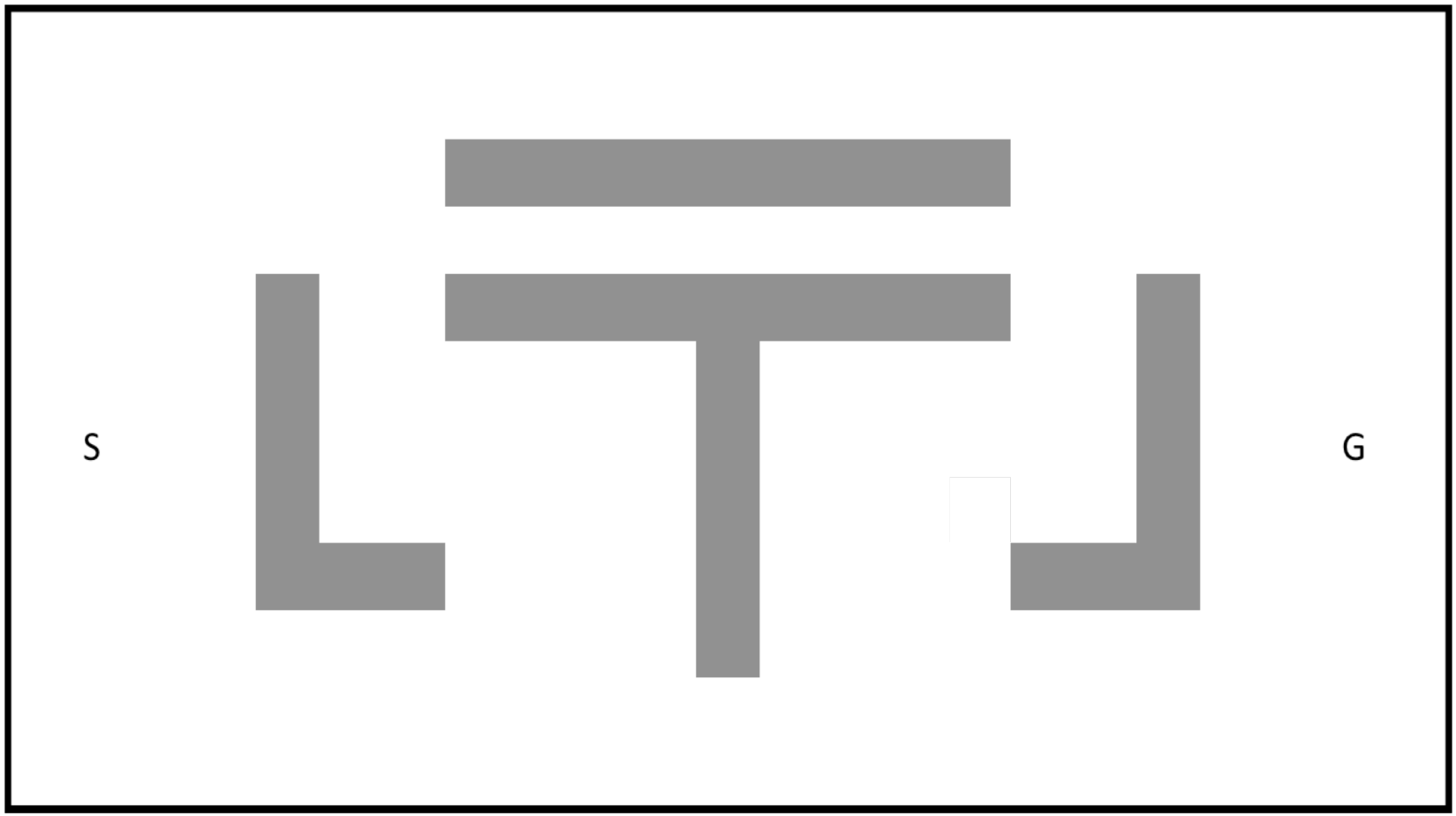

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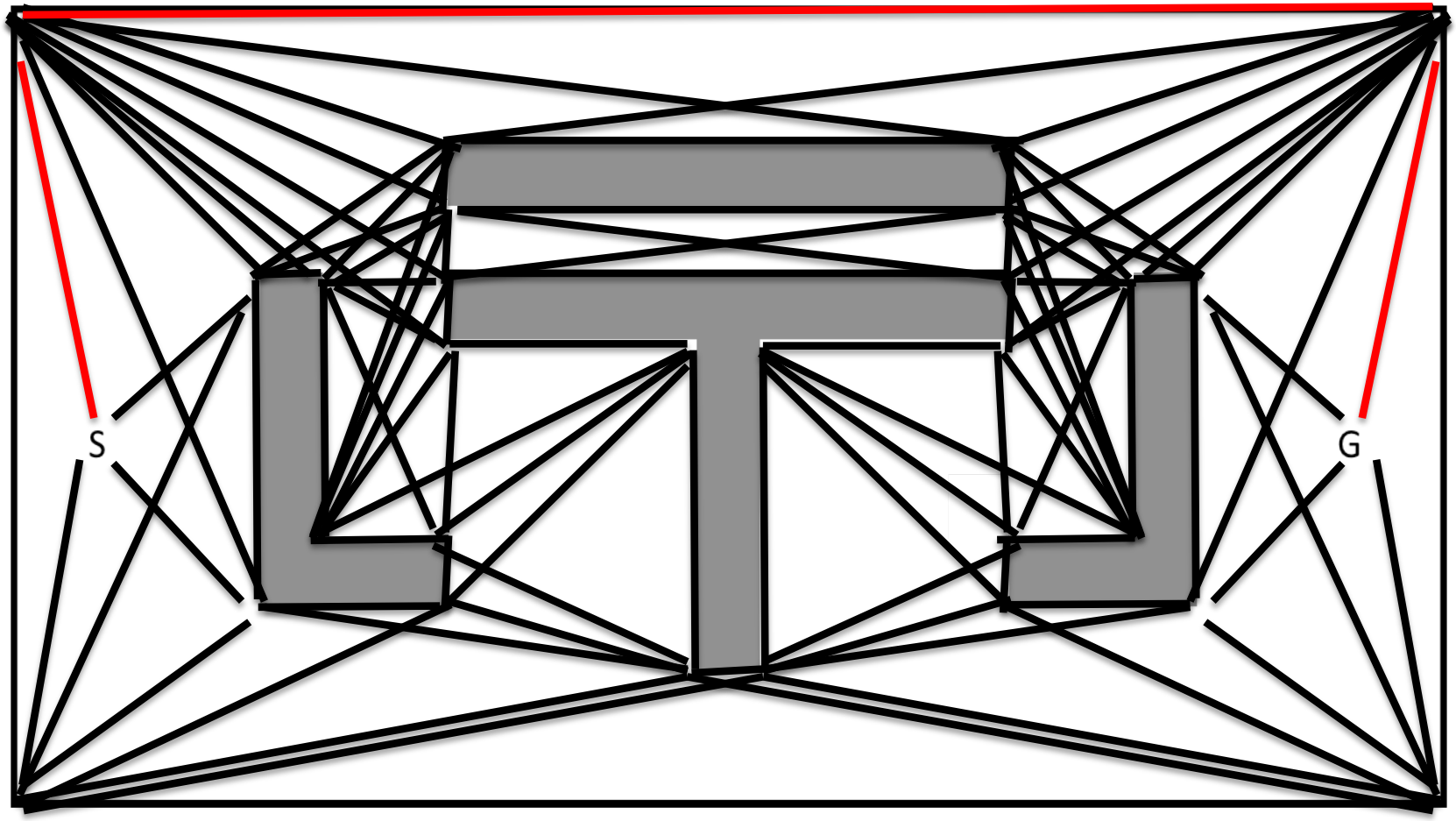
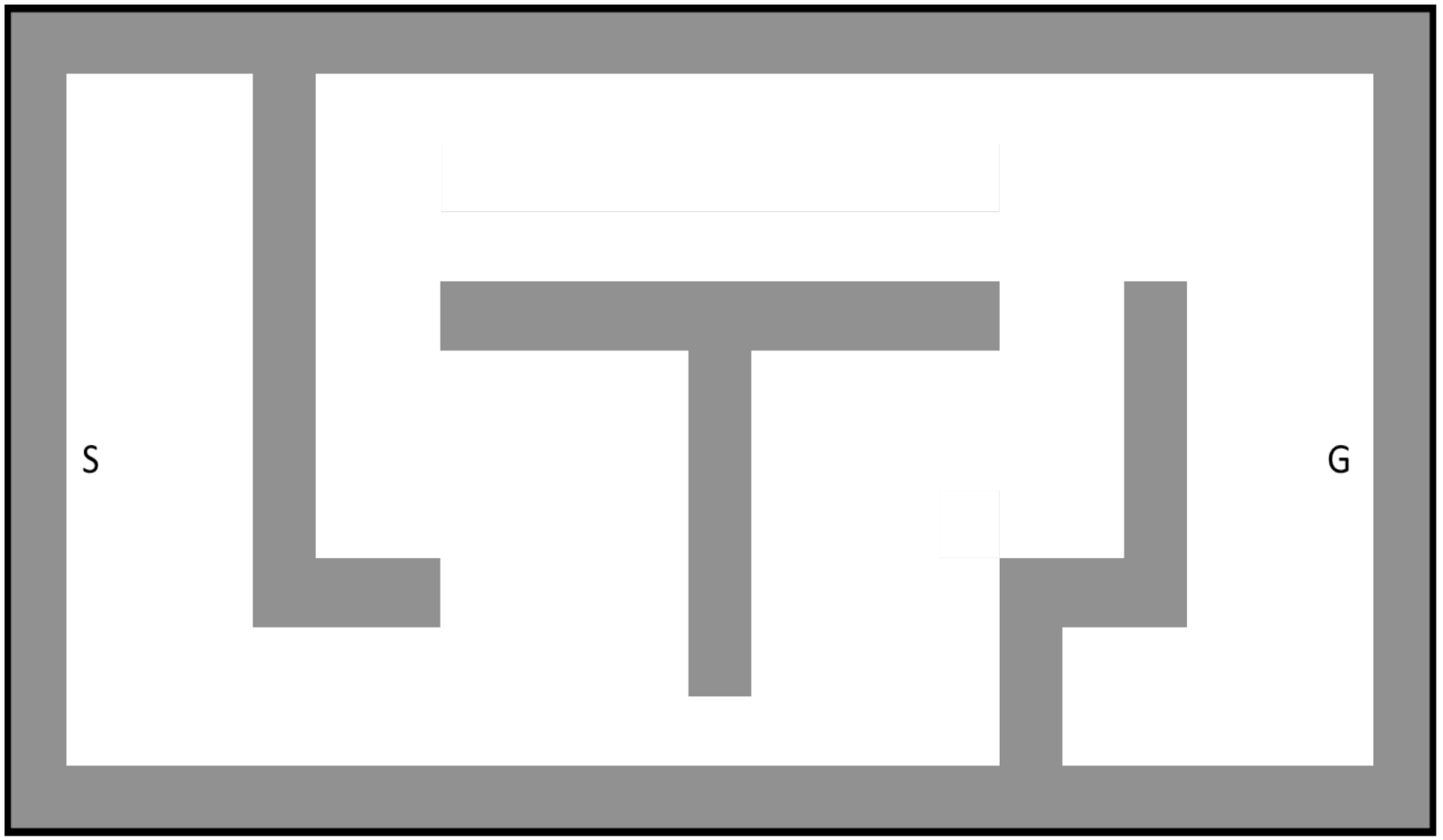


Roadmaps – Visibility Graph

Apply the Roadmap Visibility Graph algorithm to the scene below where darker elements correspond to obstacles.
Show the complete visibility graph including start “S” and goal “G”.
Highlight a final shortest path from start “S” and goal “G” based on least number of individual edges.



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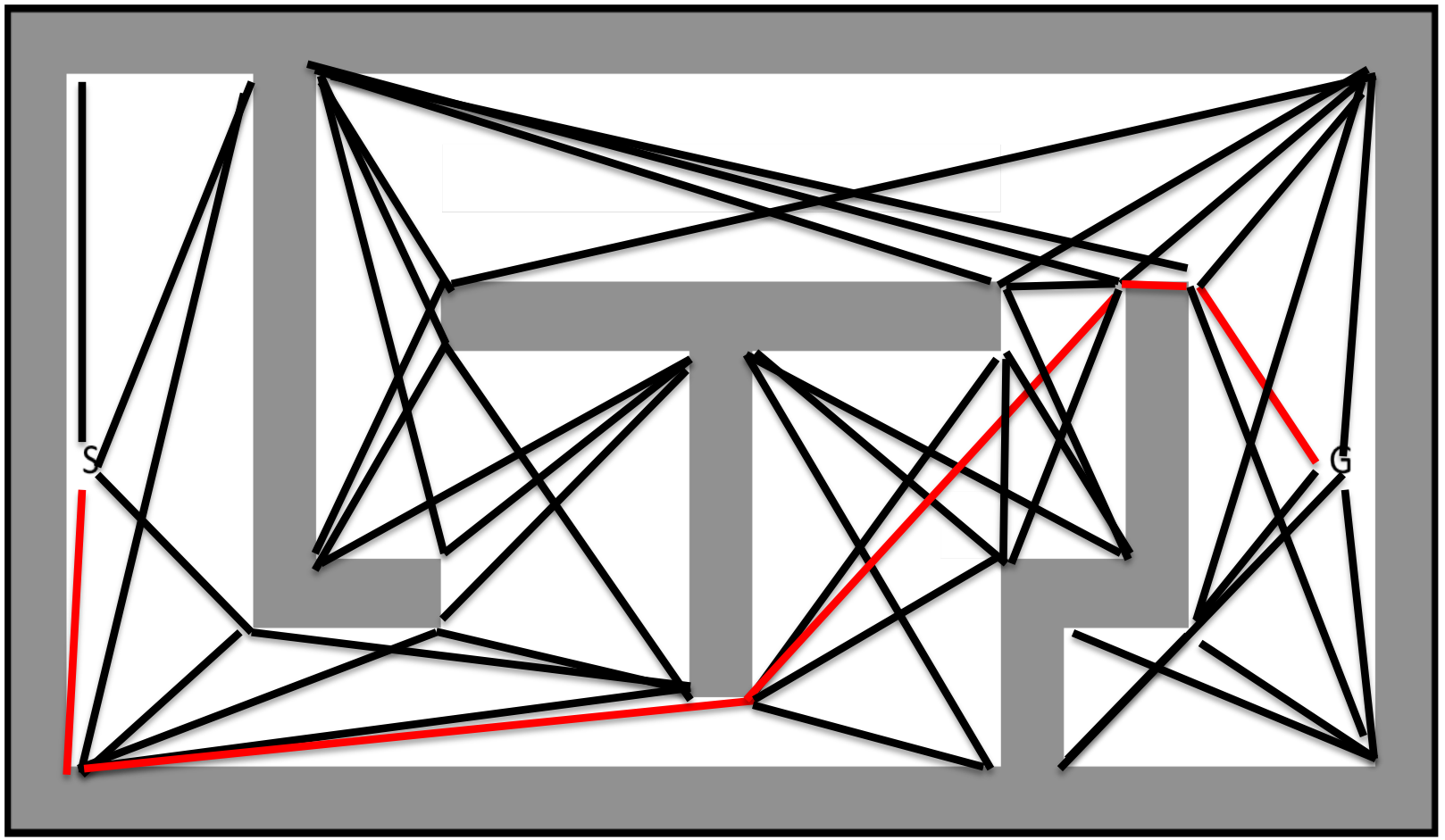
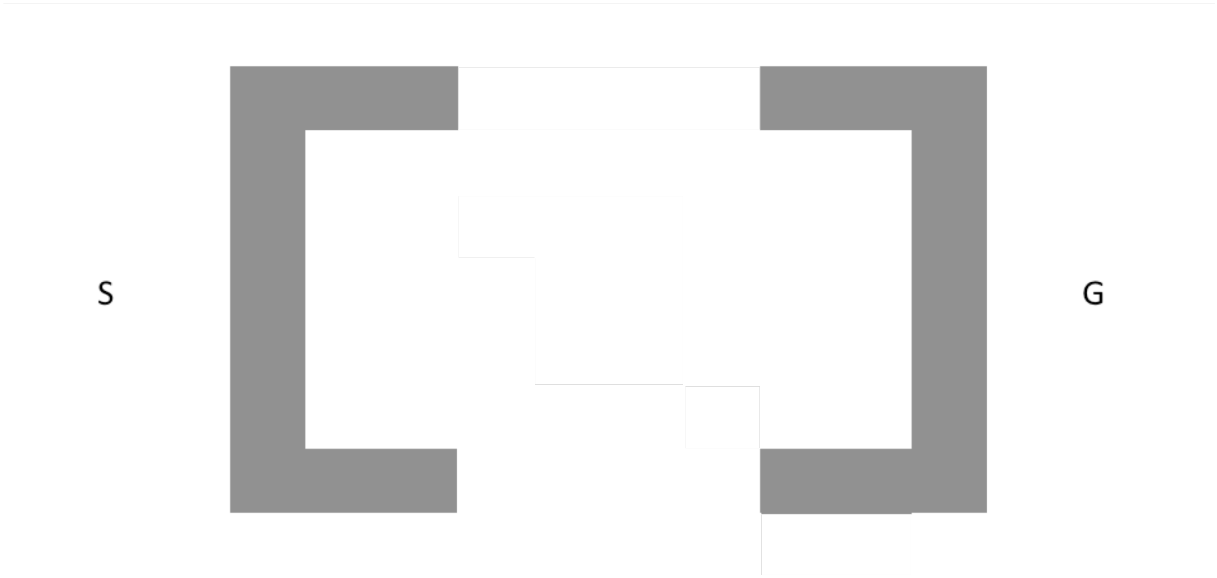


Roadmaps – Visibility Graph

Spring 2018

Apply the Visibility Graph algorithm to the scene below where darker elements correspond to obstacles.

- Highlight the shortest(s) visibility graph path based on the least number of individual edges between from start “S” and goal “G” for the figure below.



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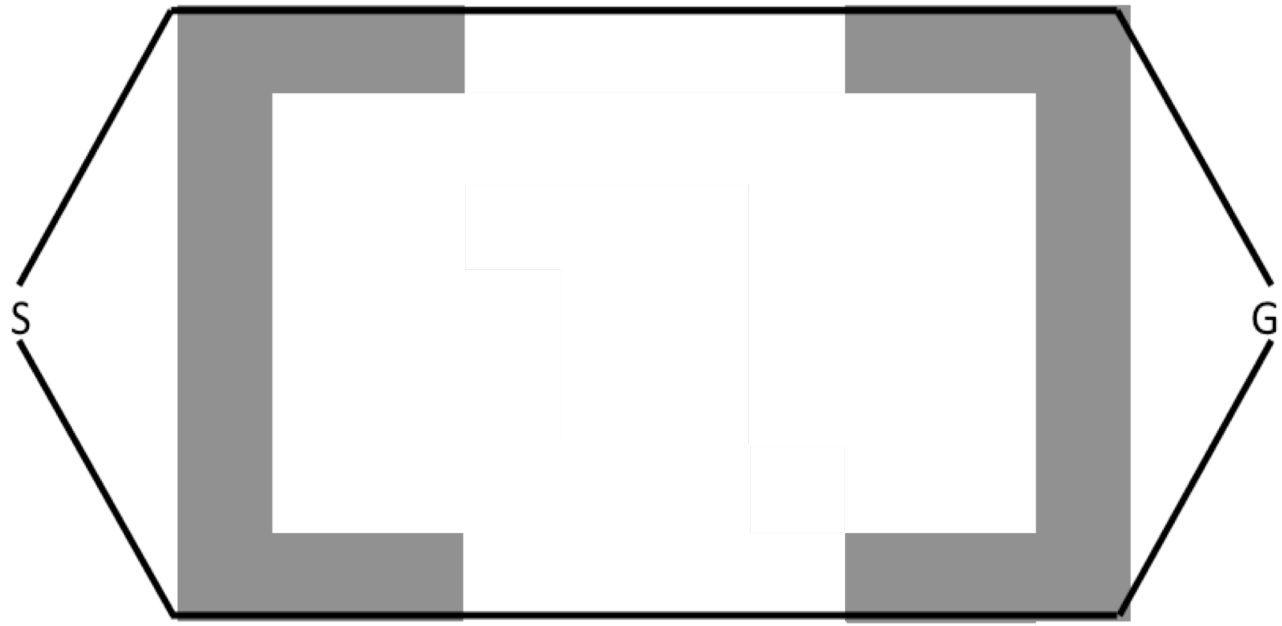

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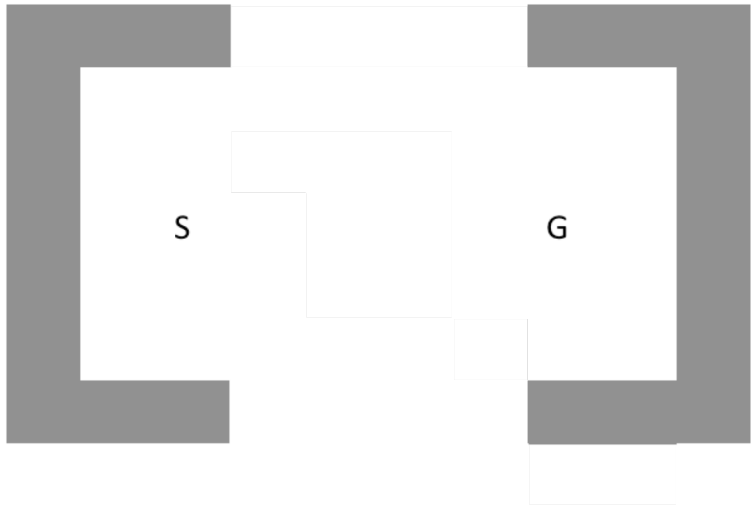

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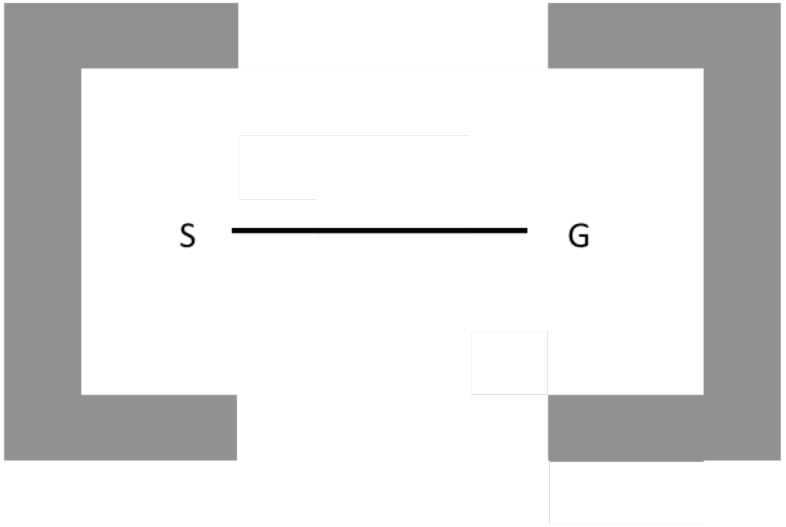
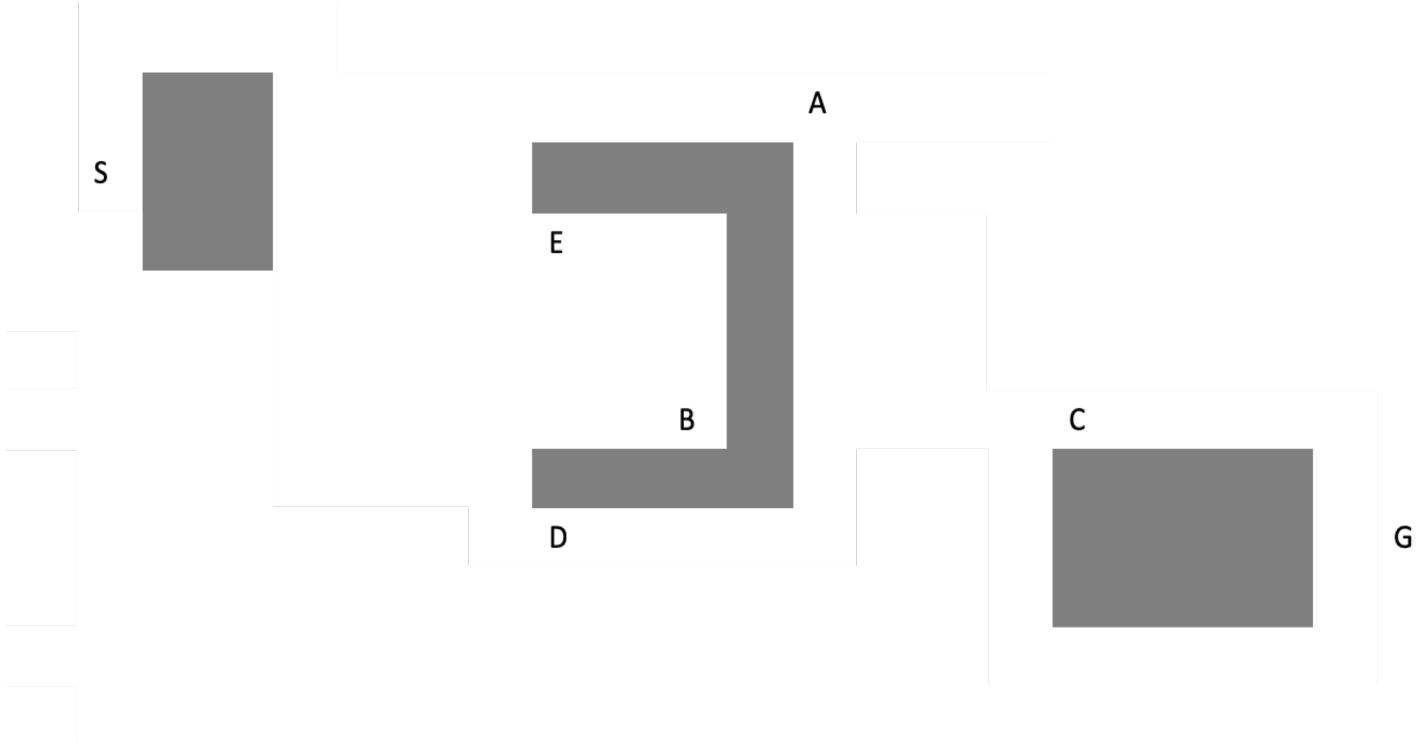


Roadmaps – Visibility Graph

Spring 2018

Apply the Visibility Graph algorithm to the scene below where darker elements correspond to obstacles.

- Apply the Roadmap Visibility Graph algorithm to show ONLY the edges starting or ending at vertices A, B, C, D, E, as specified by the “Roadmaps - Visibility Graph” algorithm.



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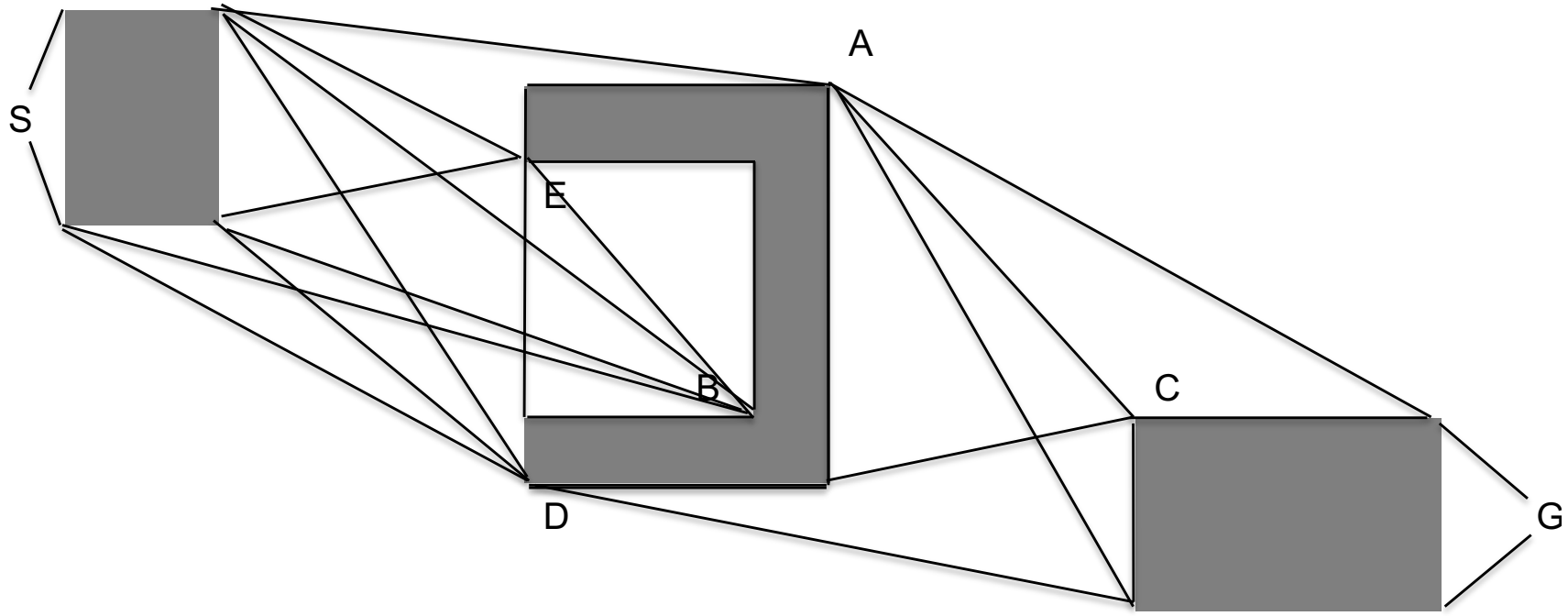

Roadmaps – Visibility Graph

Fall 2018

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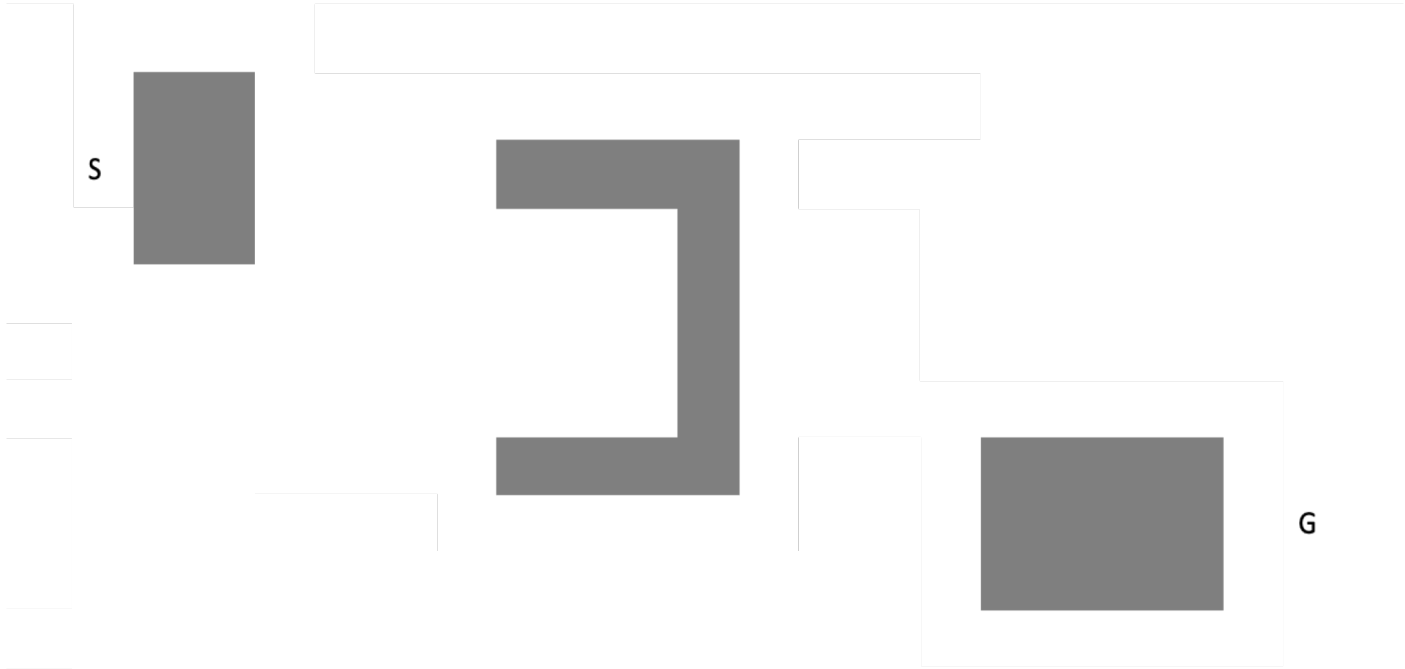
- Apply the Roadmap Visibility Graph algorithm to show the edges corresponding to at least one of the shortest path between “S” and “G”.



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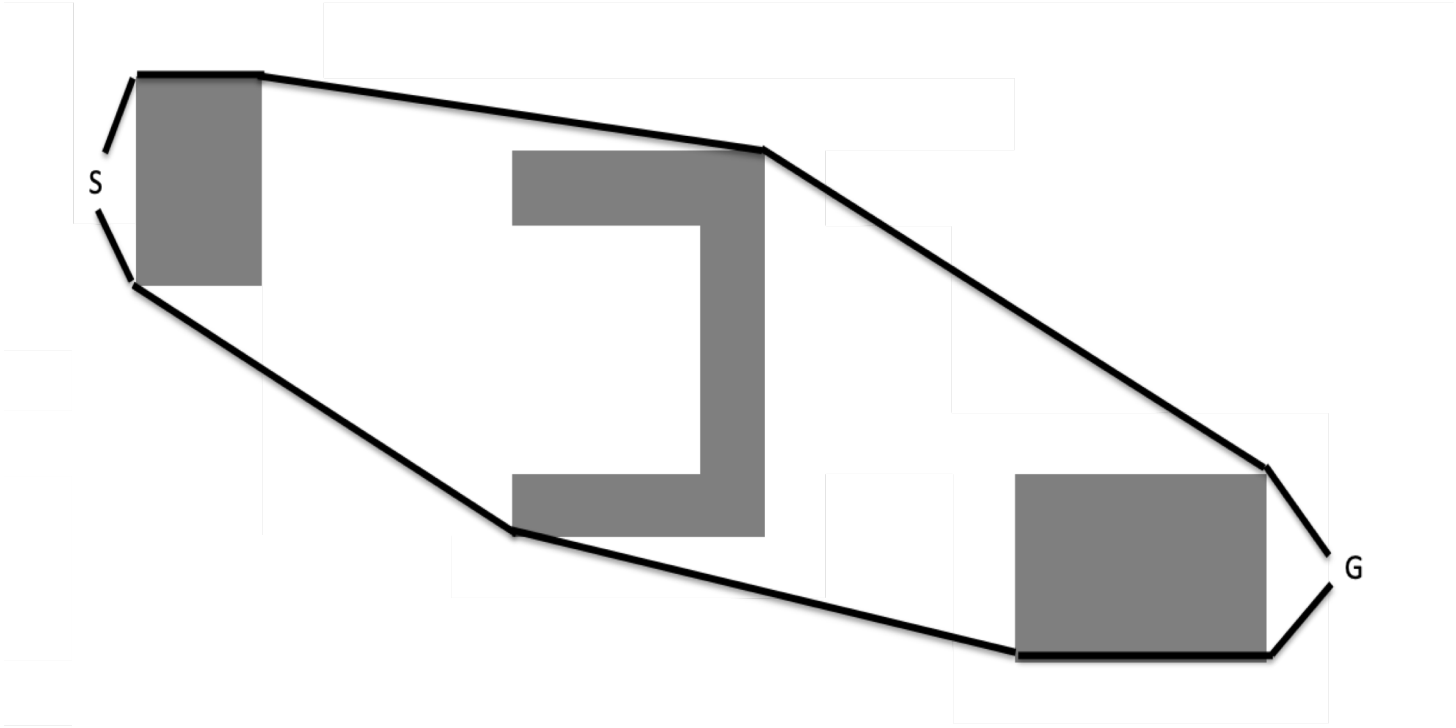

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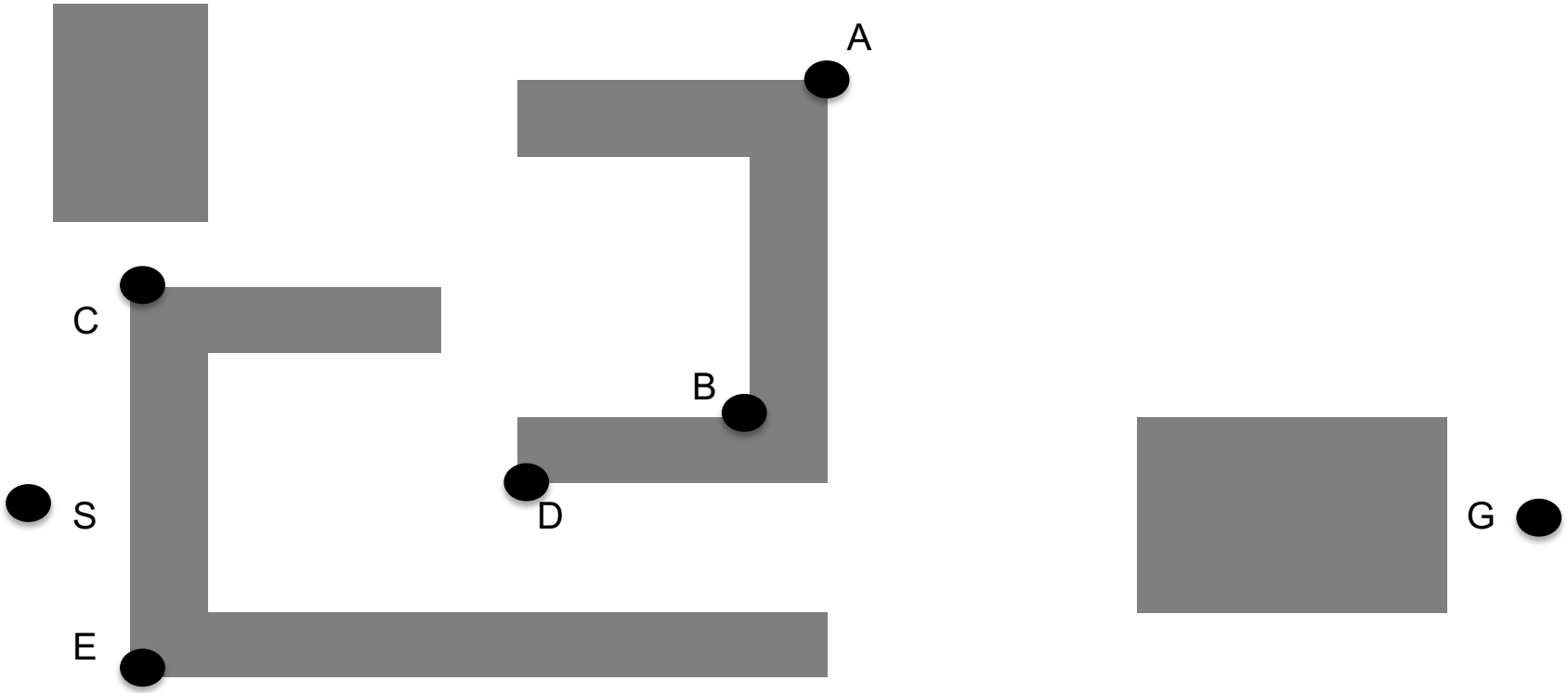

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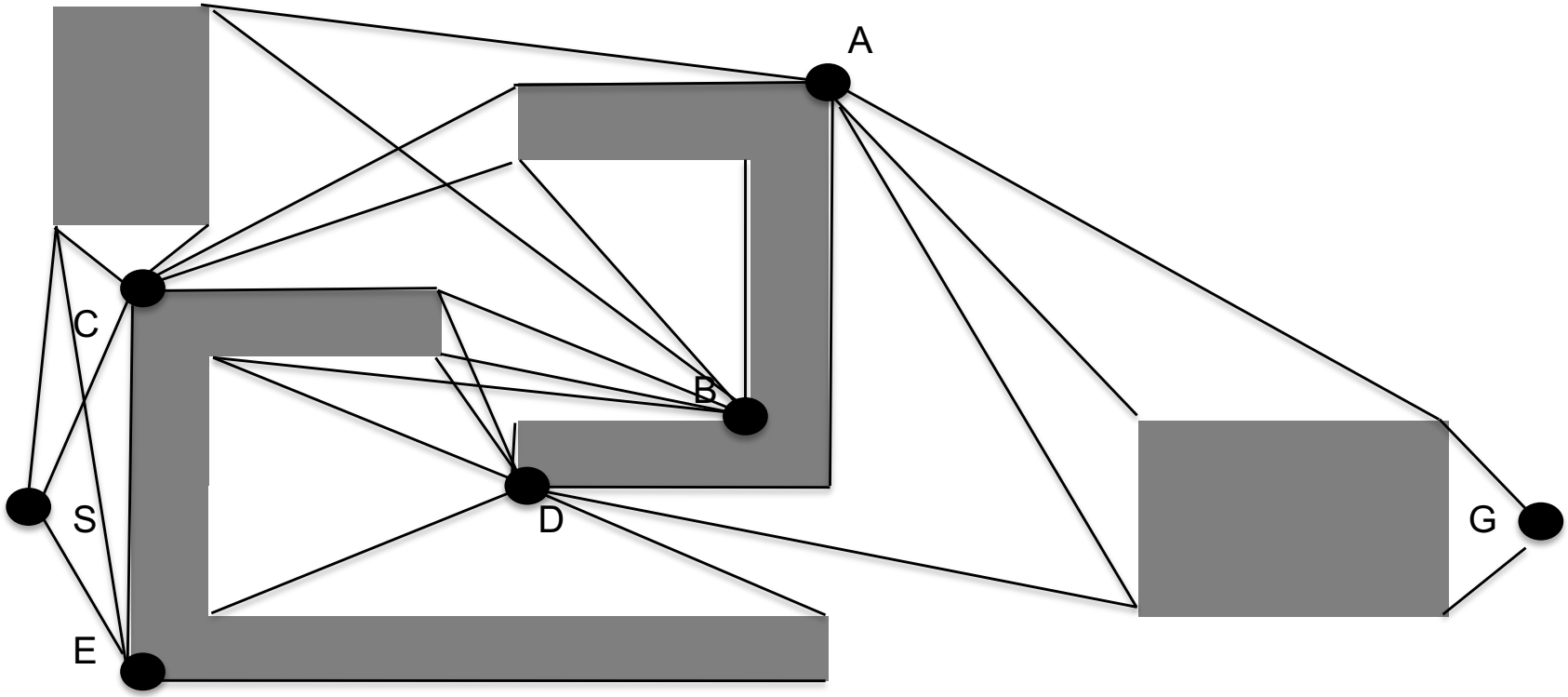

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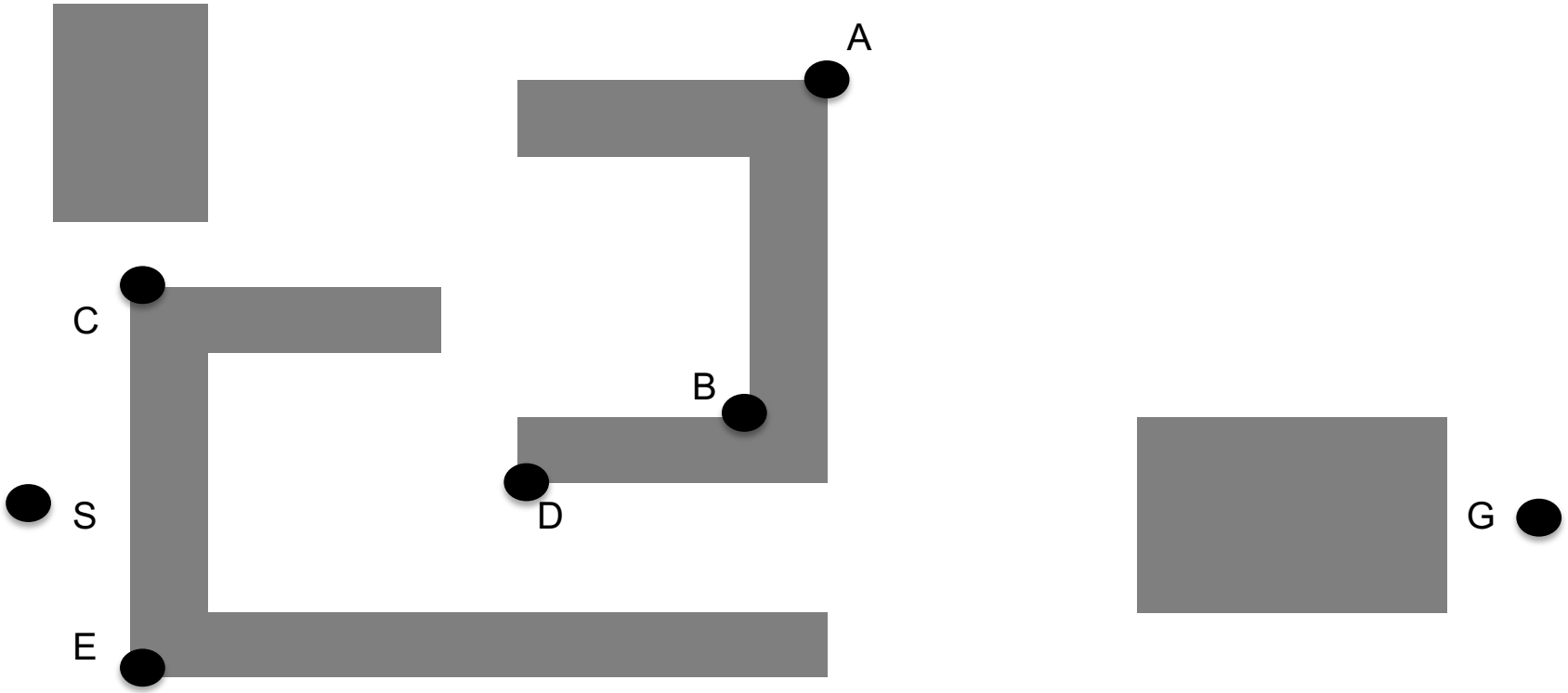

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