SMOOTHING VORONOI-BASED PATH WITH MINIMIZED LENGTH AND VISIBILITY USING COMPOSITE BEZIER CURVES

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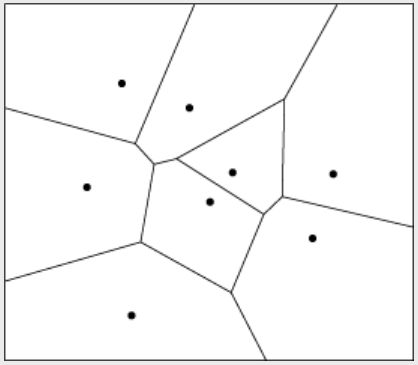
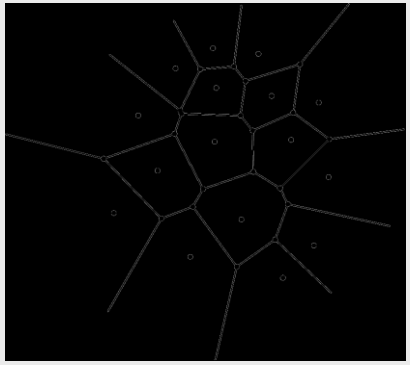
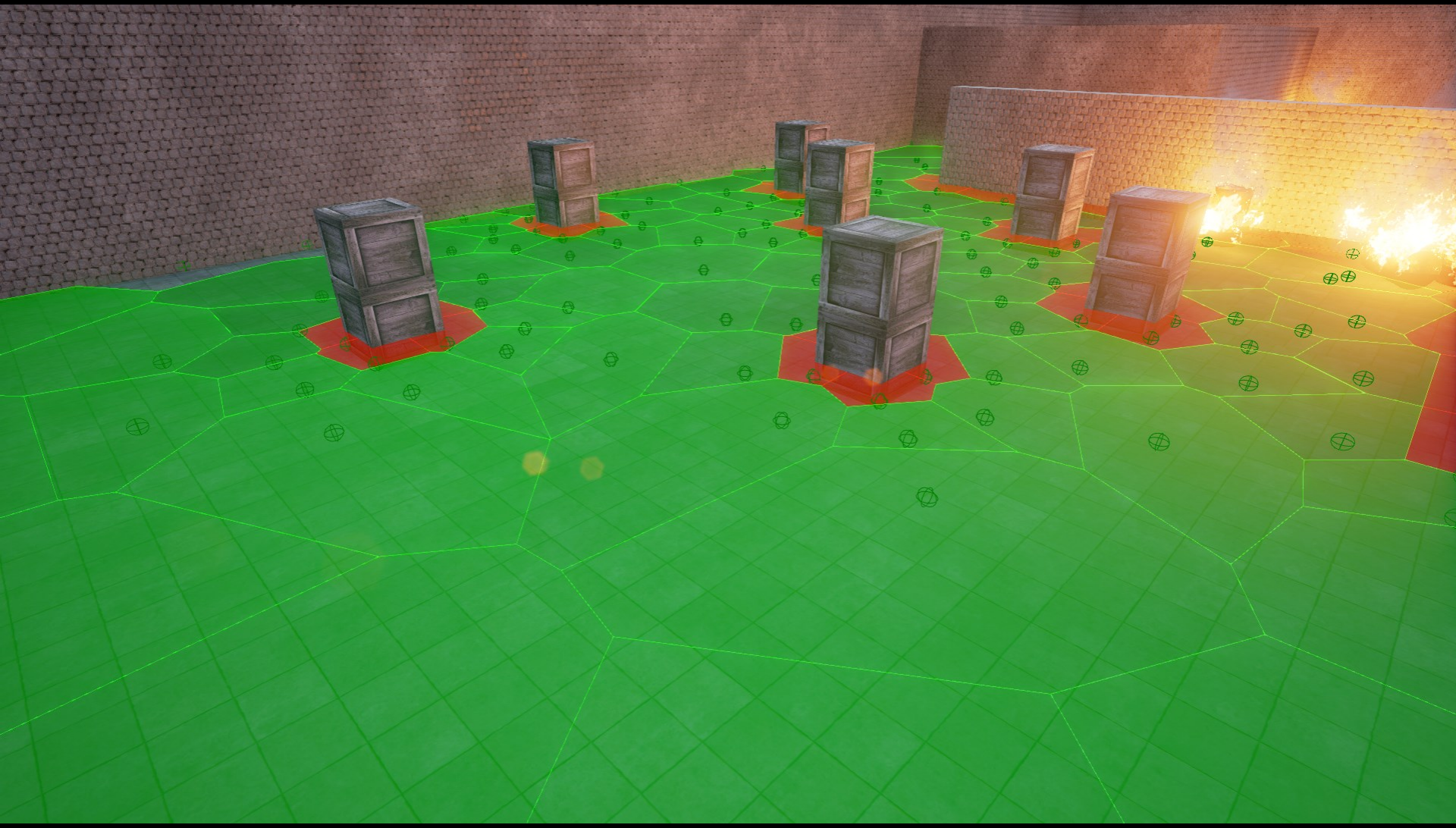
VORONOI-BASED NAVIGATION MESH

- Let $\boldsymbol{P} = \{\boldsymbol{p_0}, \boldsymbol{p_1} \ldots \boldsymbol{p_n}\}$ be a set of points called sites
- Let $\boldsymbol{VD(p_i)} = \{\boldsymbol{x}: |\boldsymbol{p_i} - \boldsymbol{x}| \leq |\boldsymbol{p_j} - \boldsymbol{x}|, \forall \boldsymbol{j} \neq \boldsymbol{i}, \boldsymbol{x} \in \mathbb{R}^2\}$ be a polygon of a mesh
- Let a union of connected polygons be a **Voronoi surface**
- Then a union of Voronoi surfaces is a **Voronoi-based navigation mesh**



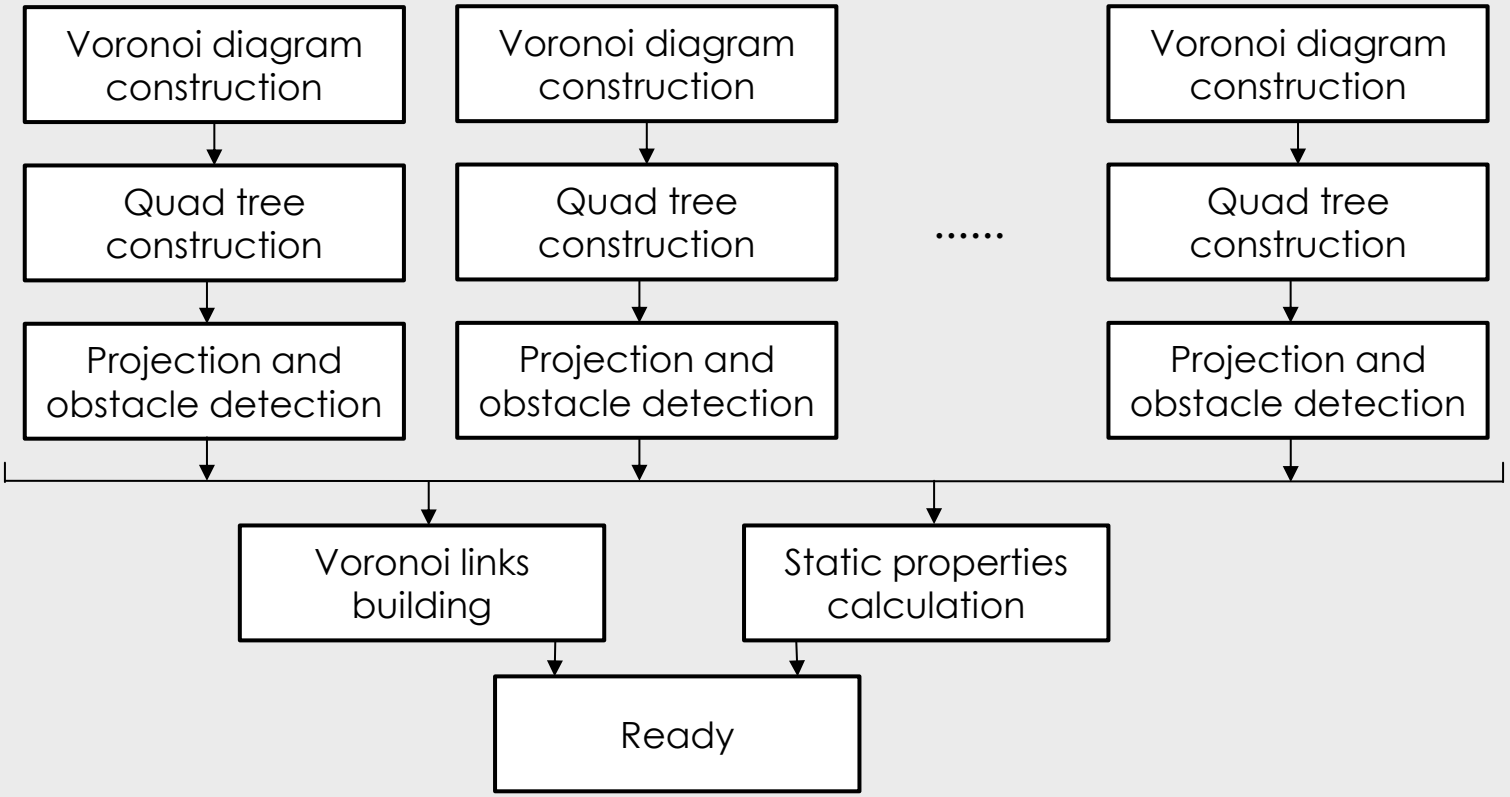




VORONOI-BASED NAVIGATION MESH

- Provides an opportunity to find paths considering tactical properties
- Allows to solve such problems as:
  - Predicting actions of opposing team
  - Searching for sniper and cover positions
  - Adopting to dynamically changing situation
- Helps to smooth produced paths
- Helps to track movement as a sequence of polygons

CONSTRUCTION PIPELINE



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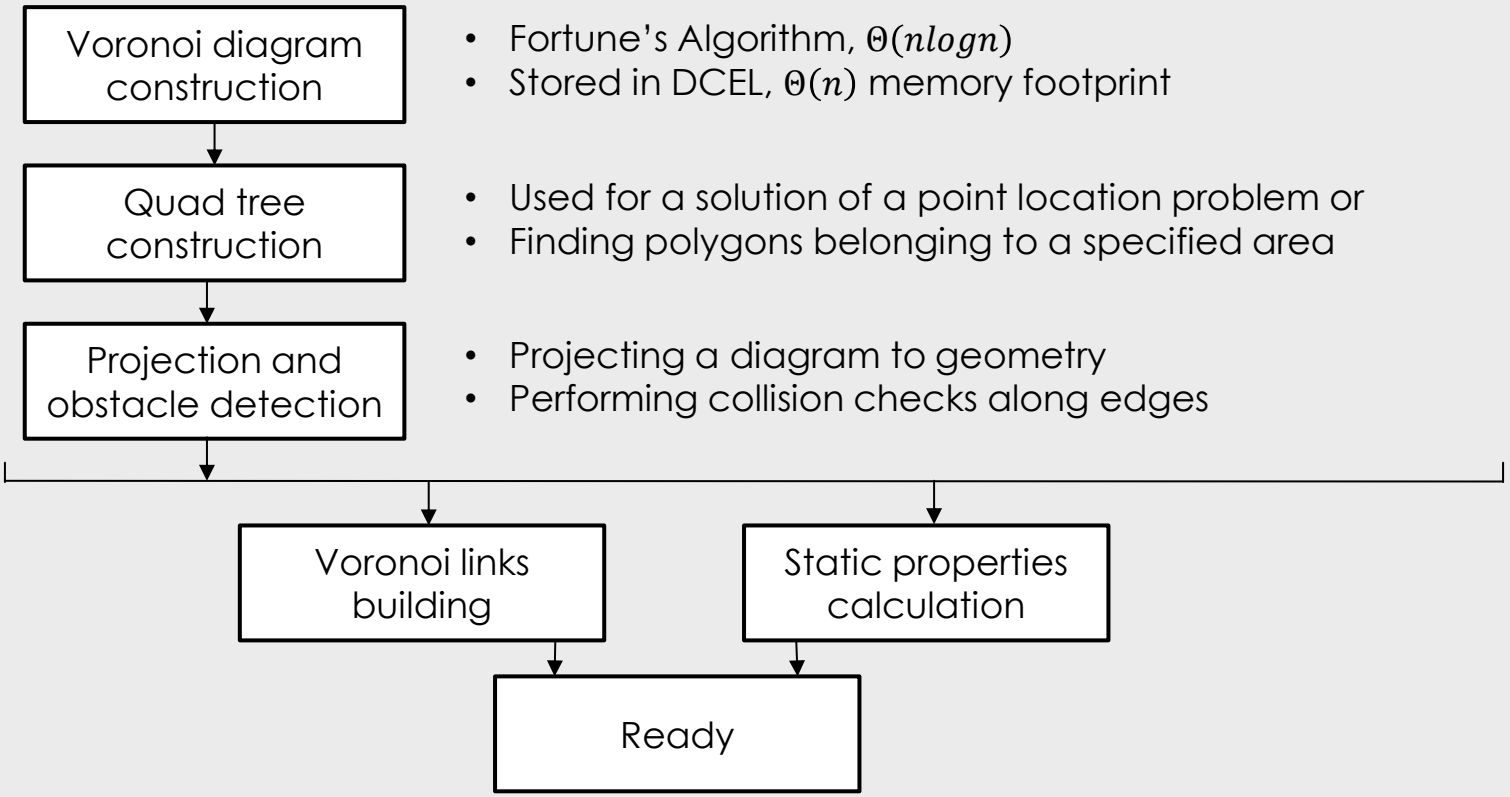

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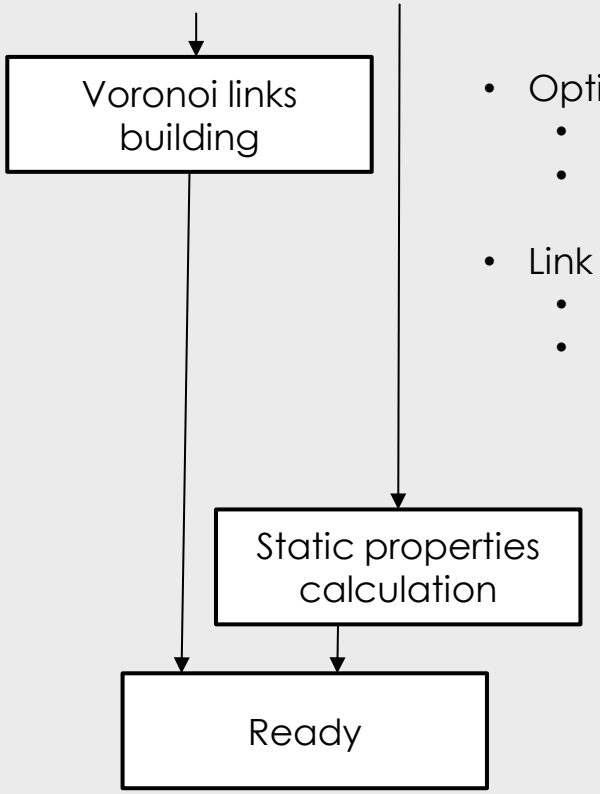
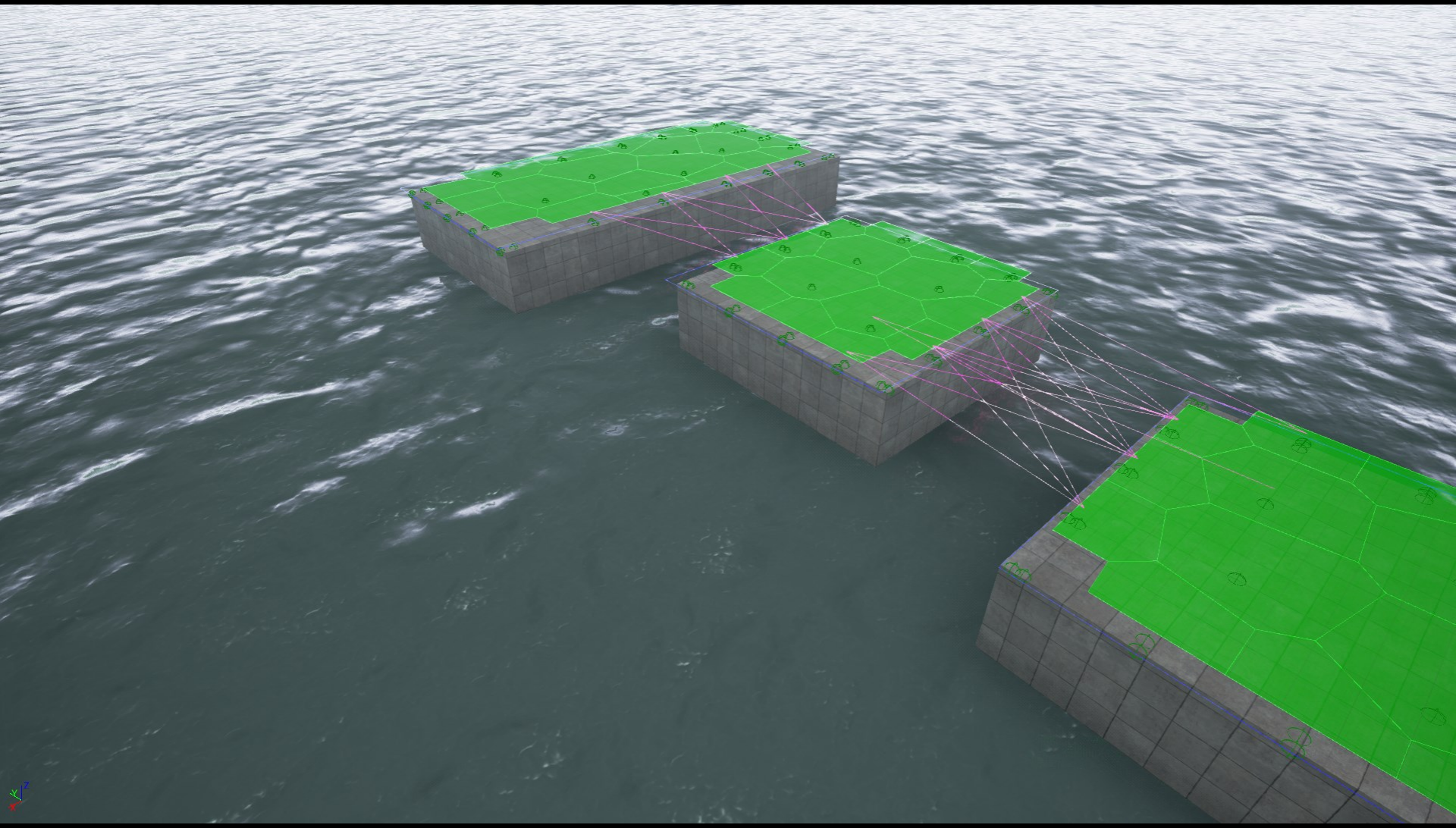
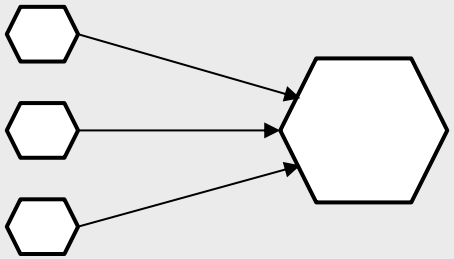


- Optimizations:
  - One end of a link should be a border polygon
  - Candidates for the second end are found using quad trees
- Link candidates are eliminated if:
  - Height difference is too high
  - Segment of polygons' sites intersects edge of the border polygon with is not near the border (in order to prevent redundant links)

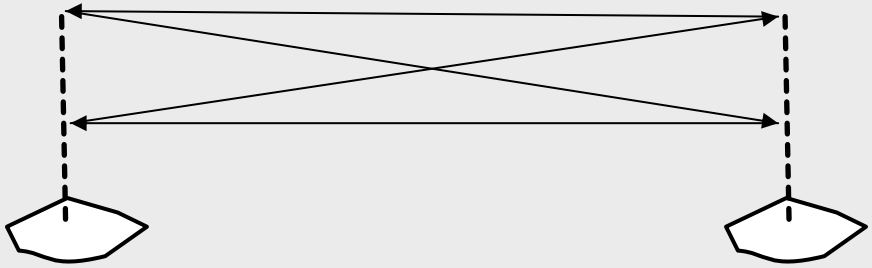


TACTICAL PROPERTIES CALCULATION

- LET **VISIBILITY** BE A VALUE FROM 0 TO 1 INDICATING AN AMOUNT OF AREA VISIBLE FROM A POLYGON WITHIN A GIVEN RANGE



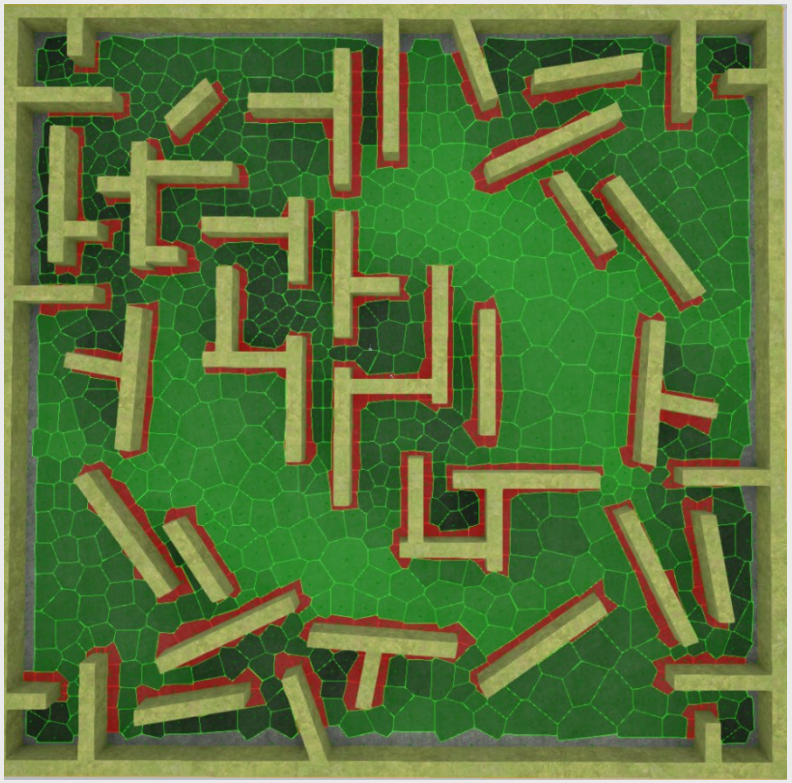
- The sum of areas of visible polygons is divided by some predetermined constant and then clamped to [0, 1] range
- Several line collision checks between a pair of polygons may be performed in order to distinguish a case of partial visibility



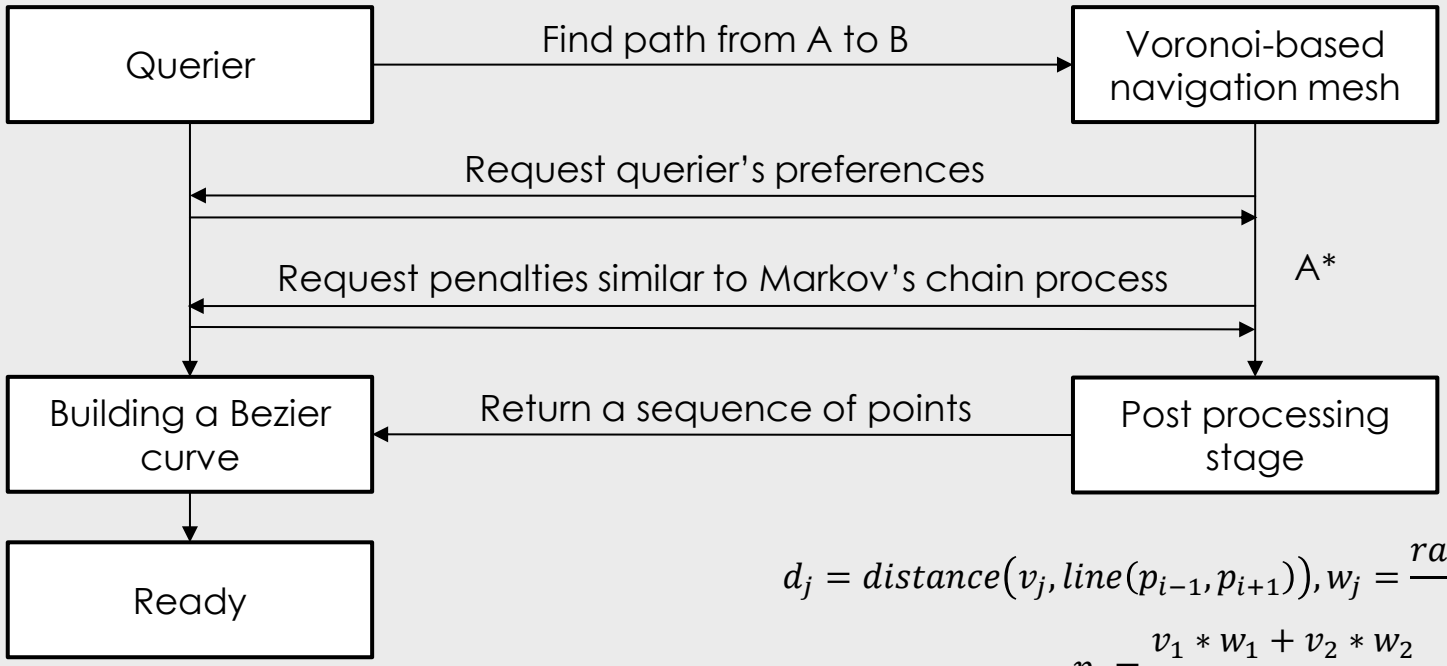
TACTICAL PROPERTIES CALCULATION

- Visibility measure allows us to:
  - Find covers and predict where opponents could hide
  - Search for paths moving along which will be detected with the lowest probability according to a map topology

- Other tactical properties consist of:
  - Influence map
  - Frag map
  - Danger map
  - Loot map
  - Sniper positions



PATH PLANNING PIPELINE



$$d_j = distance\big(v_j, line(p_{i-1}, p_{i+1})\big), w_j = \frac{rand(1,b)}{d_j}, j = 1,2$$

$$p_i = \frac{v_1 * w_1 + v_2 * w_2}{w_1 + w_2}$$

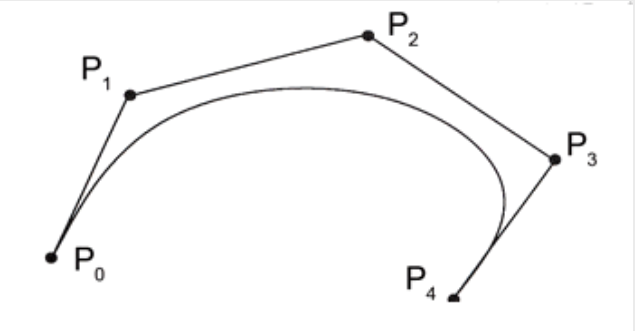
BUILDING A COMPOSITE BEZIER CURVE

A sequence of points → Insert additional points → Split into pieces with collision-free convex hull → Removal of crowded points → Ensure C1 continuity → Ready

- Strategy:

$$\sum_i distance(Piece[i].FirstPoint, Piece[i].LastPoint) \rightarrow min$$

- Complexity: $\theta(n^3)$
- Ray casts: $\theta(n^2)$

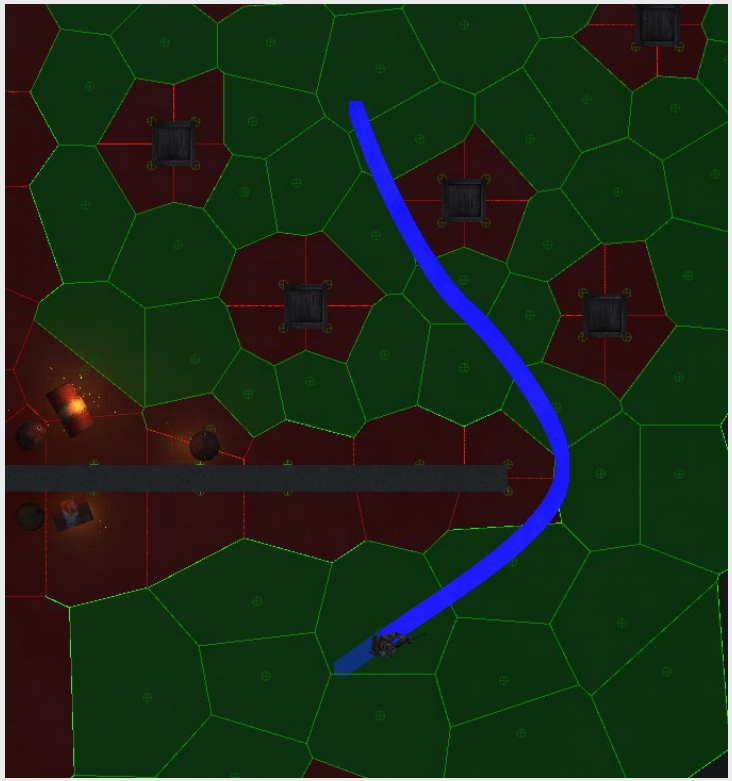


EXPERIMENT AND CONCLUSION

- Comparison with the shortest path length

\	1	2	3	4
AD, %	5.9	12.5	27	37.5
VD, %	0.3	1	0.7	2.1

- [1, 2] Piecewise path with visibility penalty multiplier equaled 0 and 10;
- [3, 4] Smoothed path with visibility penalty multiplier equaled 0 and 10.



THANKS FOR ATTENTION

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