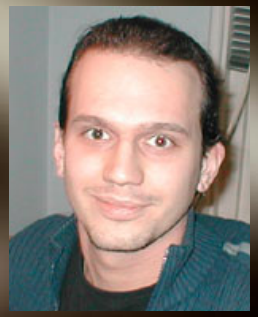
Killzone's AI: Dynamic Procedural Tactics

Arjen Beij & William van der Sterren

Killzone's AI: Dynamic Procedural Tactics



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Contents

- Dynamic procedural tactics
- Position picking
- Position Evaluation functions
- Tactical path-finding
- Suppression Fire
- World Representation
- Conclusions

Dynamic Procedural Tactics

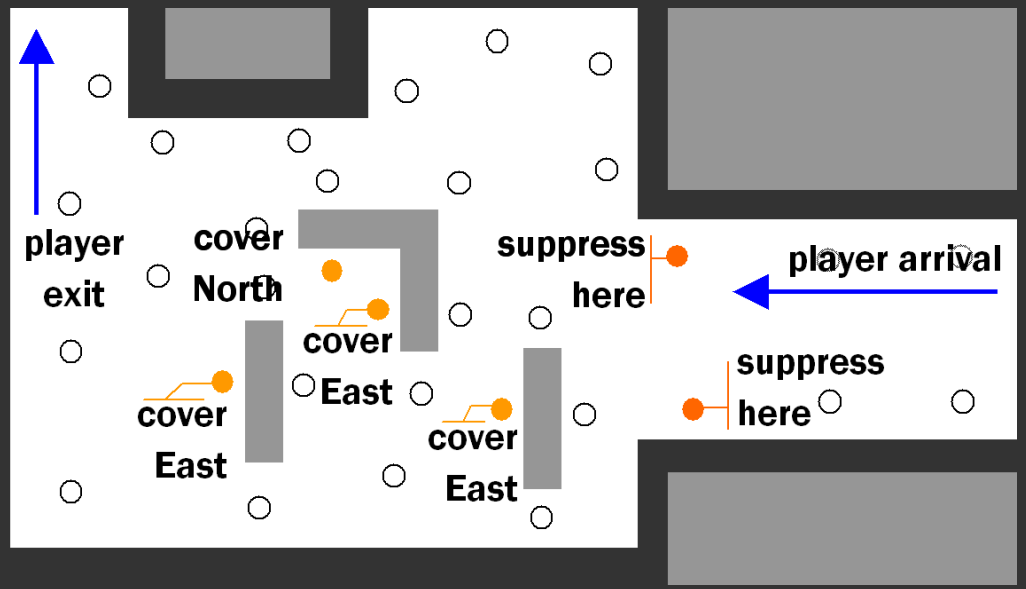
Dynamic procedural tactics =

- Having the rules and concepts to dynamically compute solutions to tactical problems

AI Tactics

Common approach

- Level designer placed hints
- Triggered scripted behavior



Dynamic Procedural Tactics

Game-play benefits

- Works for any number of players
- Fights anywhere

Production benefits

- Reuse of AI behavior
- Quick level prototyping
- Roll out improvements game wide

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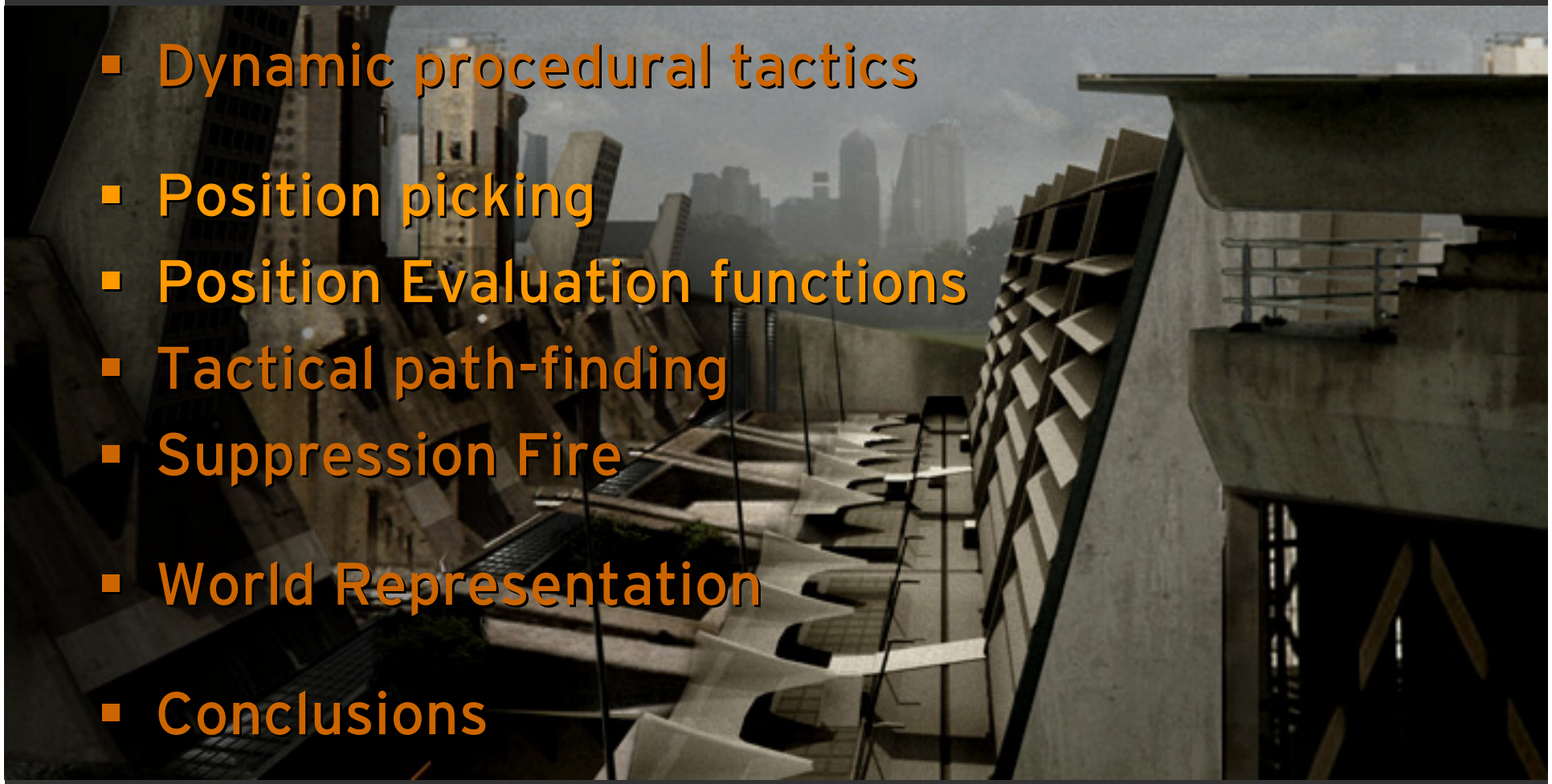

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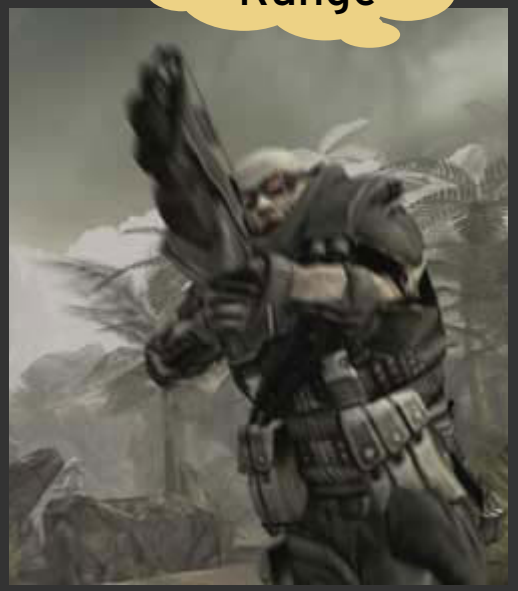
Position Picking

- Picking a good position is half the battle in ‘fire & maneuver’ combat
- Account for dozens of (dynamic) factors
- How to pick that position?



Position Evaluation Functions

Determining the most appropriate position

- Given *n* potential destinations
- To compare positions, need a single value

Use position evaluation function

- Weighted sum
- Combines basic factors

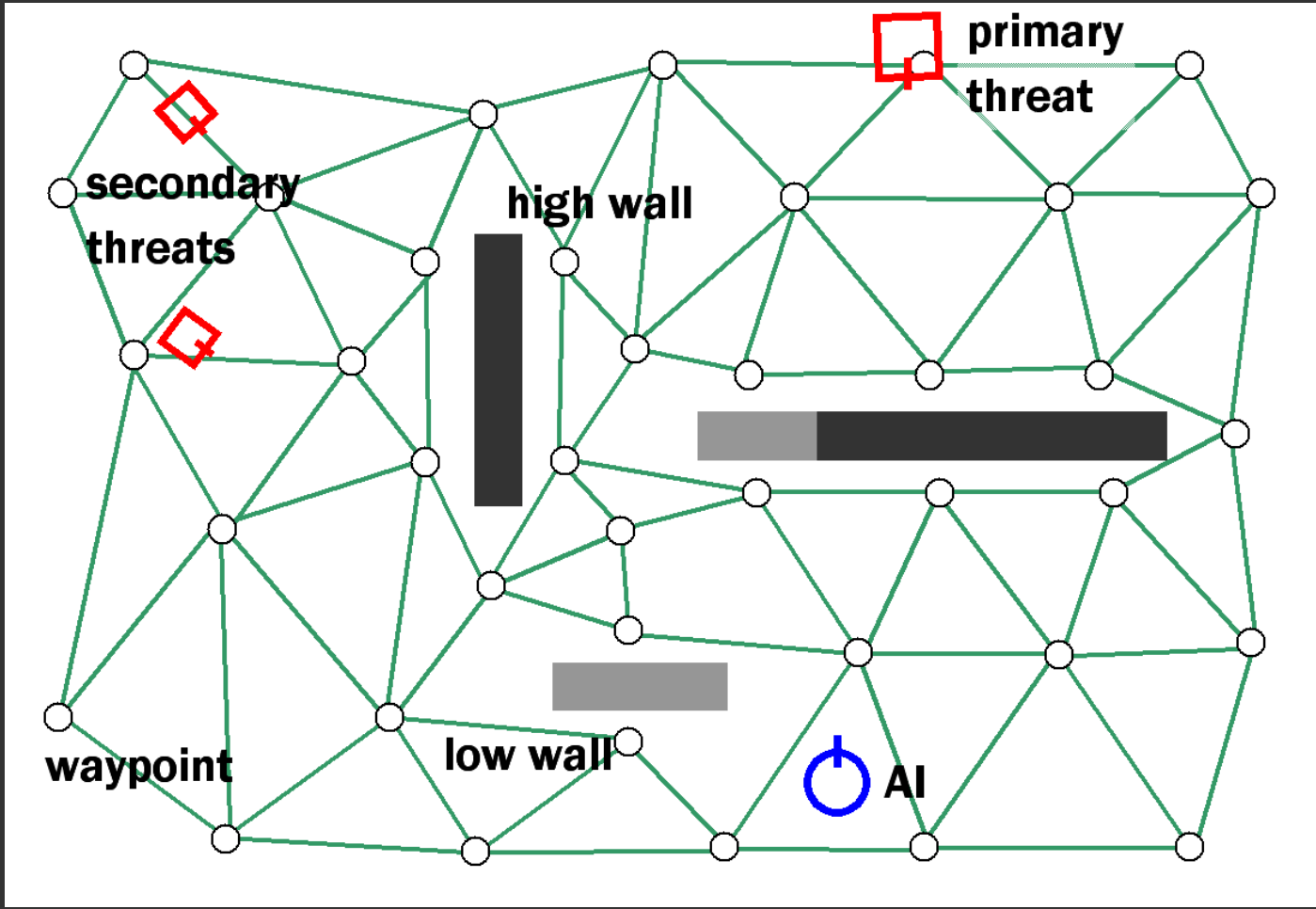
Example: Picking an Attack Position 1

Example: Picking an attack position

- Multiple threats
  - Attack primary threat
  - Cover from other threats preferred
- Partial cover from primary
- Proximity
- Preferred fighting range

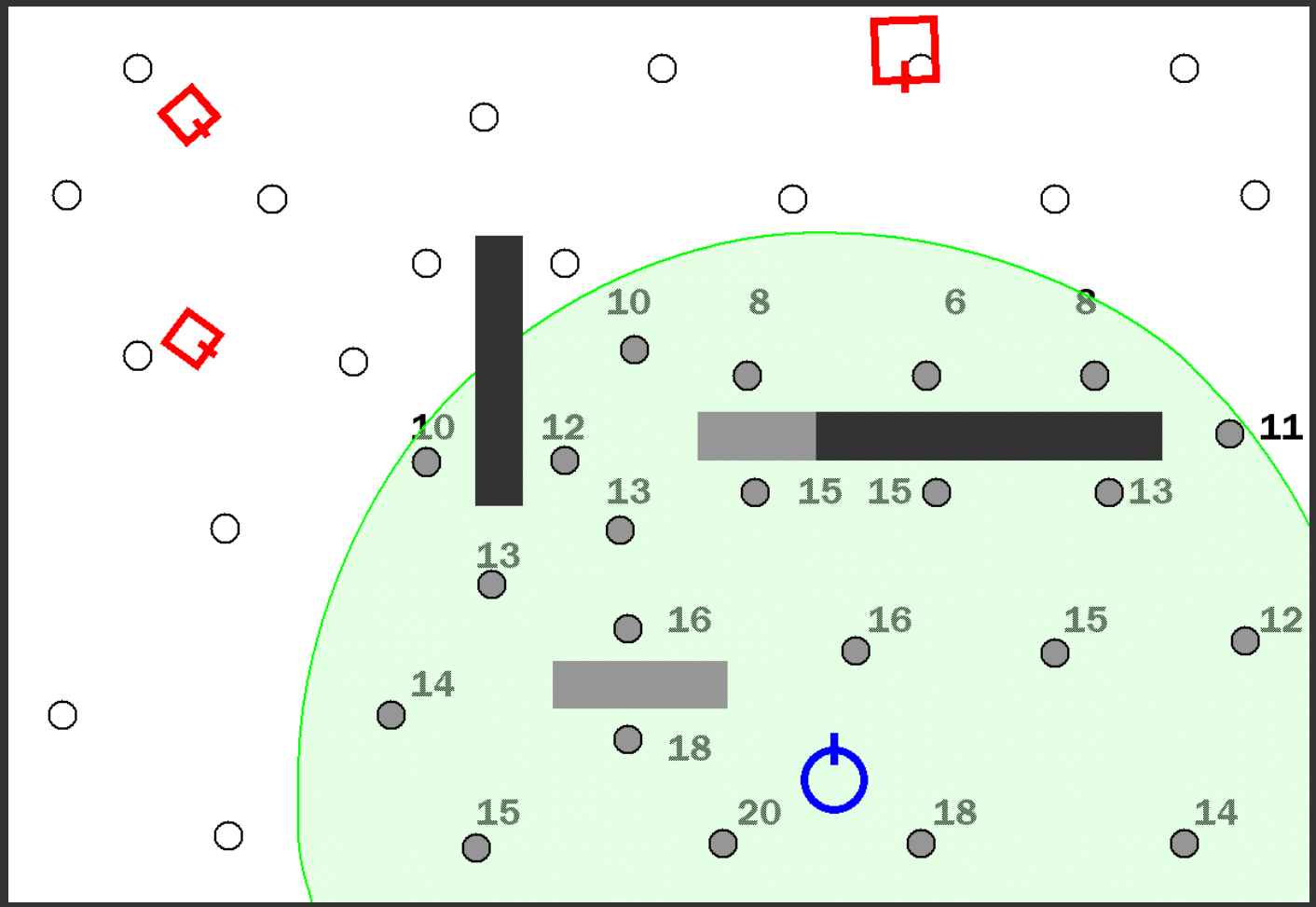
Combine into a single value per position

Example: Picking an Attack Position 2



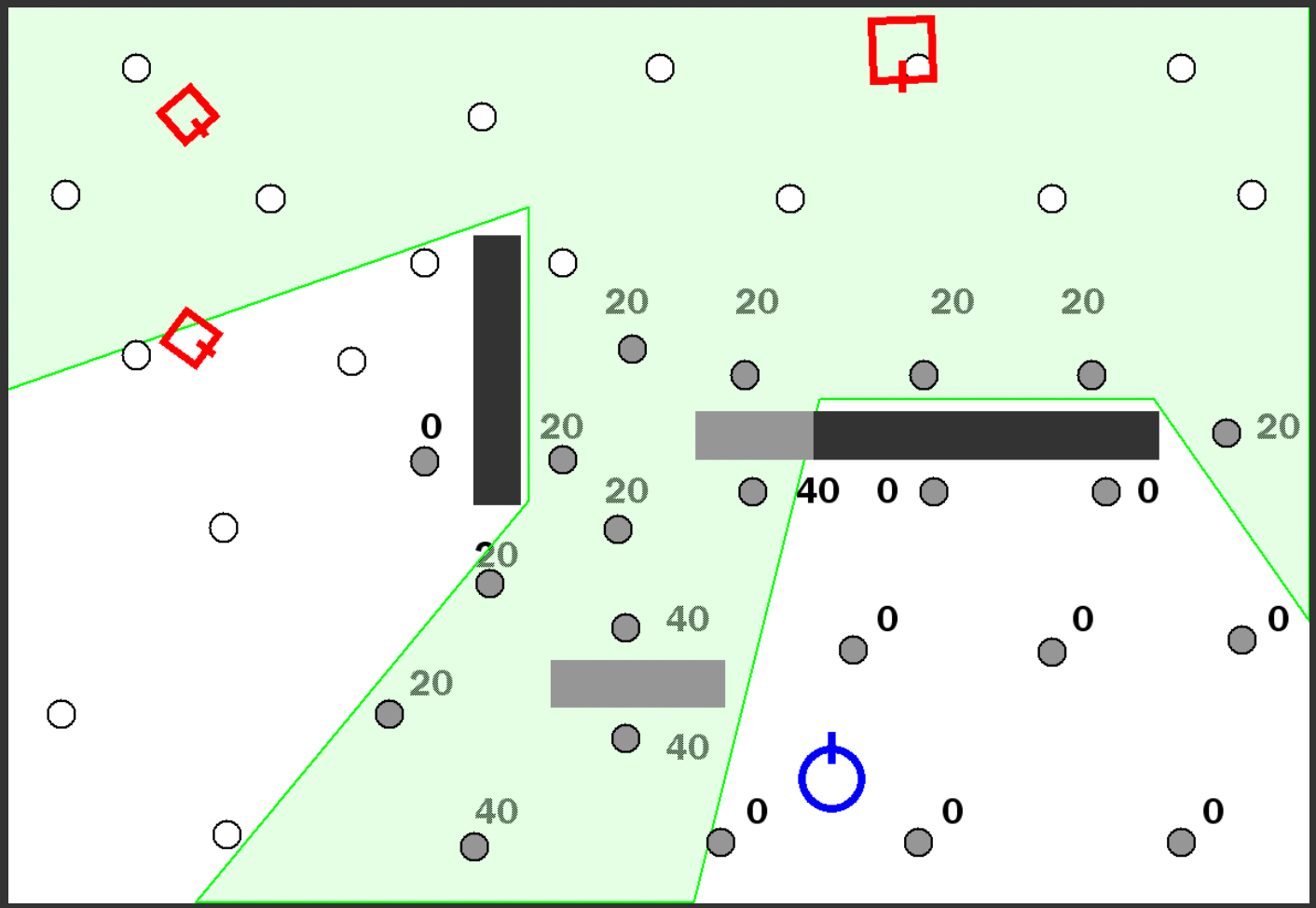
Initial situation: three threats, some walls and a waypoint graph

Example: Picking an Attack Position 3



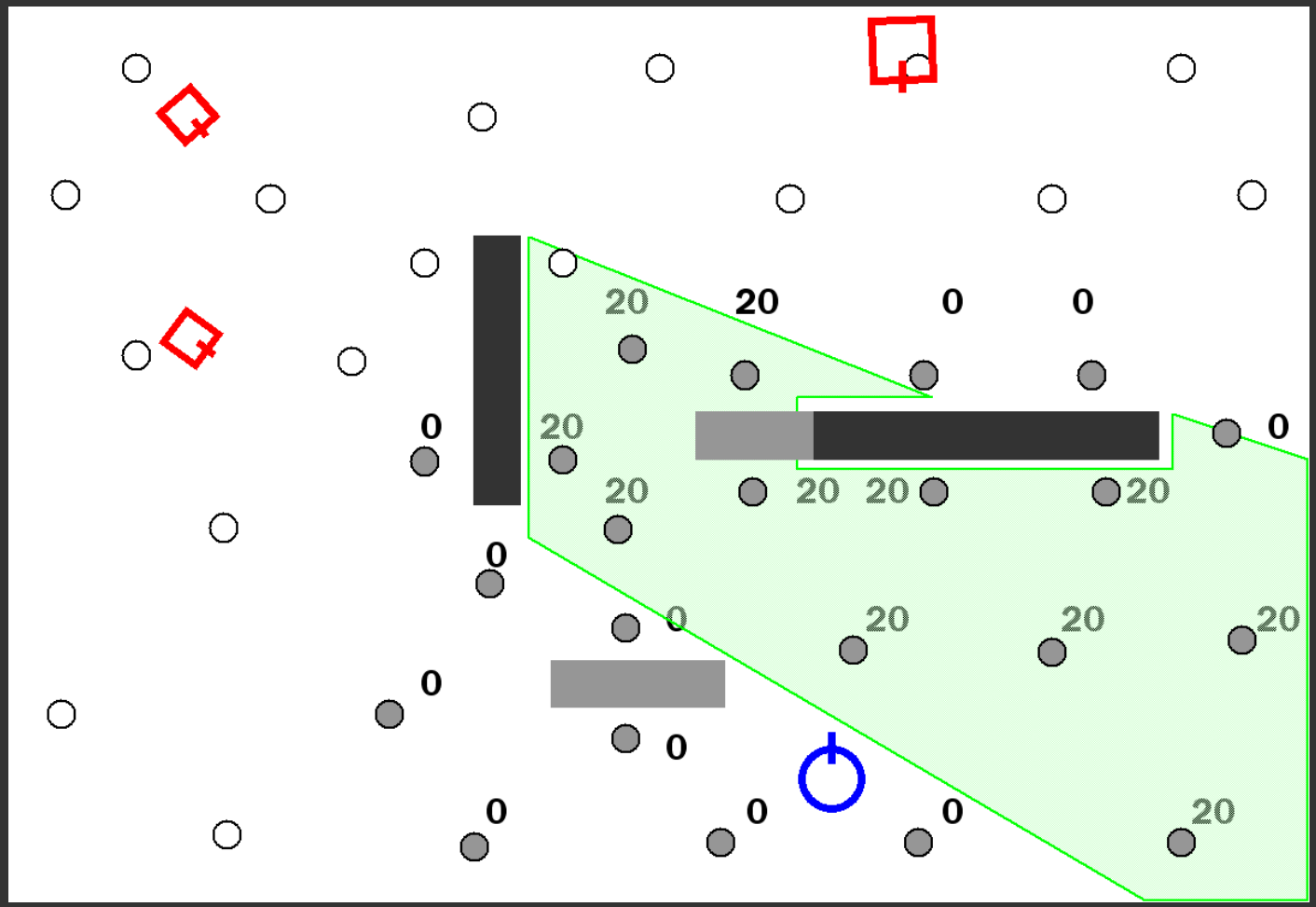
Selected nearby waypoints, annotated with proximity (weight 20)

Example: Picking an Attack Position 4



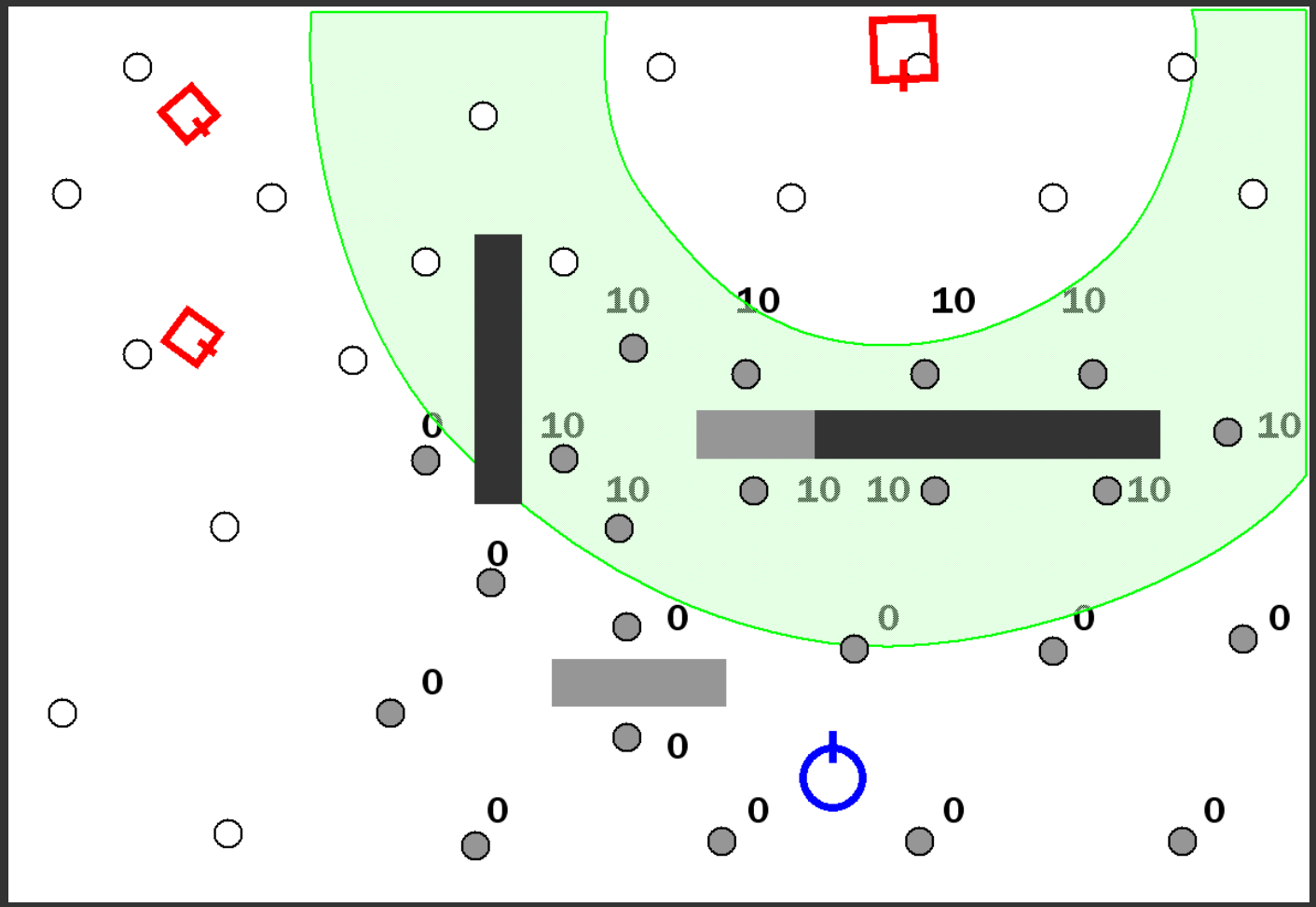
Annotations for LoF to primary threat (40 if partial cover, 20 otherwise)

Example: Picking an Attack Position 5



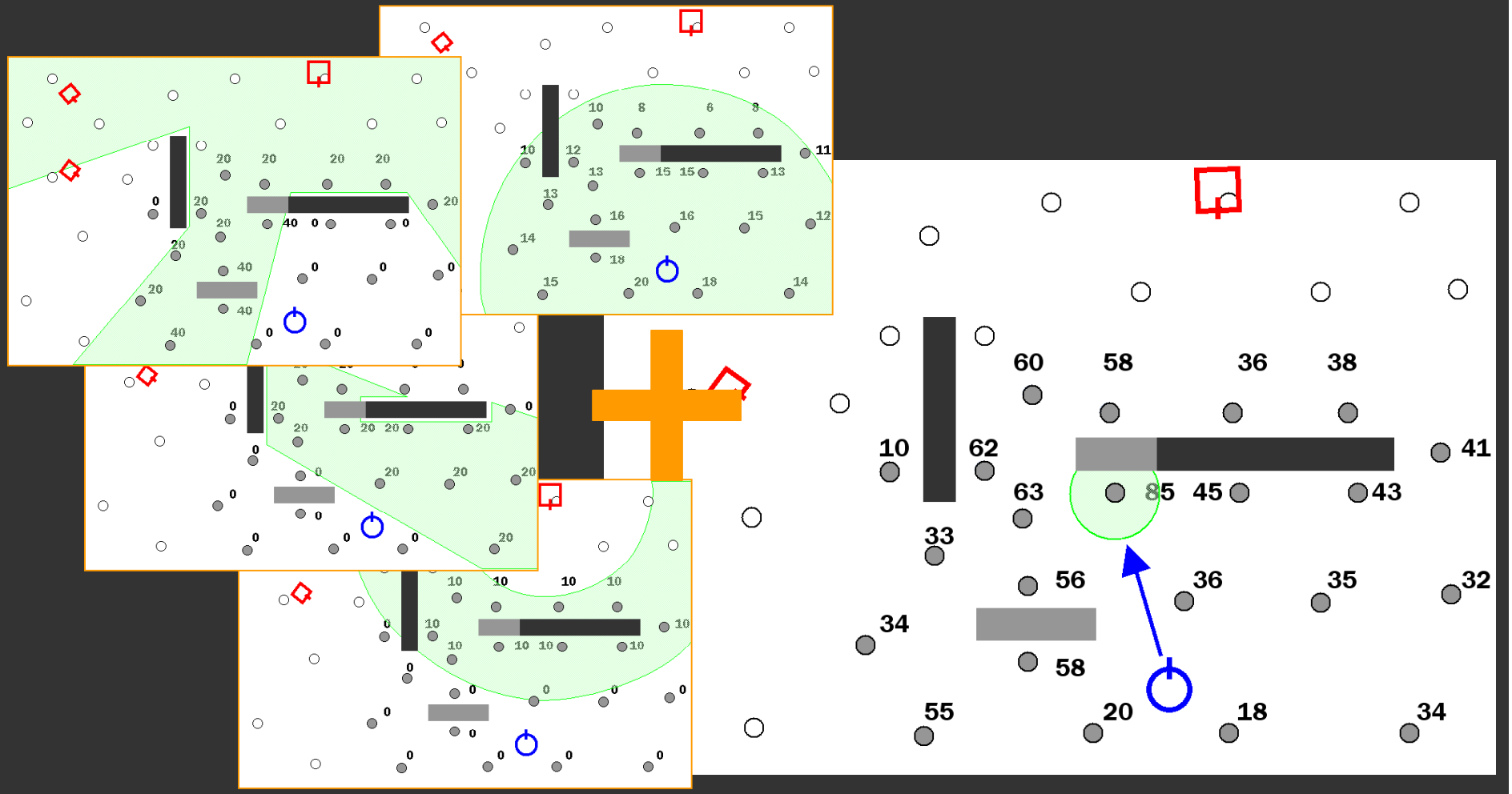
Annotations for cover from secondary threats (weight 20)

Example: Picking an Attack Position 6



Annotations positions inside preferred fighting range (weight 10)

Example: Picking an Attack Position 7

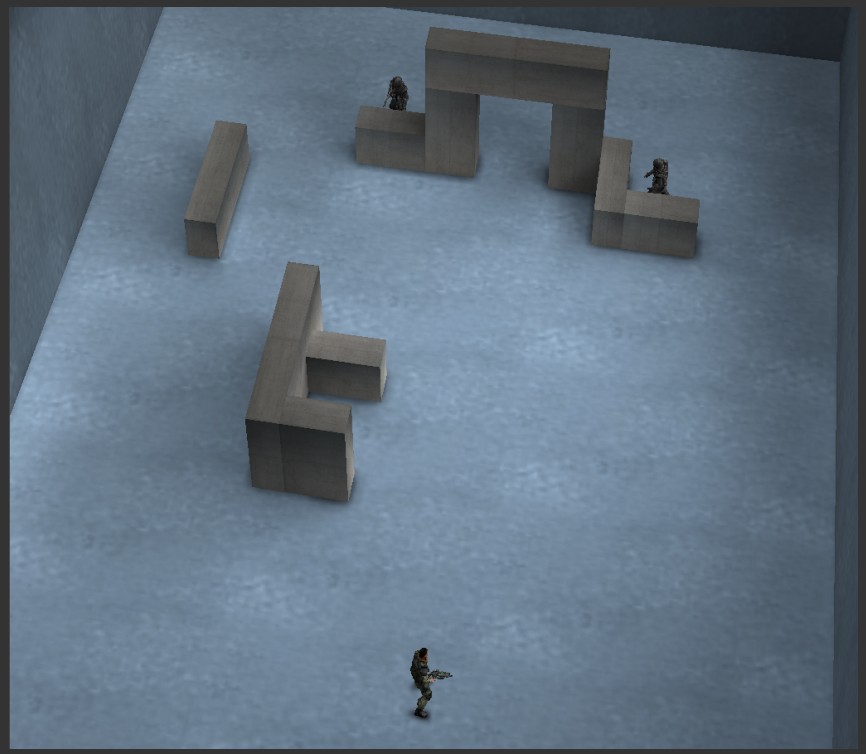


Adding up all the annotations yields the most promising attack position

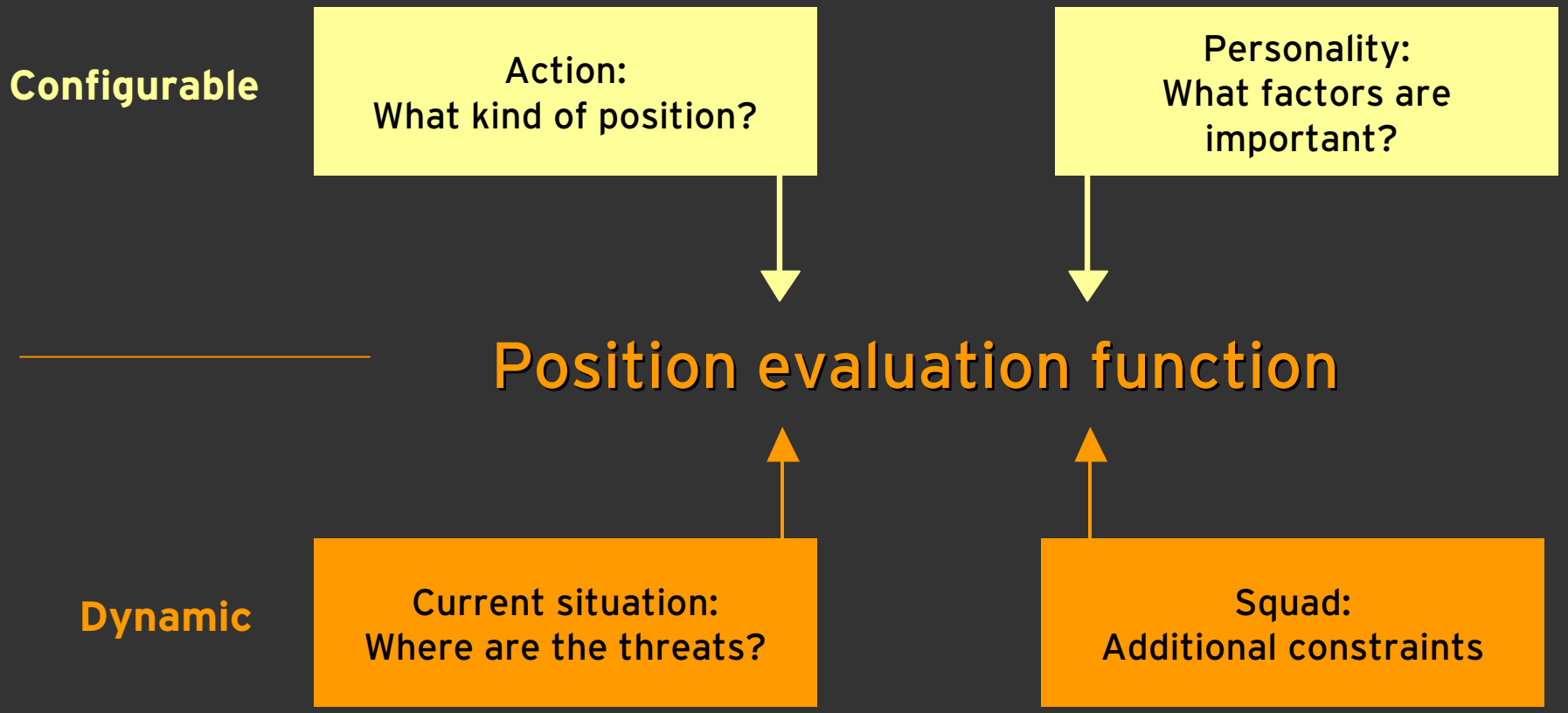
Example: Picking an Attack Position 8

Single threat

Multiple threats



Configurable and Dynamic



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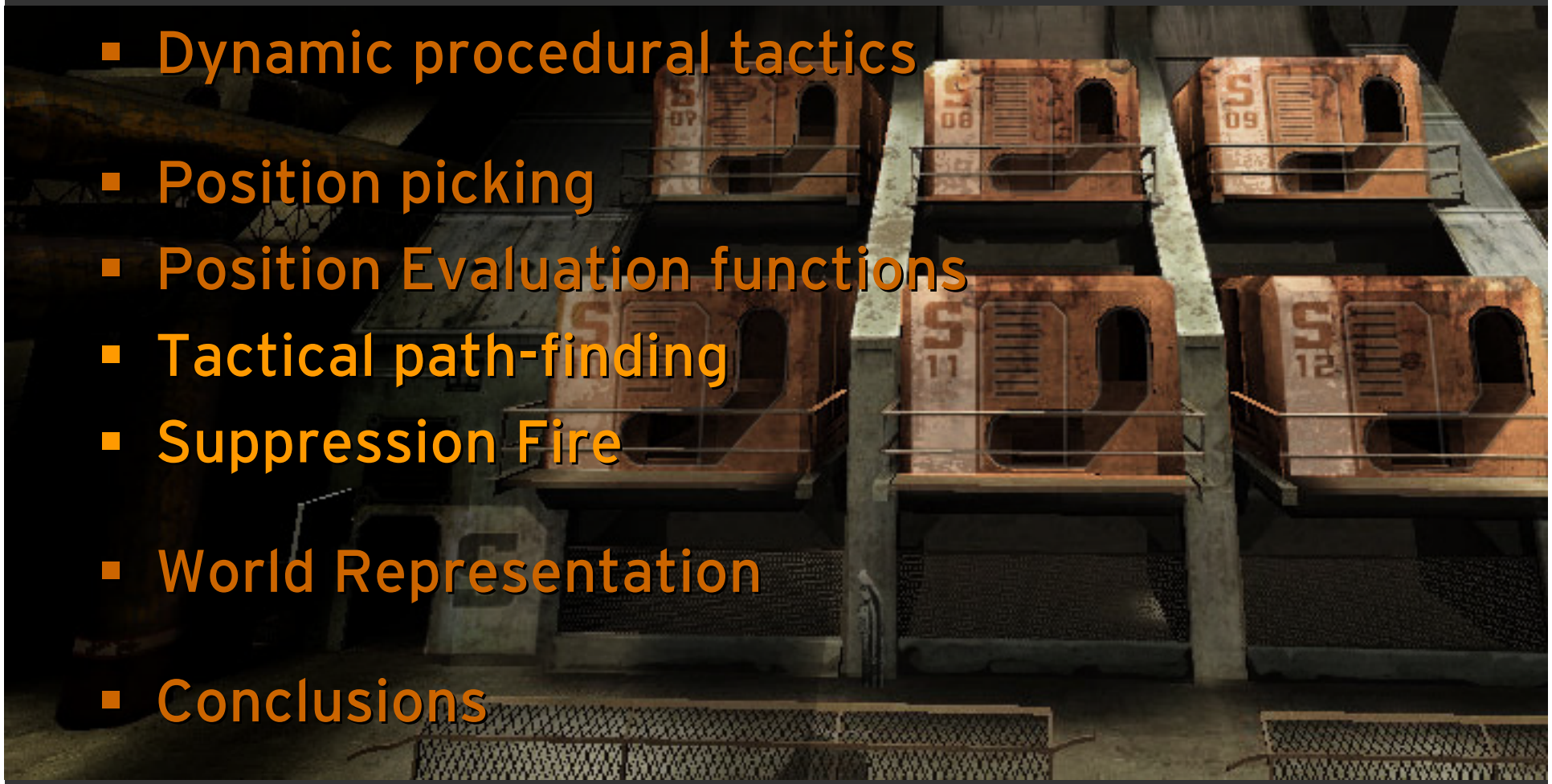

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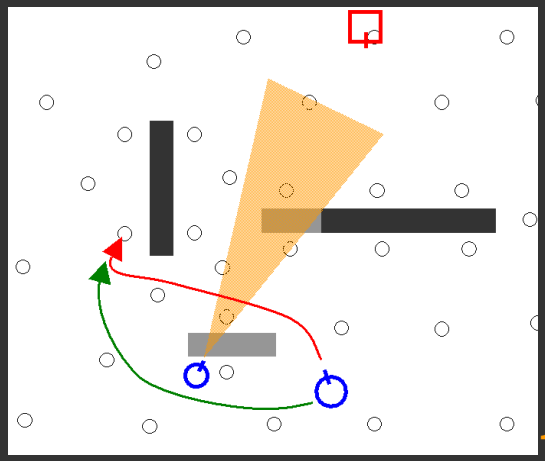
Tactical Path-finding

Shortest paths often aren't responsive or tactical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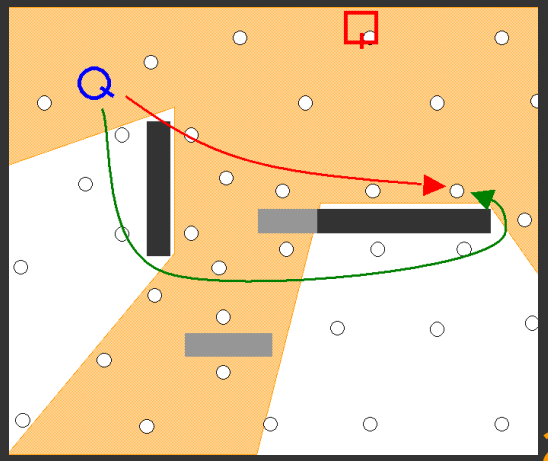
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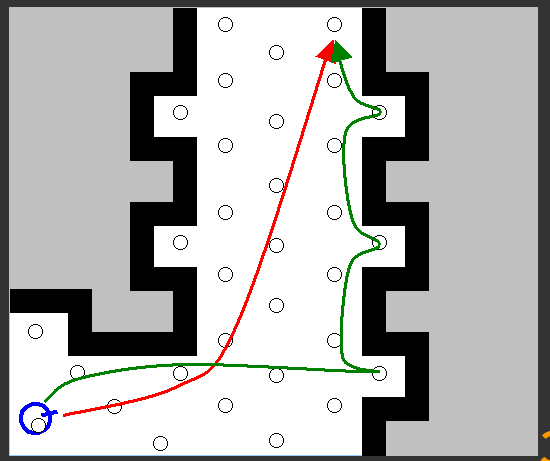
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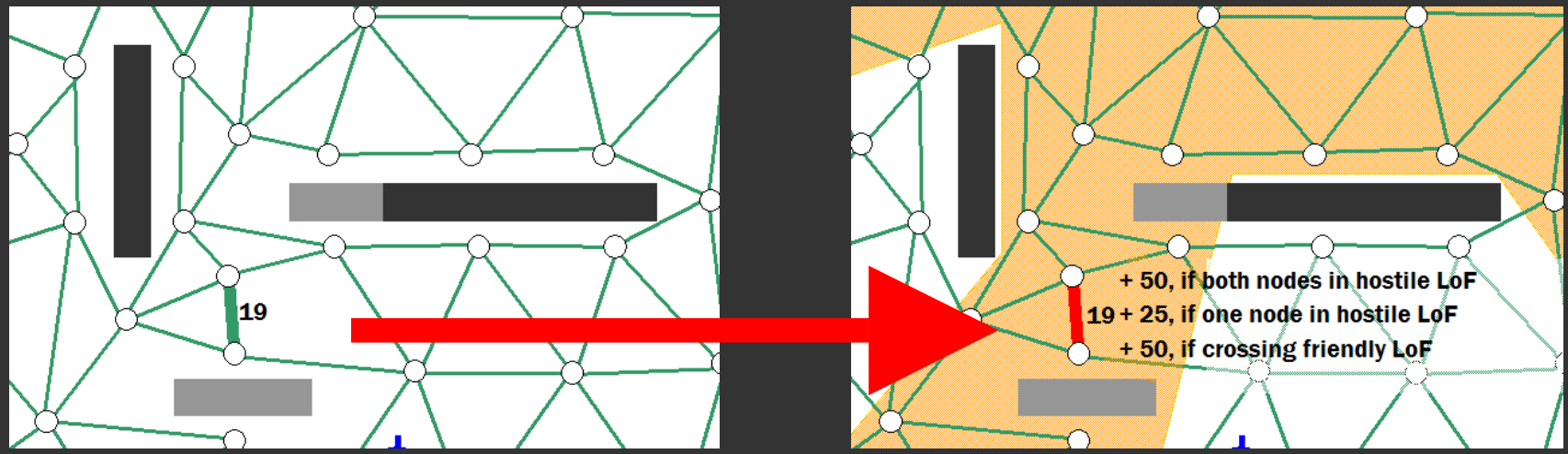
For example:

1. Paths traversing friendly lines-of-fire
2. Paths ignoring cover from hostile fire
3. Paths leaving the AI exposed unnecessarily

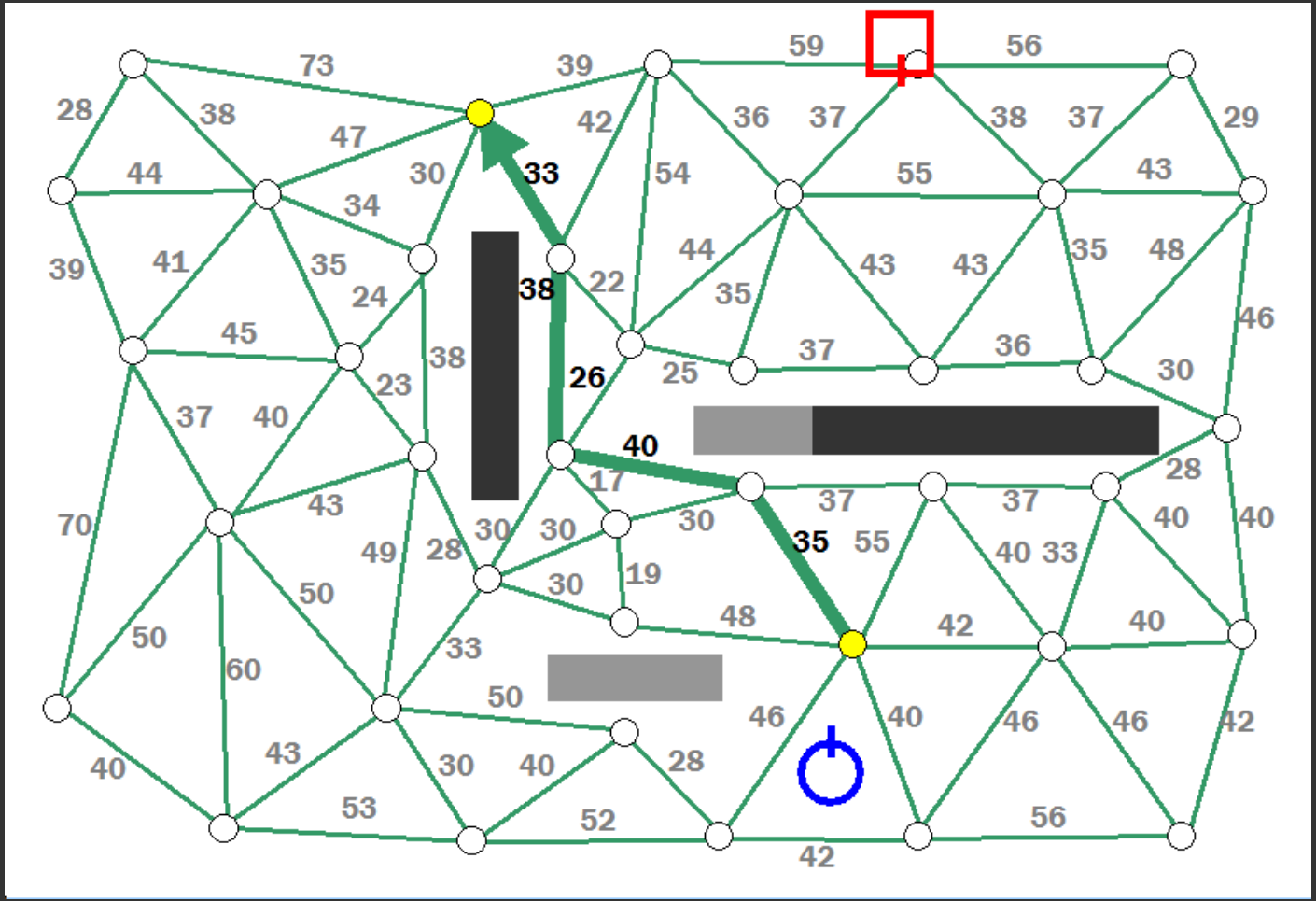
Tactical Path-finding

Position evaluations functions on the move...



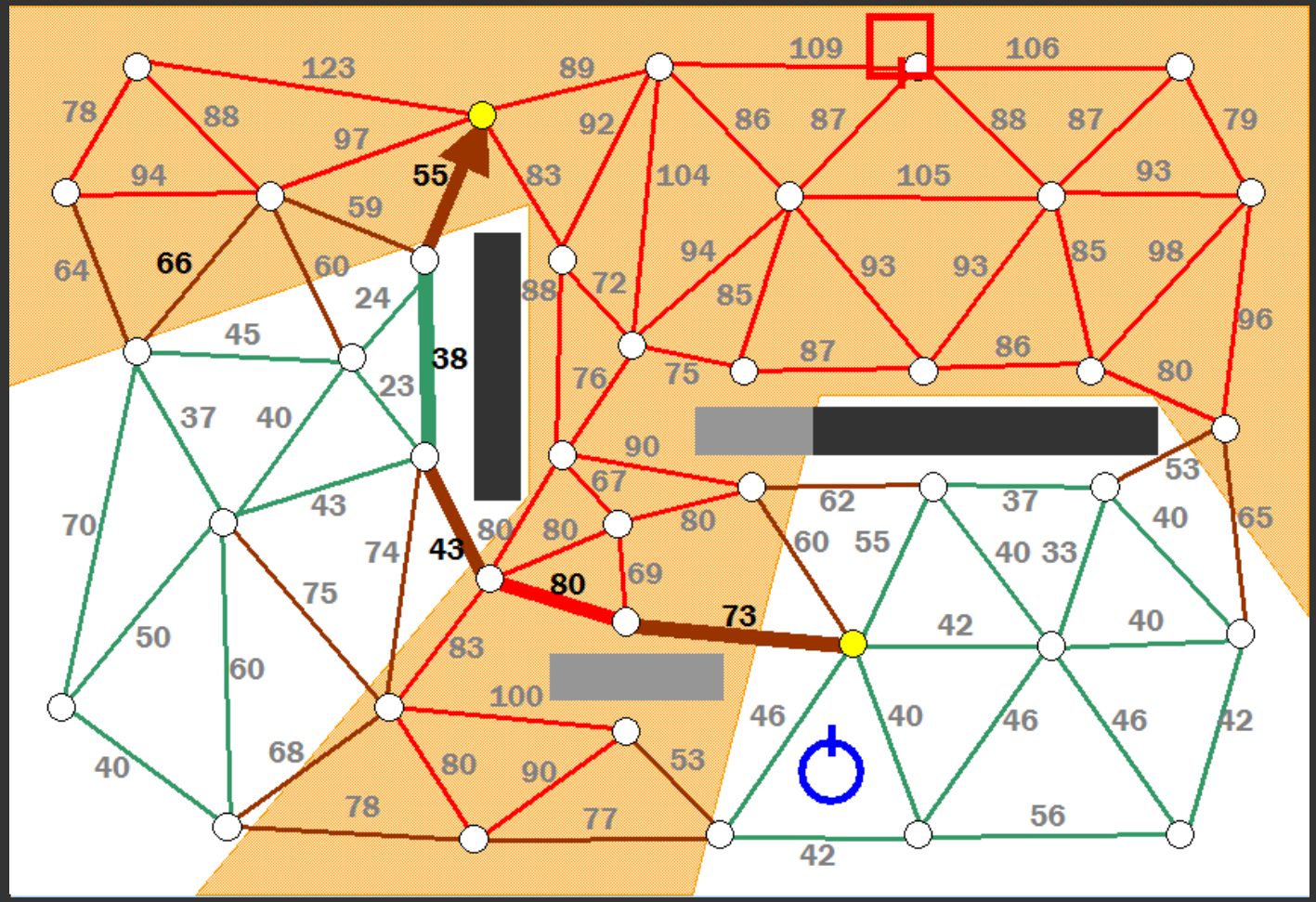
- In A*, add to the costs of traveling a link:
  - Traversing a friendly lines-of-fire
  - Being under fire from one or more threats

Example: Tactical Path-finding 1



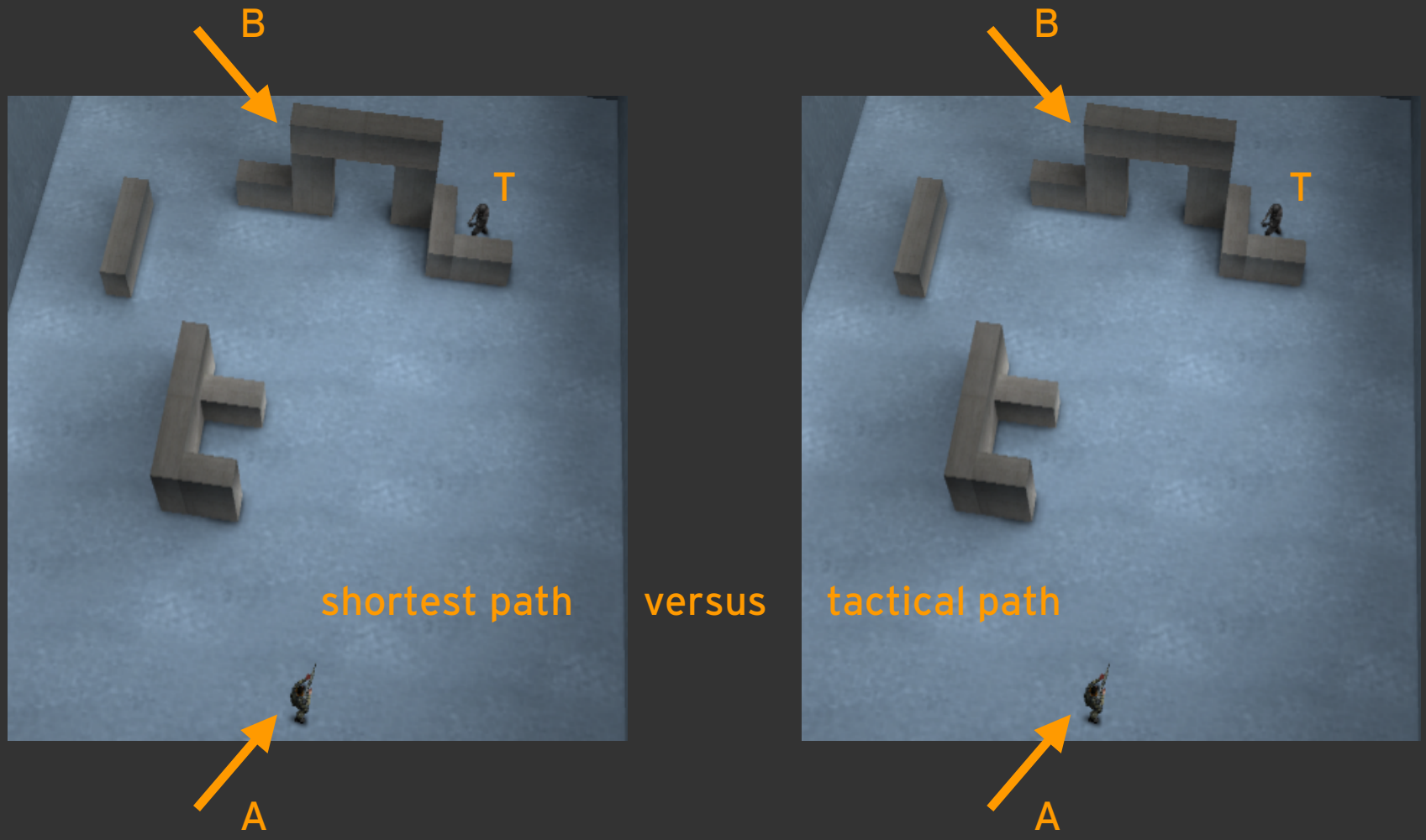
Costs to travel each waypoint link, and the resulting shortest path.

Example: Tactical Path-finding 2



Link costs now reflect being under fire, and the corresponding tactical path.

Example: Tactical Path-finding 3



Suppression Fire

Suppression fire:

- Fire near hidden threats to pin them down

Not:

- Firing into the wall behind which the threat is hiding
- Firing into locations the threat cannot reach

Example: Suppression Fire 1

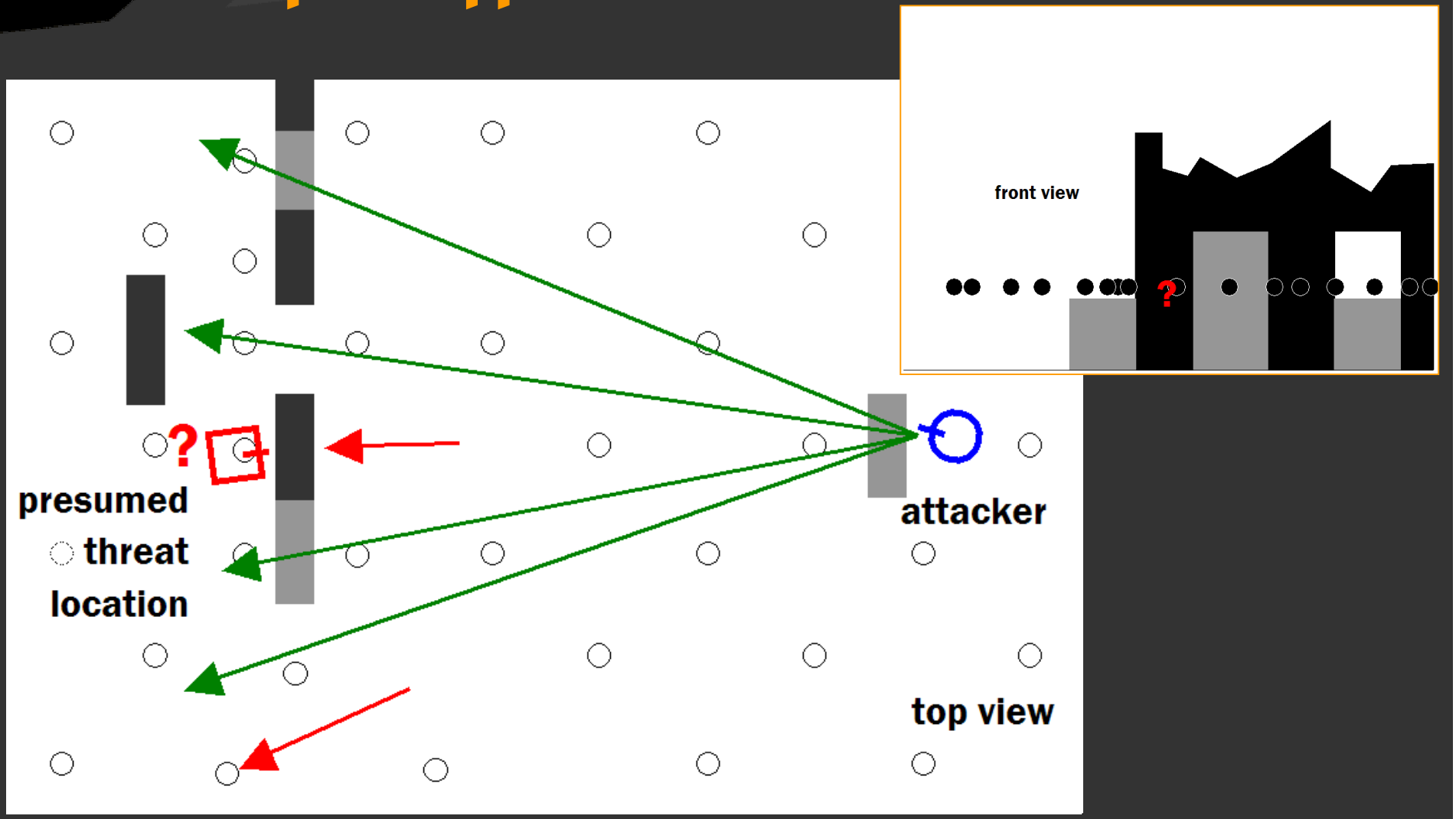
What we want

- Deny the threat use of good attack positions
- By pumping bullets into these positions

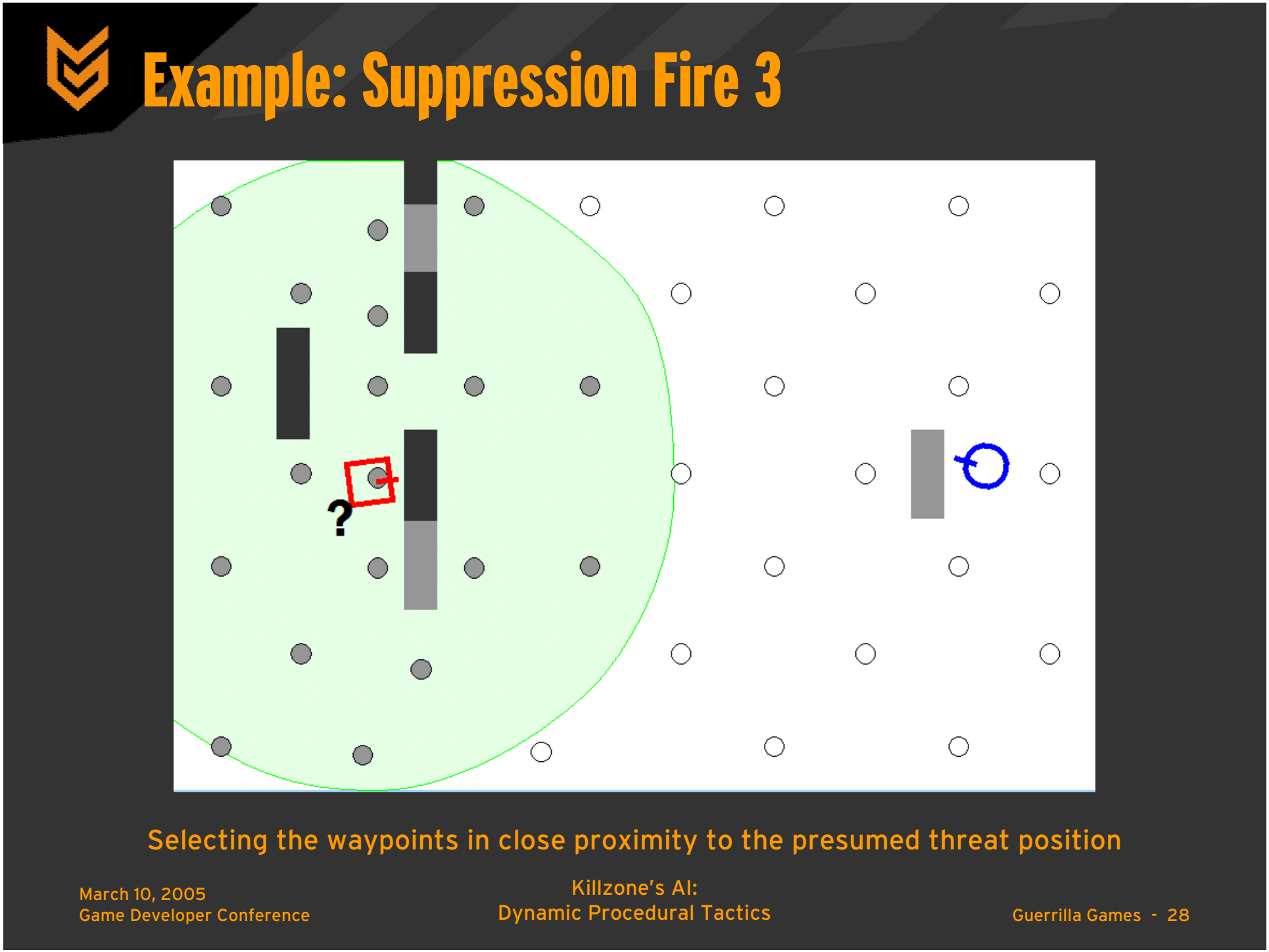
How we implement it using position evaluation

- Evaluate threat's attack positions from his perspective(!)
- Select those attack positions we can fire into

Example: Suppression Fire 2



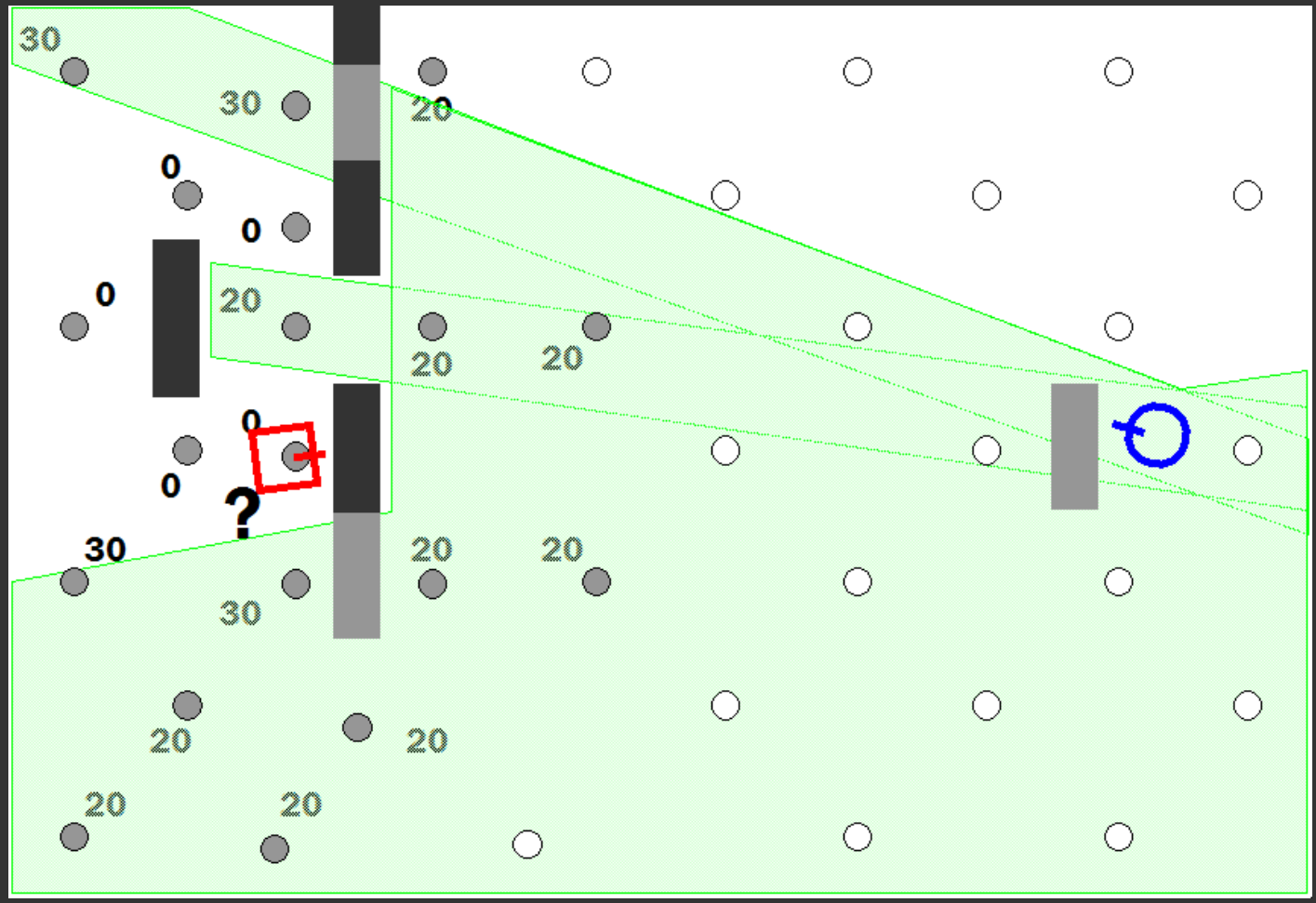
A hidden threat (left), attacker (right) and the intended suppression fire.



Example: Suppression Fire 3

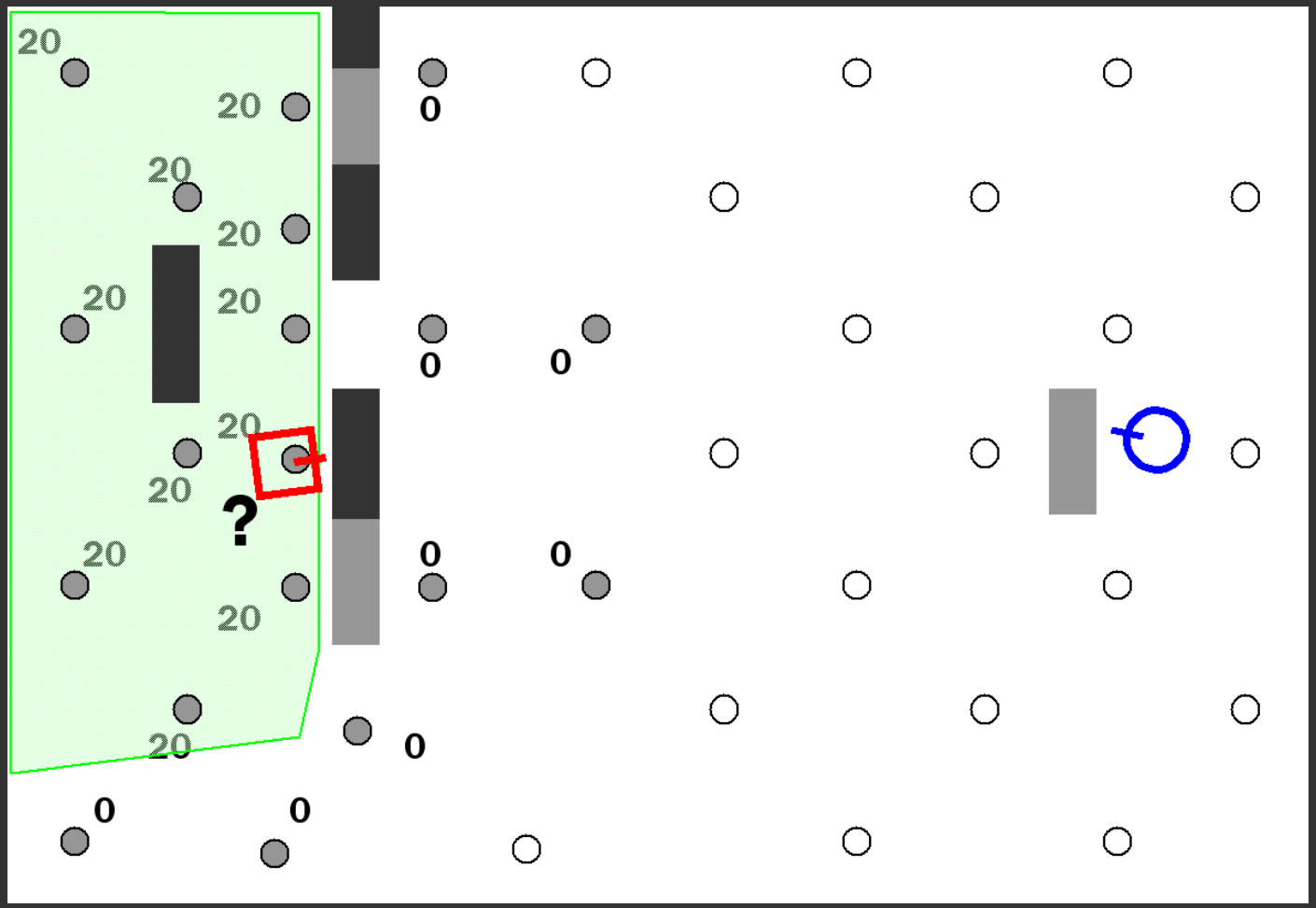
Selecting the waypoints in close proximity to the presumed threat position

Example: Suppression Fire 4



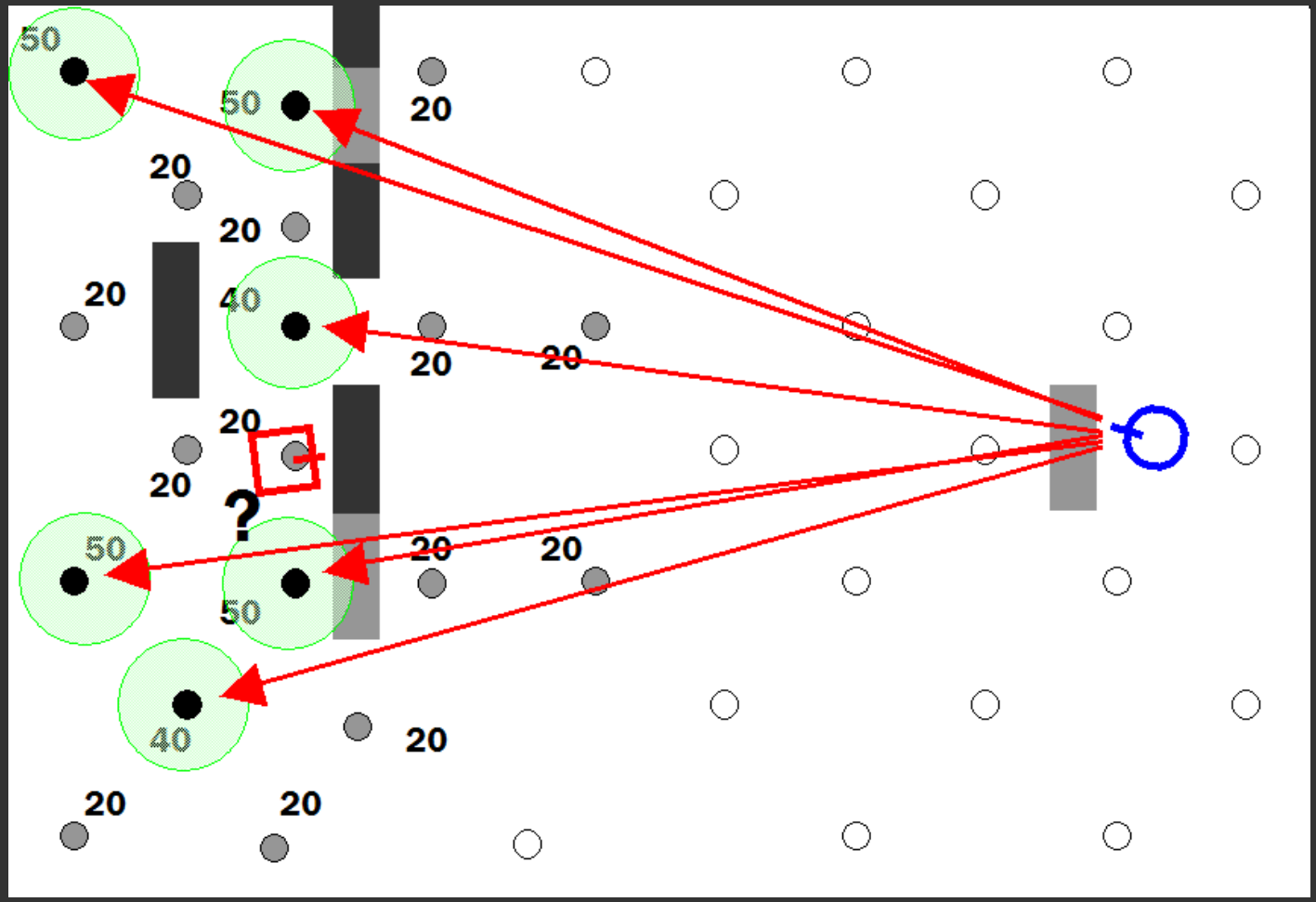
Annotations (20, 30) for offering the threat a LoF to the attacker (right).

Example: Suppression Fire 5



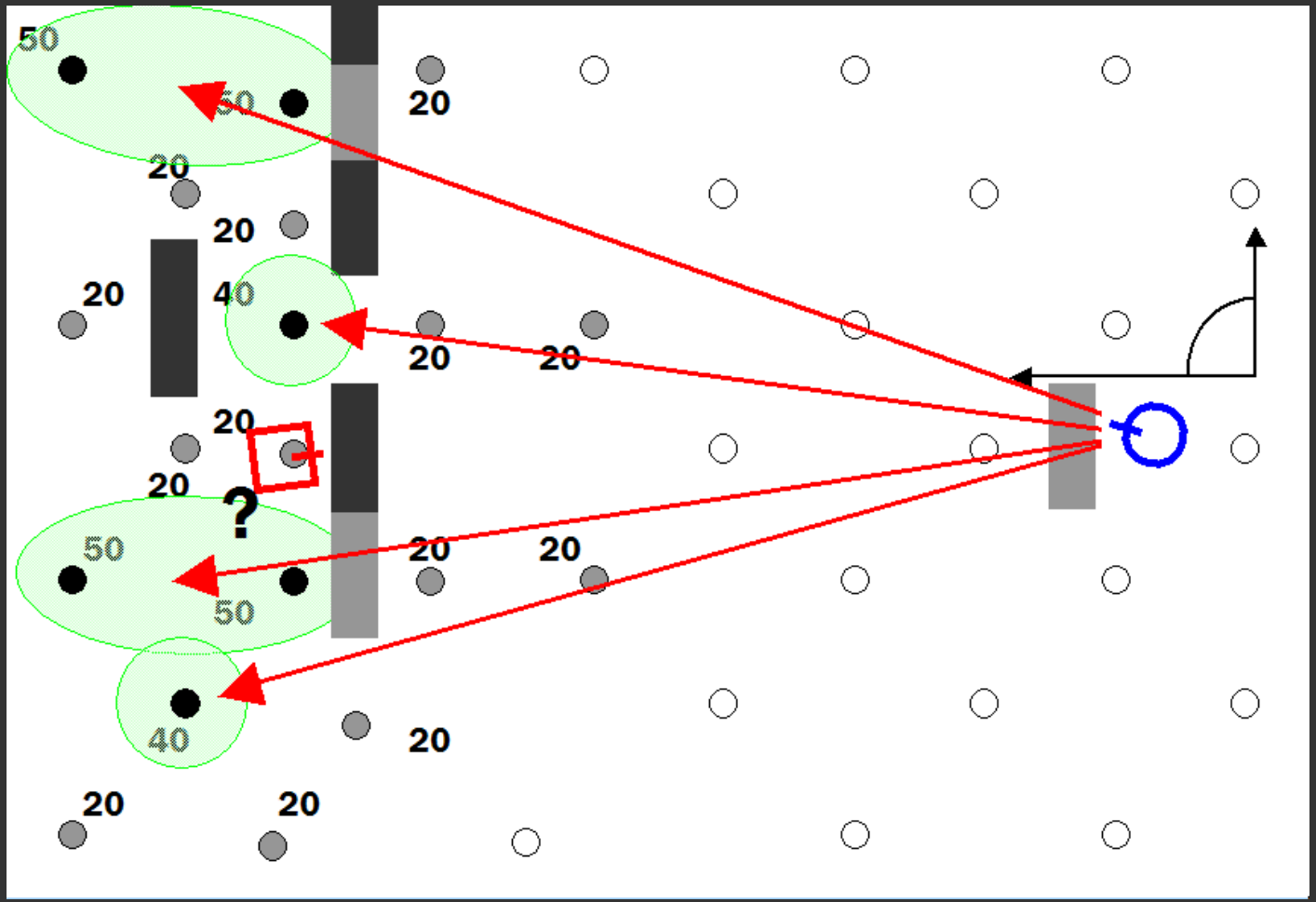
Annotation of 20 for positions offering the threat nearby cover from the attacker.

Example: Suppression Fire 6



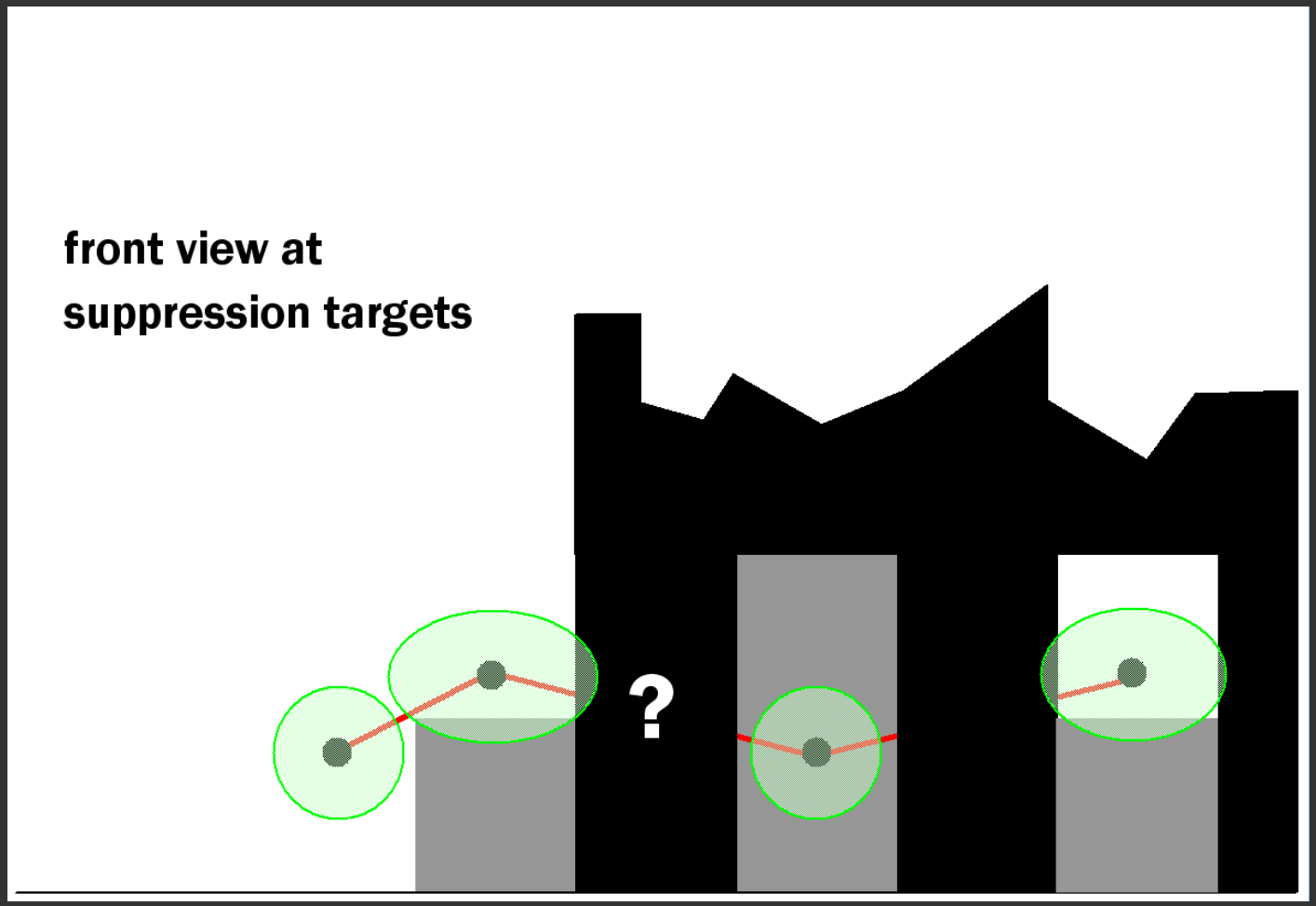
Selecting those positions with score ≥ 40 yields the suppress targets.

Example: Suppression Fire 7



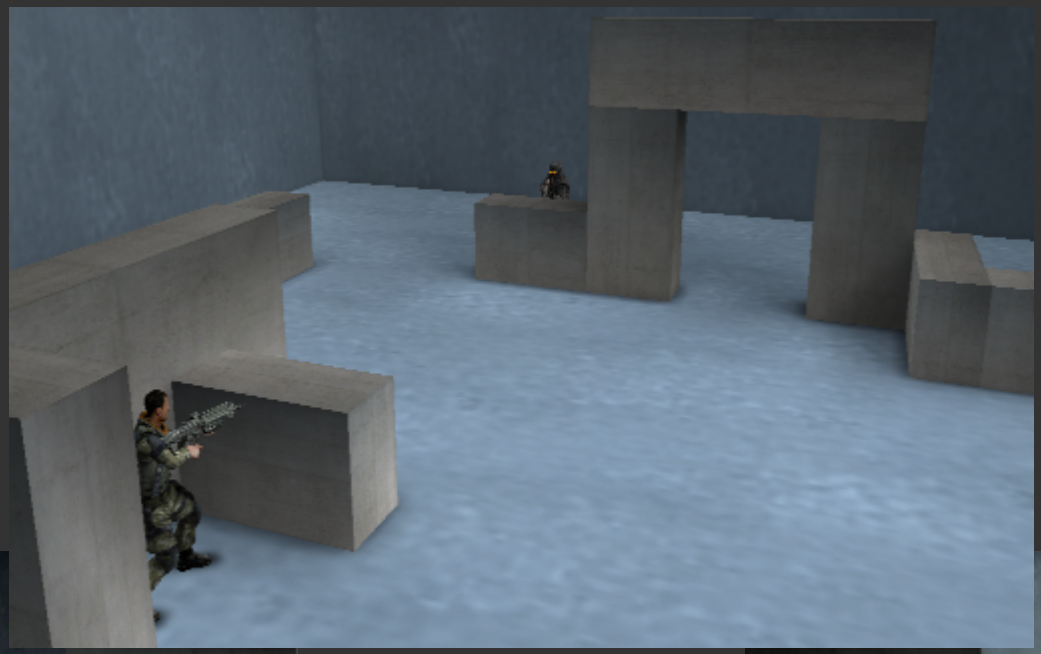
Merging suppression targets that overlap in yaw and pitch.

Example: Suppression Fire 8



The attacker's view of suppression targets near the hidden threat.

Example: Suppression Fire 9



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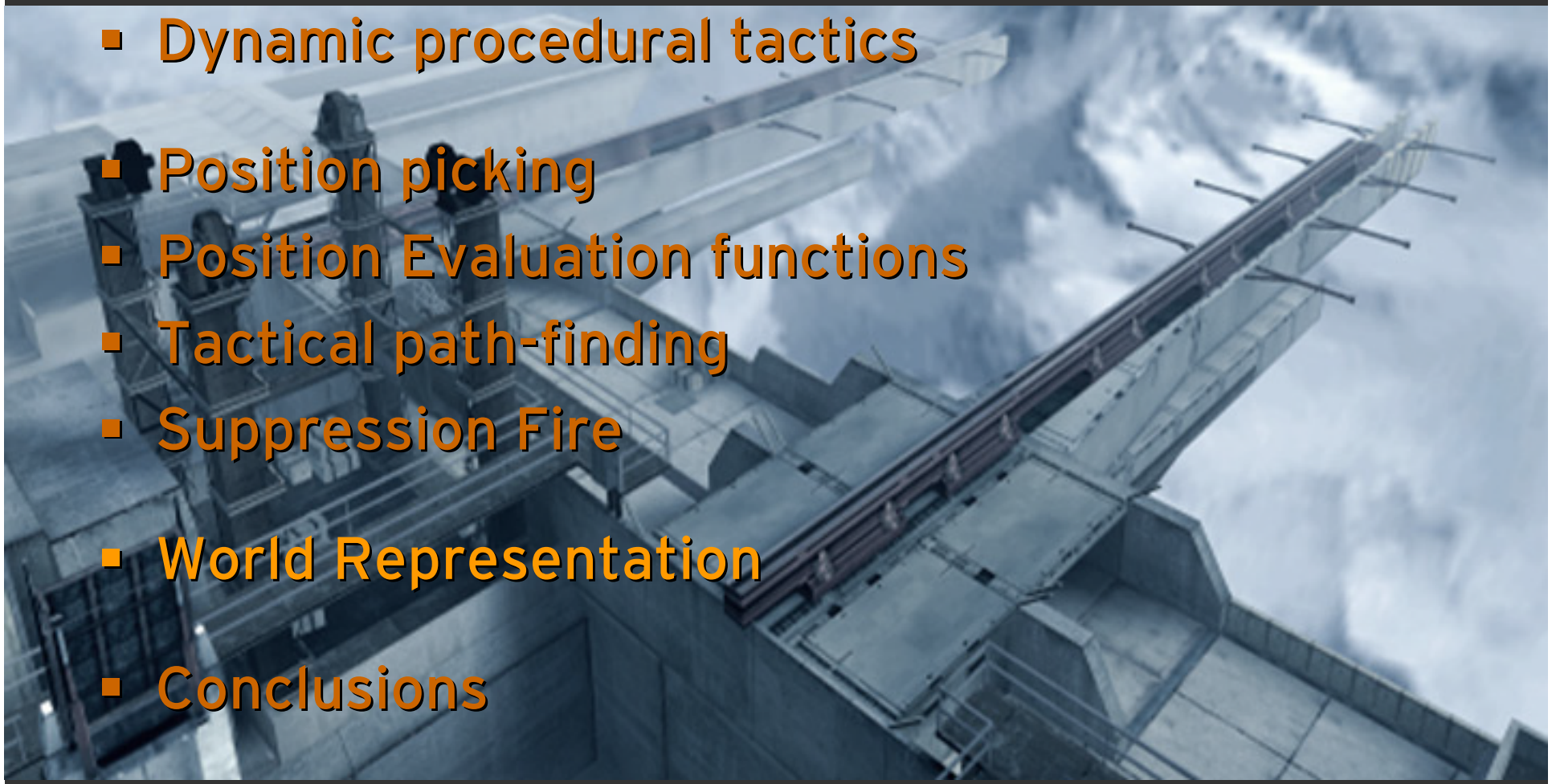

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World Representation

Pre-conditions for dynamic procedural tactics

1. Navigation info, with fine enough resolution to represent cover locations
   - Waypoints, nav meshes, cells: any will do

2. Fast Line-of-Sight/Line-of-fire checks

Lines-of-Fire Representation 1

Tactical decisions involve 100s of LoF checks

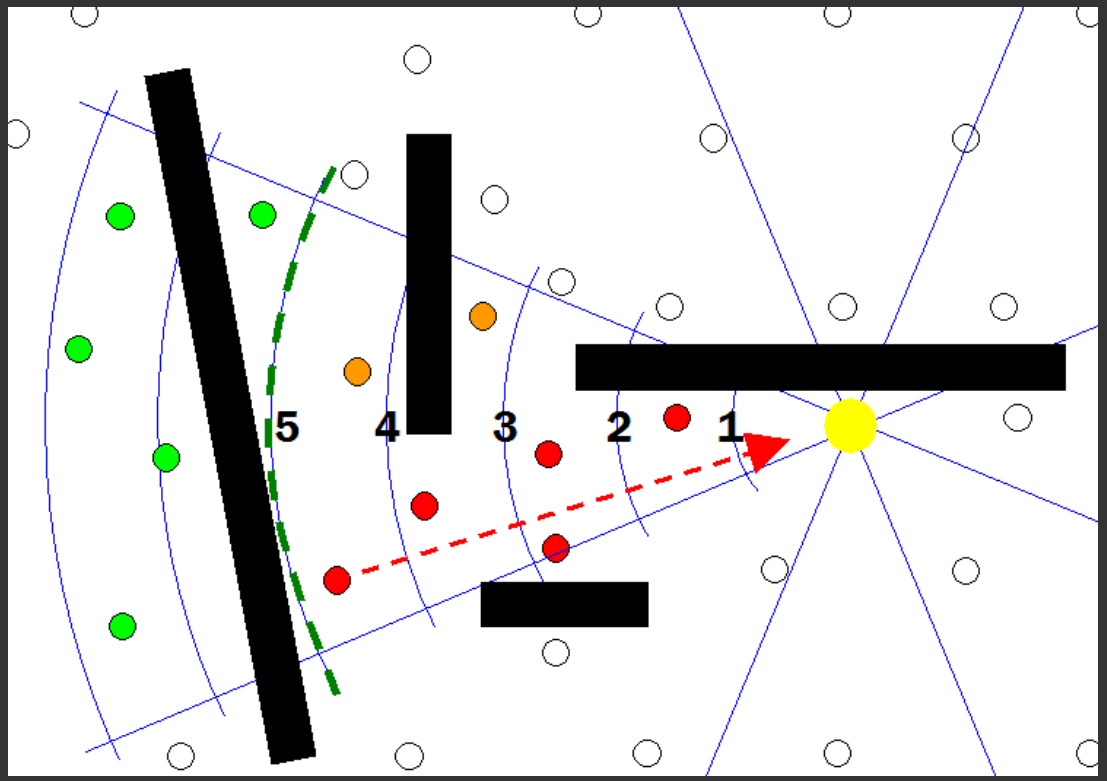
- Ray casts typically expensive
- So, offload most checks to something cheaper

Use a small pre-computed look-up table

- Multiple stances, minor movement
- Pessimistic about cover
- Polar representation

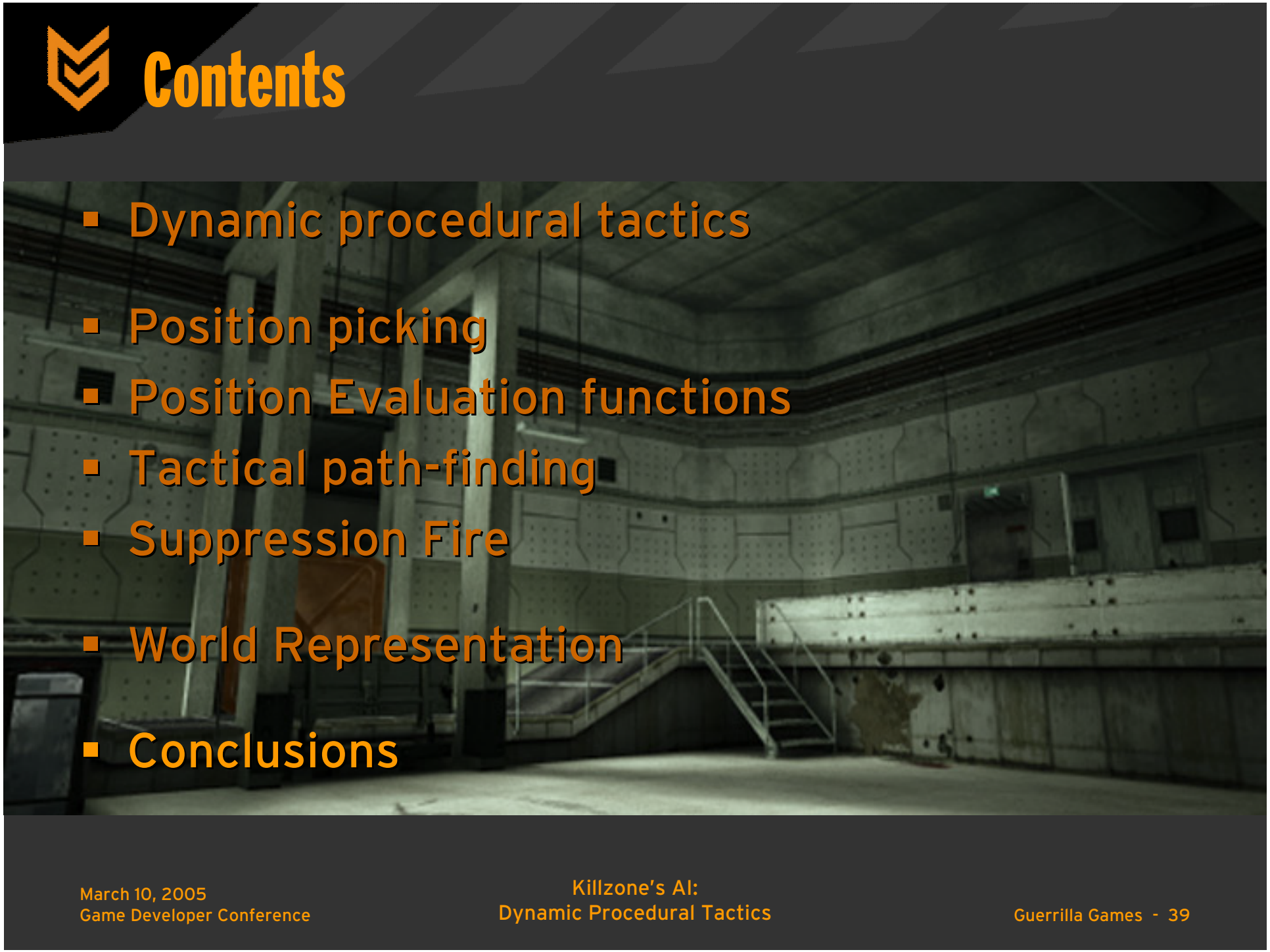
Killzone's LoF table for 4000 waypoints: 64KB

Lines-of-Fire Representation 2



Compression:
For every waypoint, per radial sector, record the largest distance from where an attacker within that sector can fire at the waypoint.

Intended Side-effect:
Those cover positions from where it would be easy to get into an attack position are often represented as having a line-of-fire.



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Conclusions

Killzone was released for PS2 late 2004

- Tactical position picking
- Tactical path-finding
- Suppression by infantry and mounted MGs
- Indirect fire for hand grenades and tank shells
- Single and multiplayer AI

- Up to 14 AI characters fighting simultaneously

Conclusions - Killzone's AI

Pros

- Share/reuse behavior across games
- Quick level prototyping
- Can be combined with scripting
- Fights anywhere, anytime, SP or MP

Cons

- Harder to control in detail
- Harder to test

Conclusions – Game AI

Position evaluation functions are powerful

- Robust decisions with many (dynamic) inputs
- Different behavior through configuration
- Many tactics can be implemented through position evaluation

Dynamic procedural tactics

- Responsive AI behavior
- Within reach of many games

Further Info

Off-line

- Our proceedings paper provides more details, notably on the terrain representation and grenade handling

- Lars Lidén, *Strategic and Tactical Reasoning with Waypoints* in AI Game Programming Wisdom, Charles River Media, 2002
- Paul Tozour, *Using a Spatial Database for Runtime Spatial Analysis* in AI Game Programming Wisdom 2, Charles River Media, 2003
- William van der Sterren, *Tactical Path-Finding with A** in Game Programming Gems 3, Charles River Media, 2002

On-line

- William's collection of links to on-line papers at: www.cgf-ai.com/links.html

Questions?