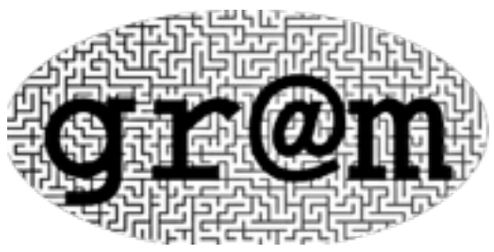
From Skyrim to Metal Gear Solid - A buddy AI journey

Jonathan Tremblay



Player

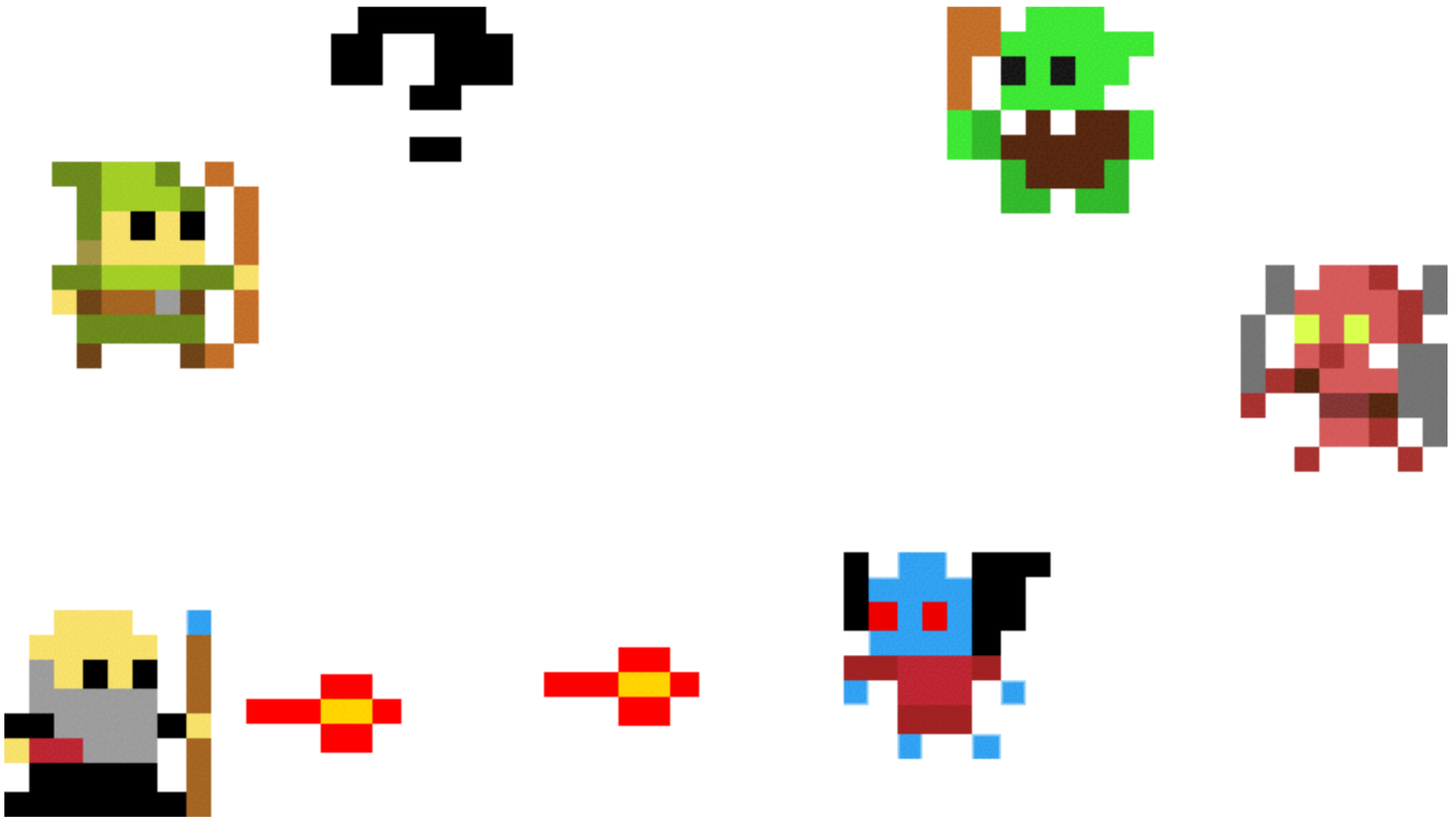
Companion

Combat: targeting an enemy

Stealth movement

Understanding player

Targeting problem



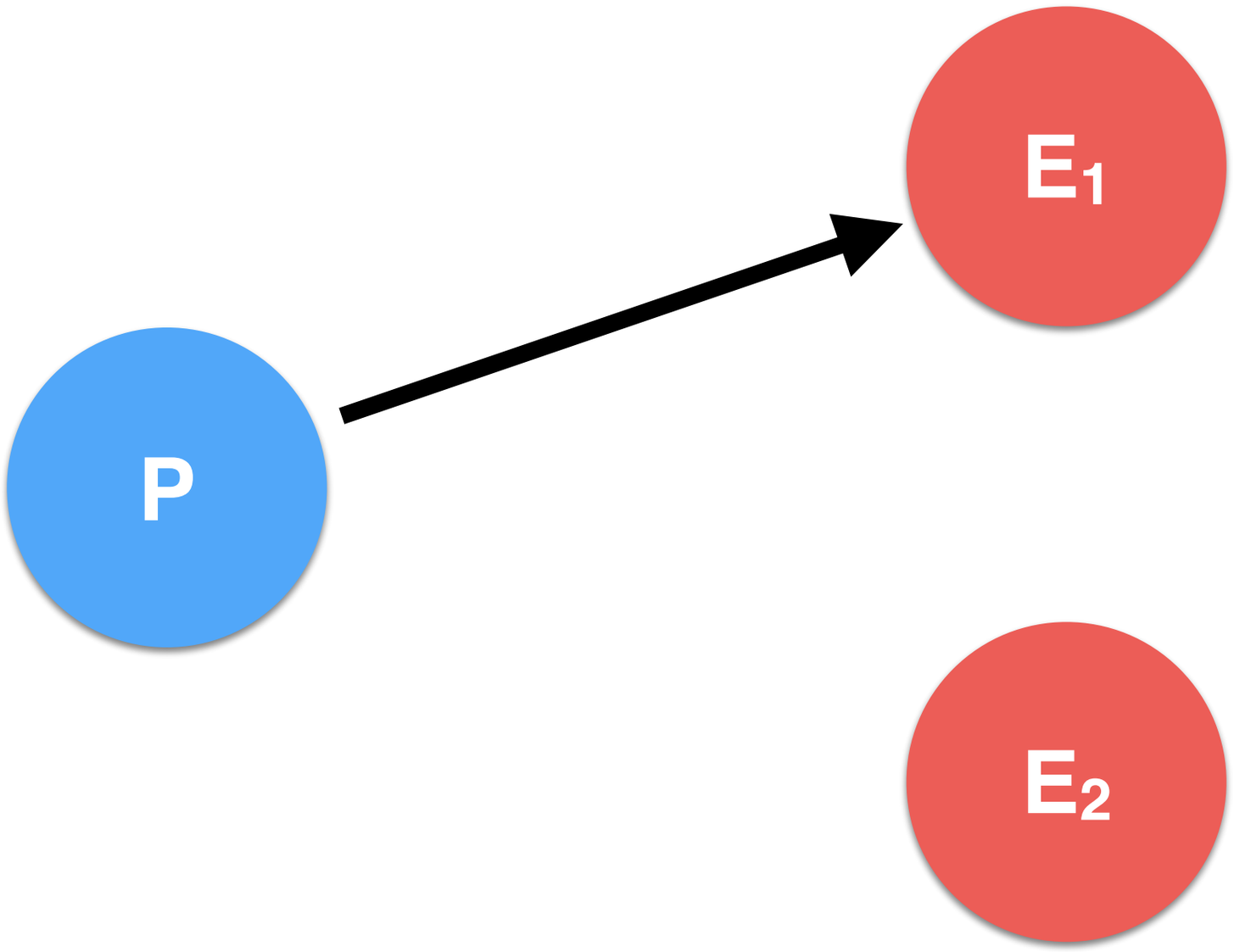
Companions' influence

- Strategies are poor
- Player needs to interact with their behaviour
- Player do not trust them

E_1

P

E_2


P
E1
E2

Attack: *a*

Health: *h*

Rules

- Entities select target to attack
- Blue team attacks first
- Attack value is subtracted from targets' health

Strategies

- Target randomly
- Target lowest health
- Target highest attack

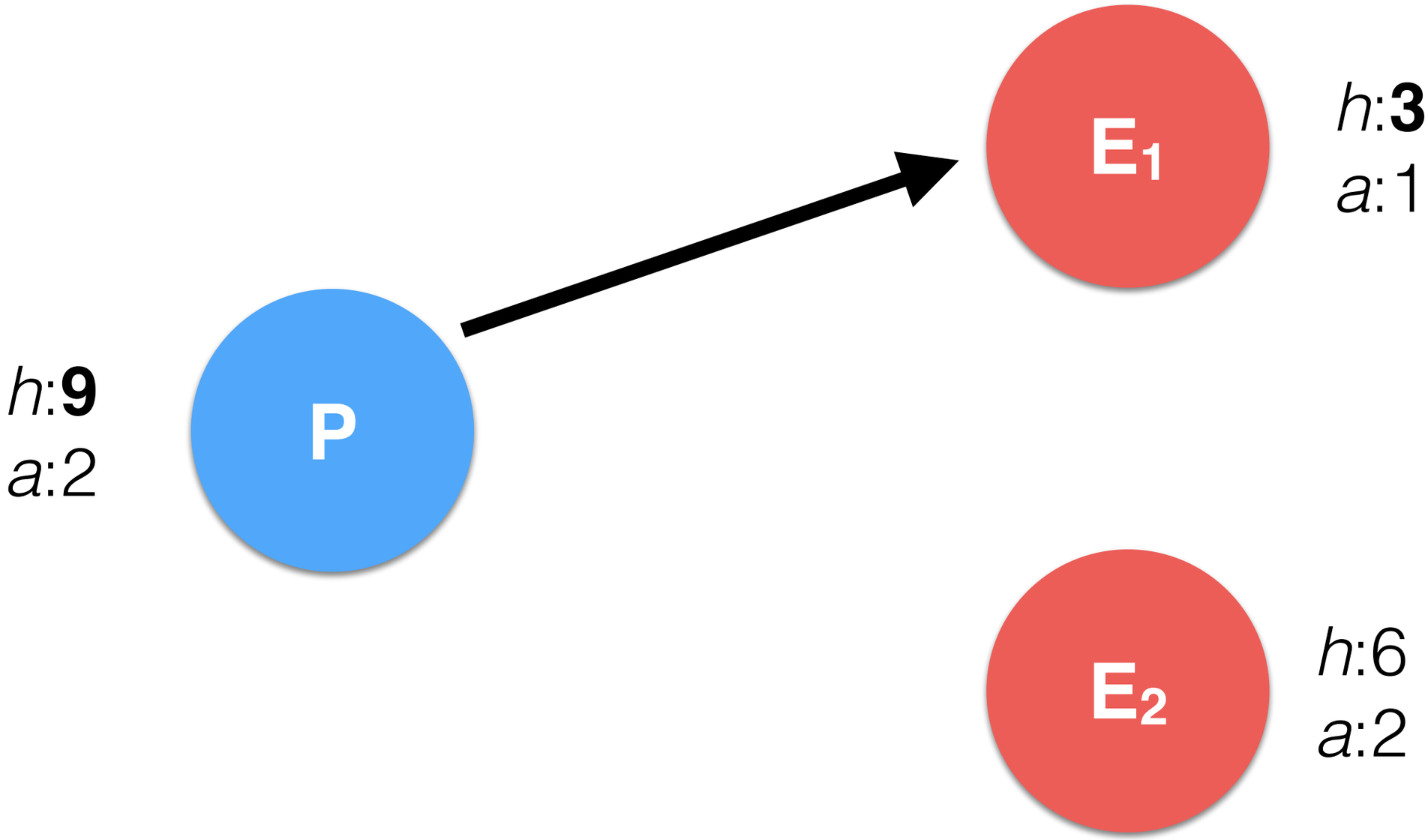
Lowest health

h:5
a:1

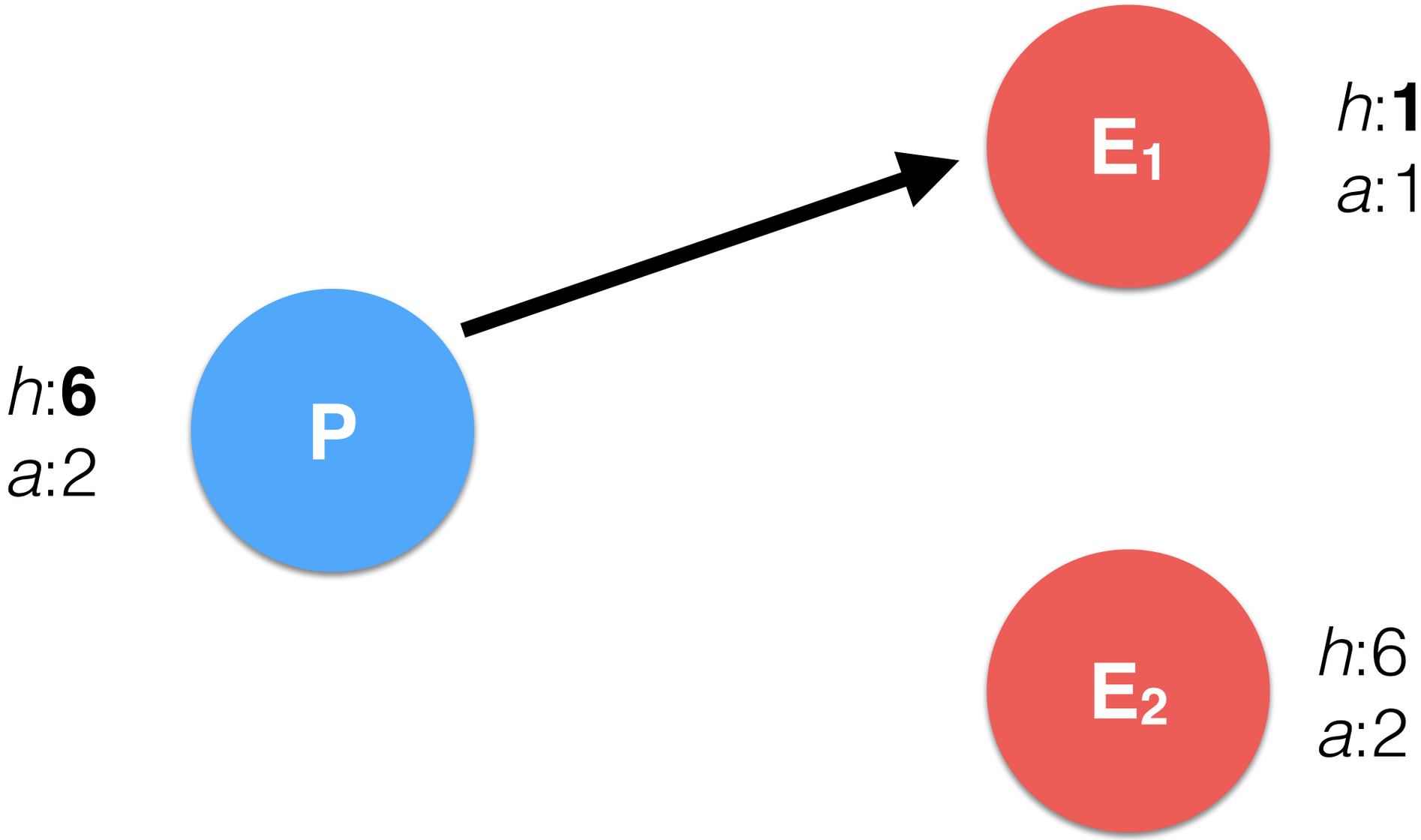
h:12
a:2

h:6
a:2

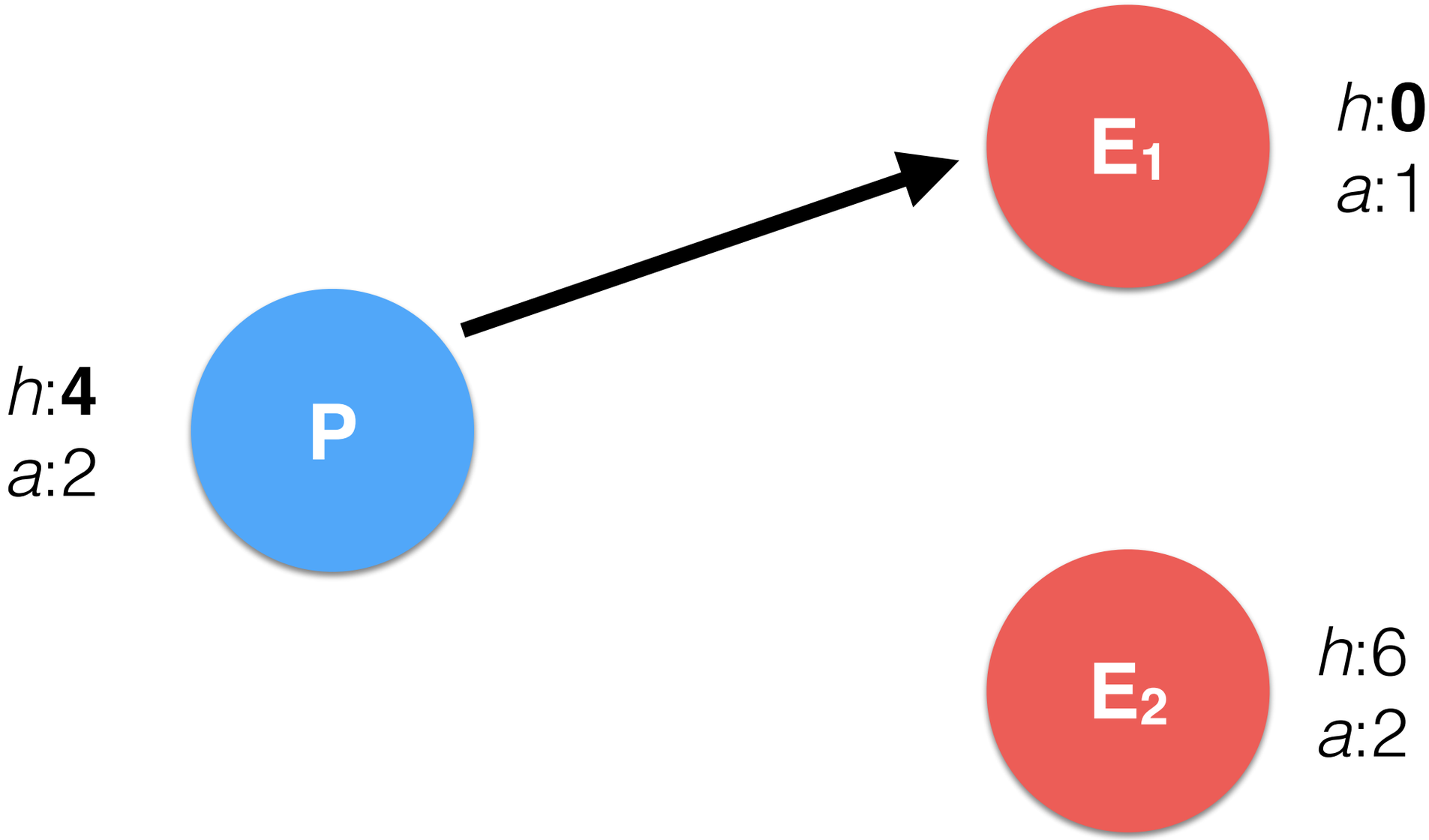
Lowest health



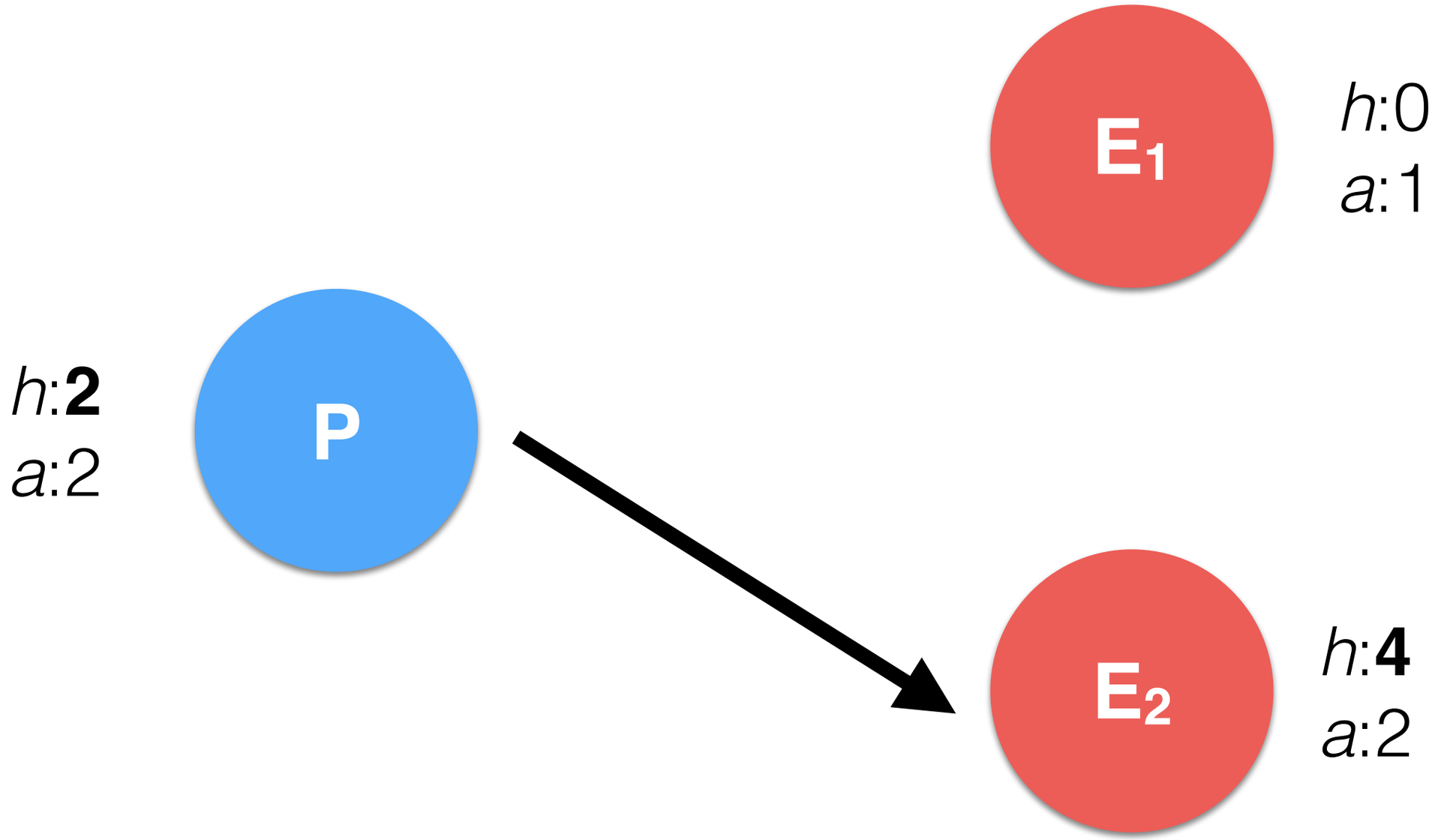
Lowest health



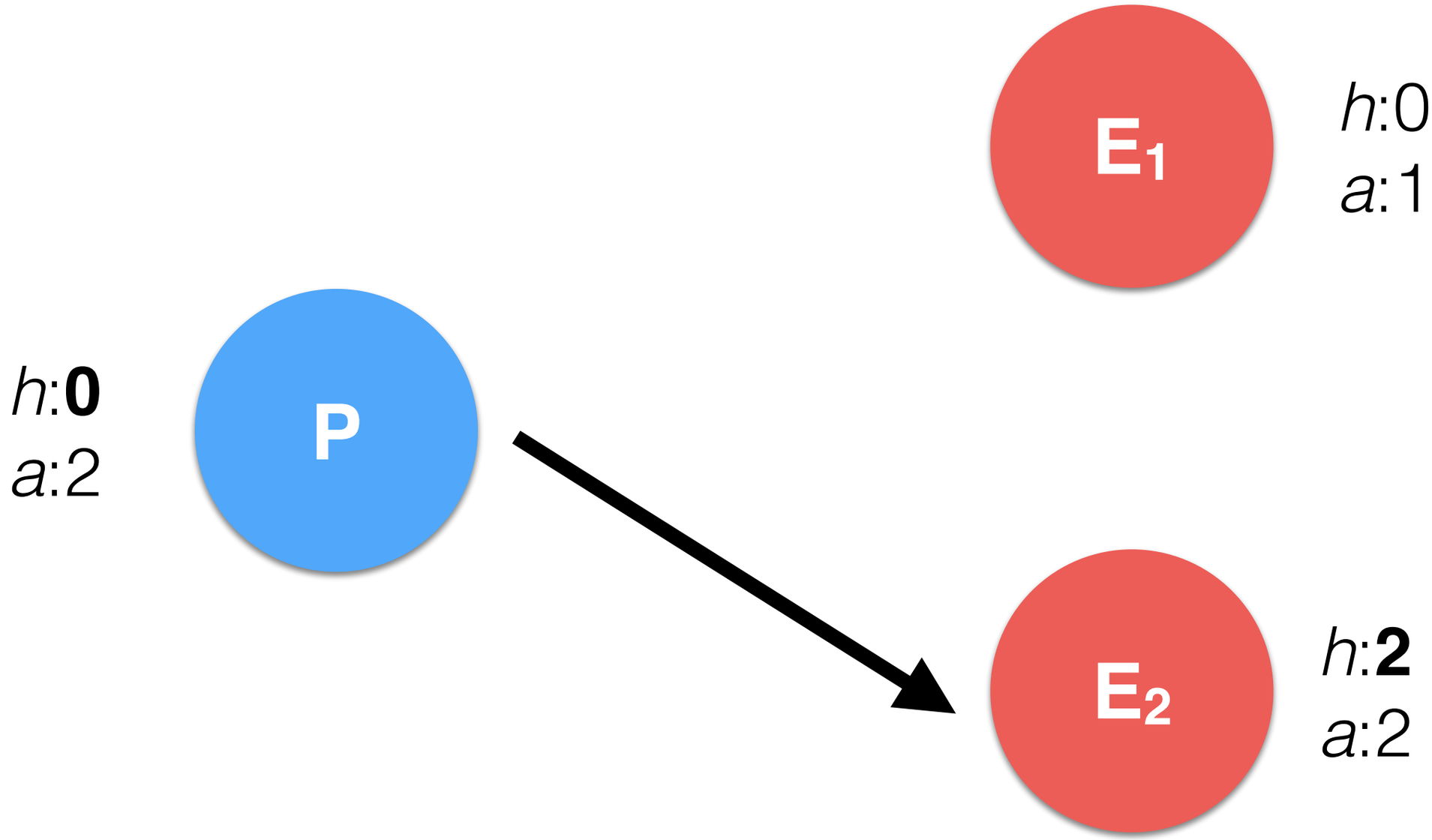
Lowest health



Lowest health



Lowest health



Lowest health

h:0
a:1

h:**0**
a:2

h:**2**
a:2

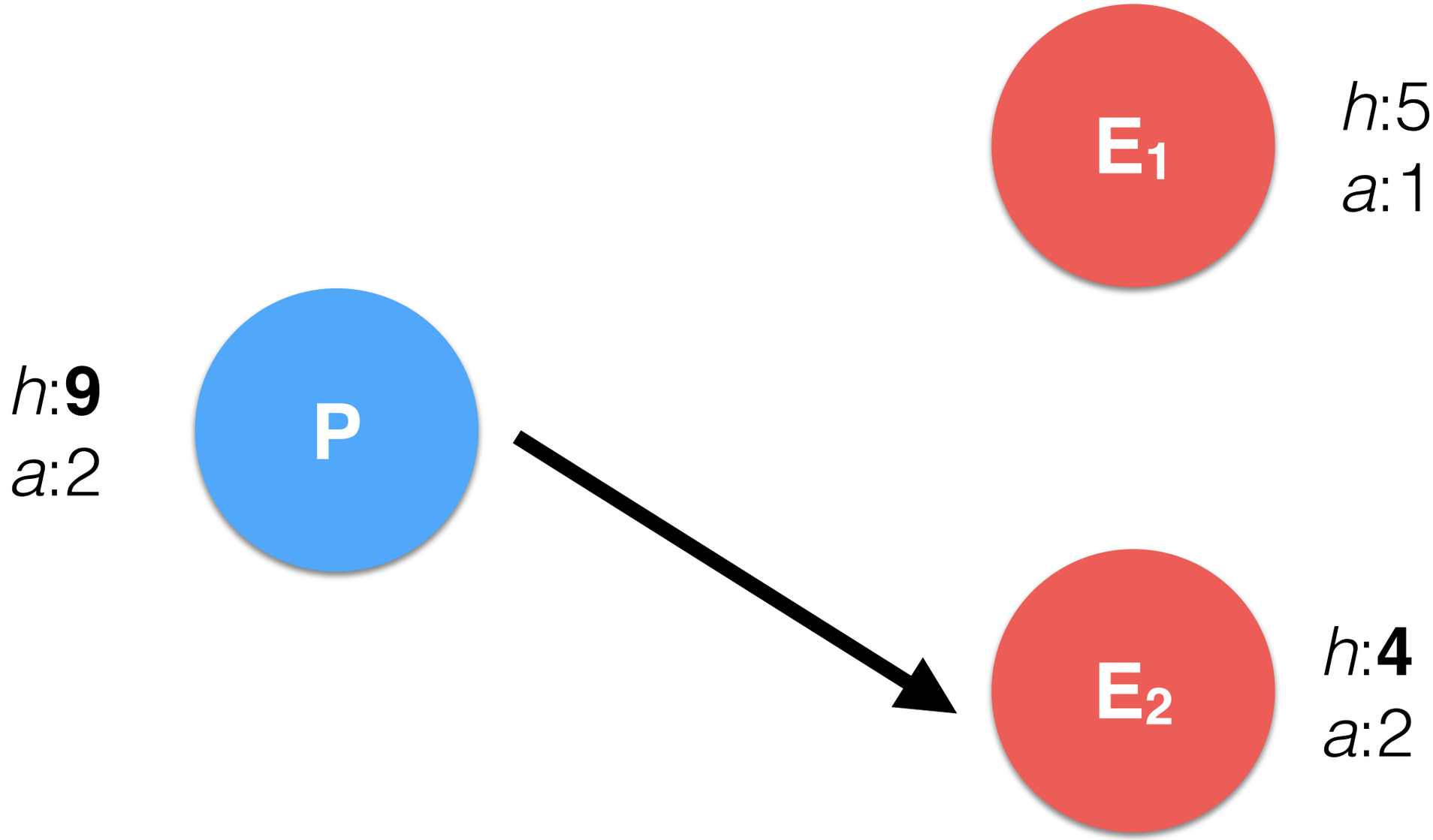
Highest Attack

h:5
a:1

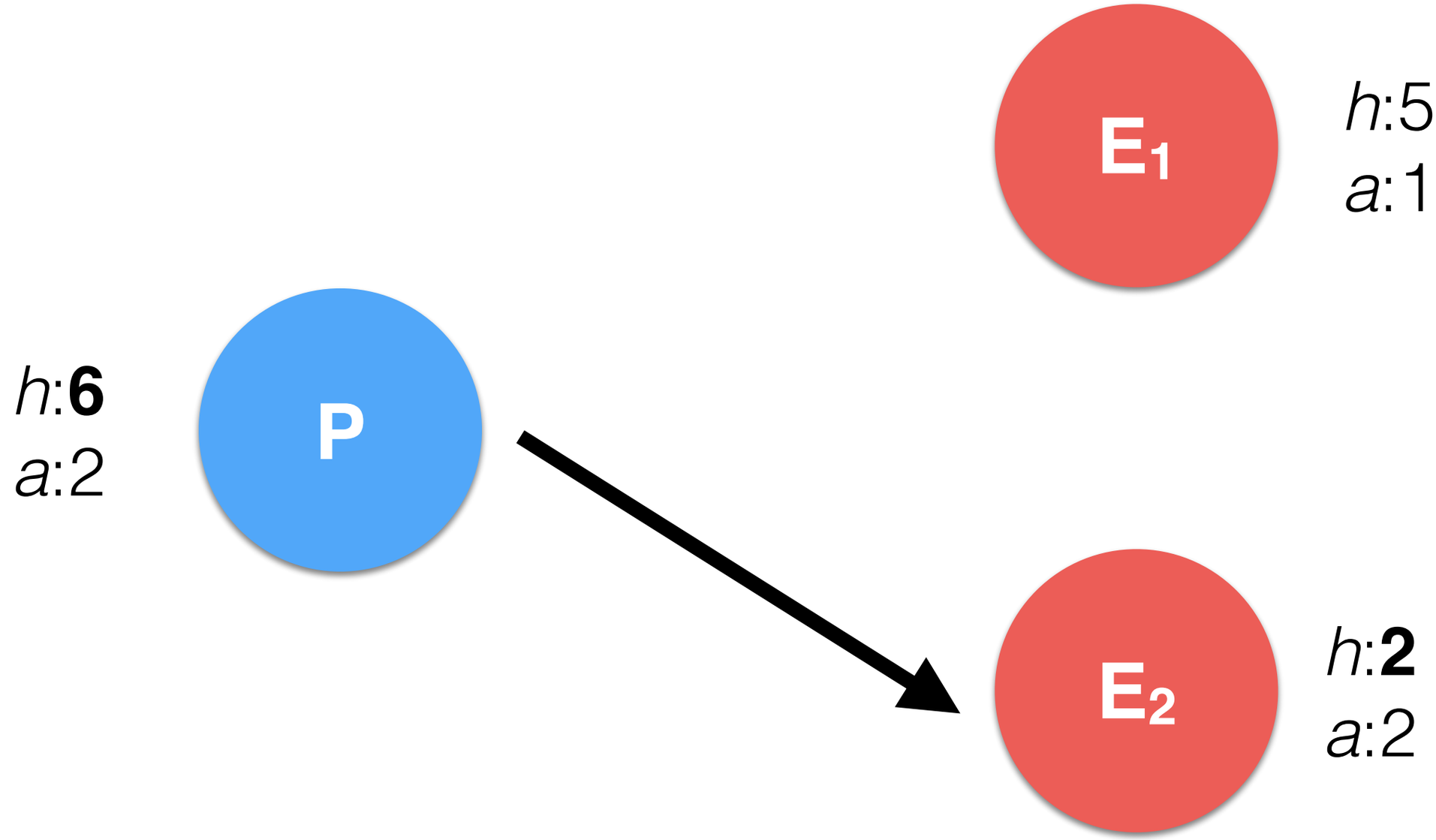
h:12
a:2

h:6
a:2

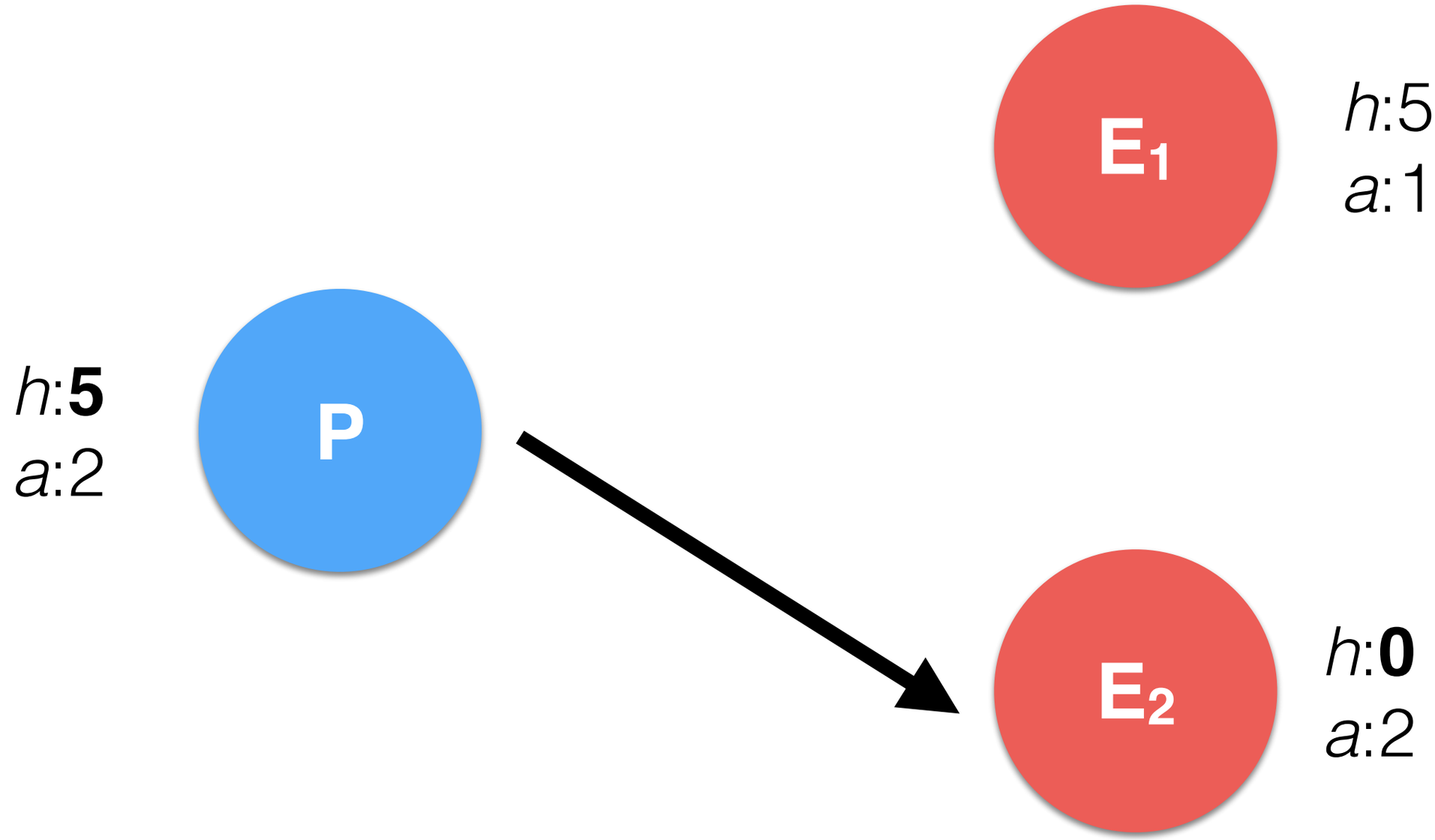
Highest Attack



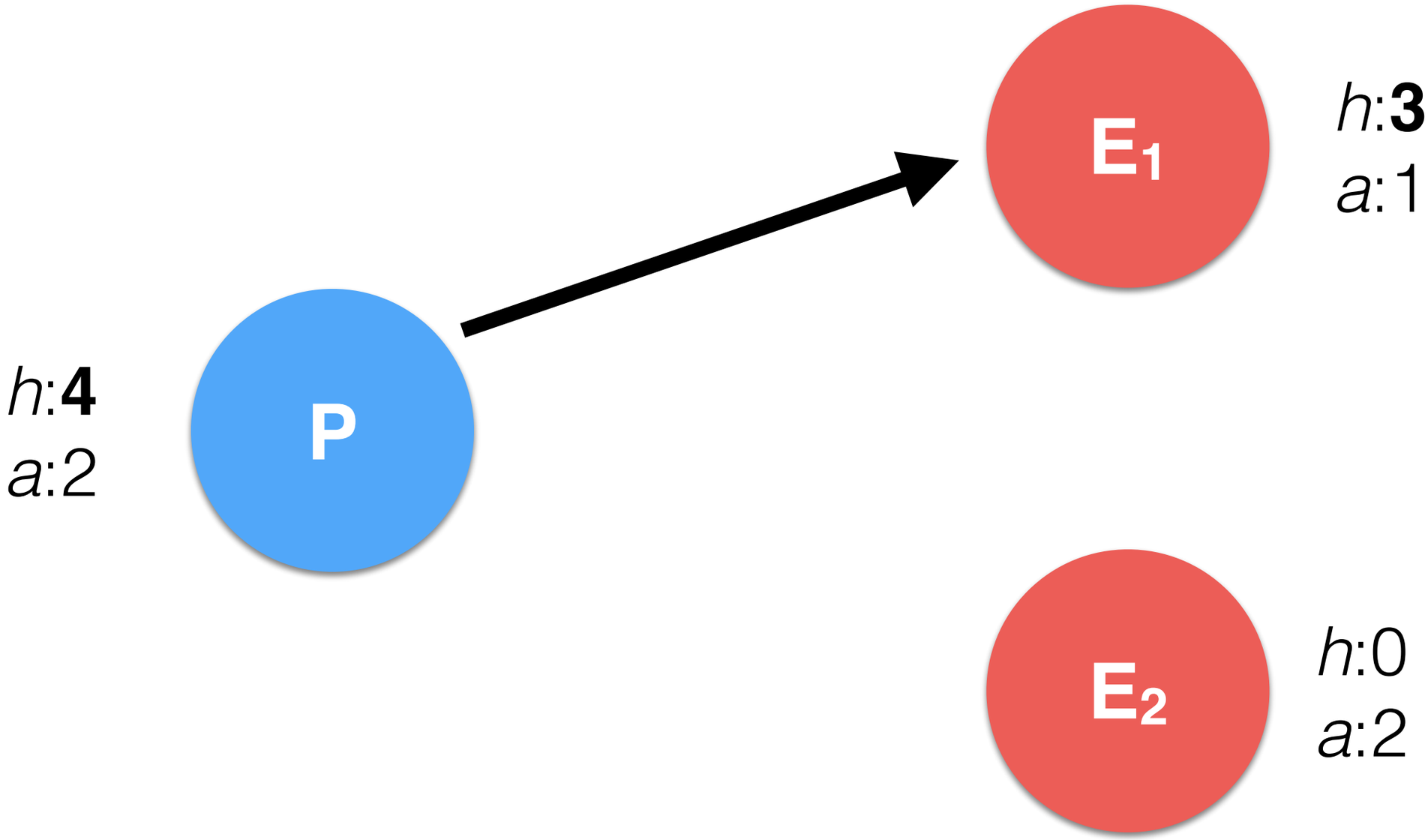
Highest Attack



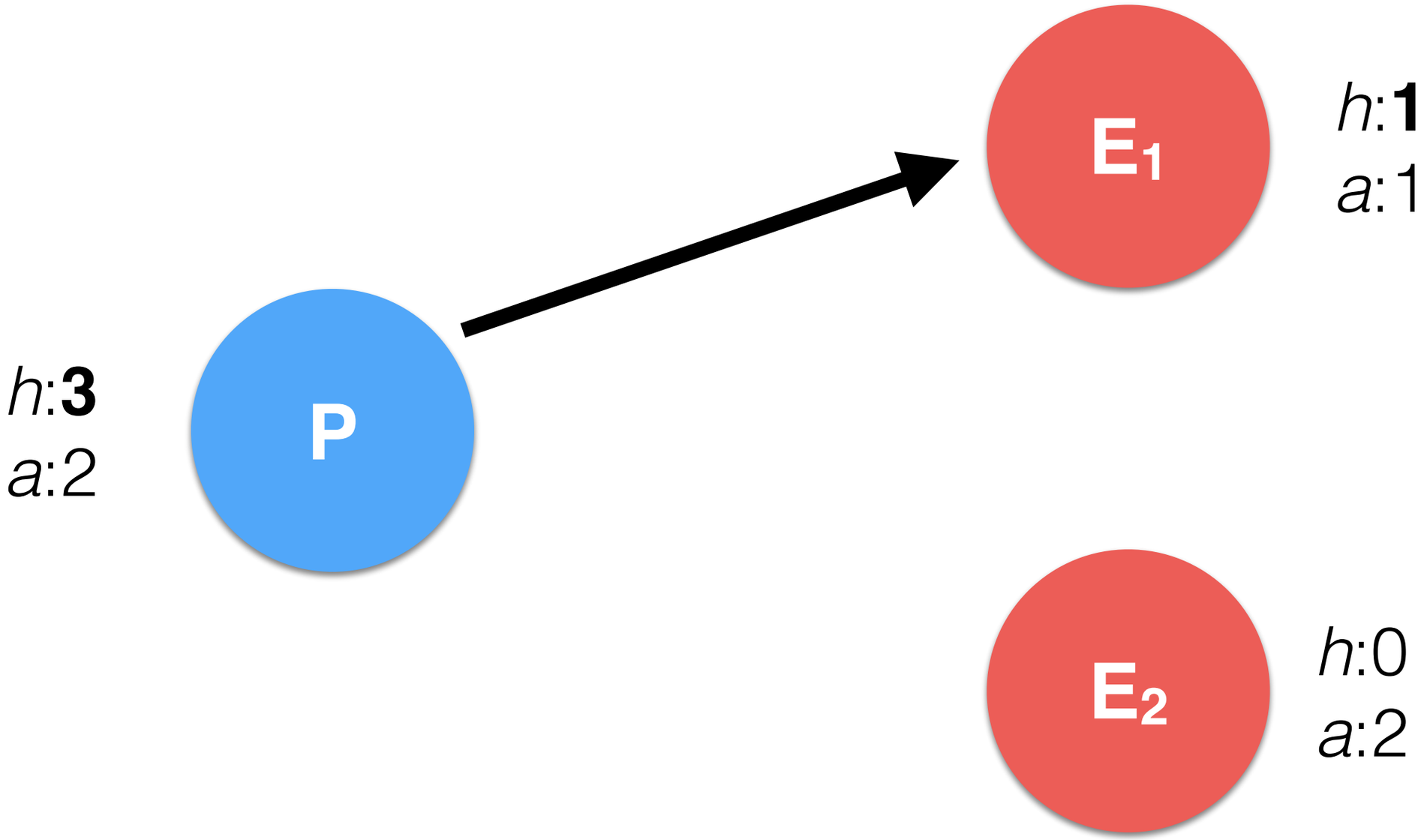
Highest Attack



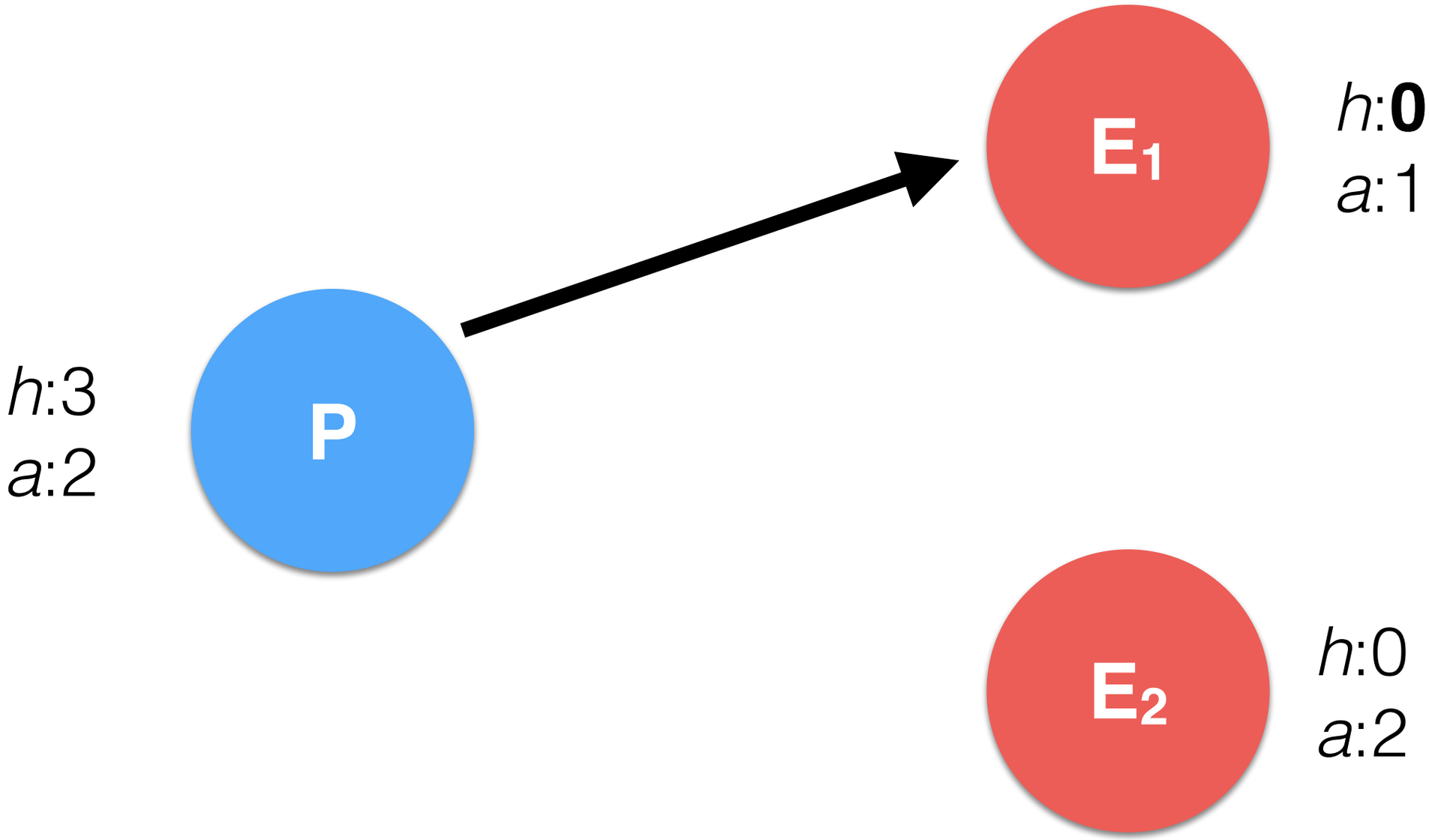
Highest Attack



Highest Attack



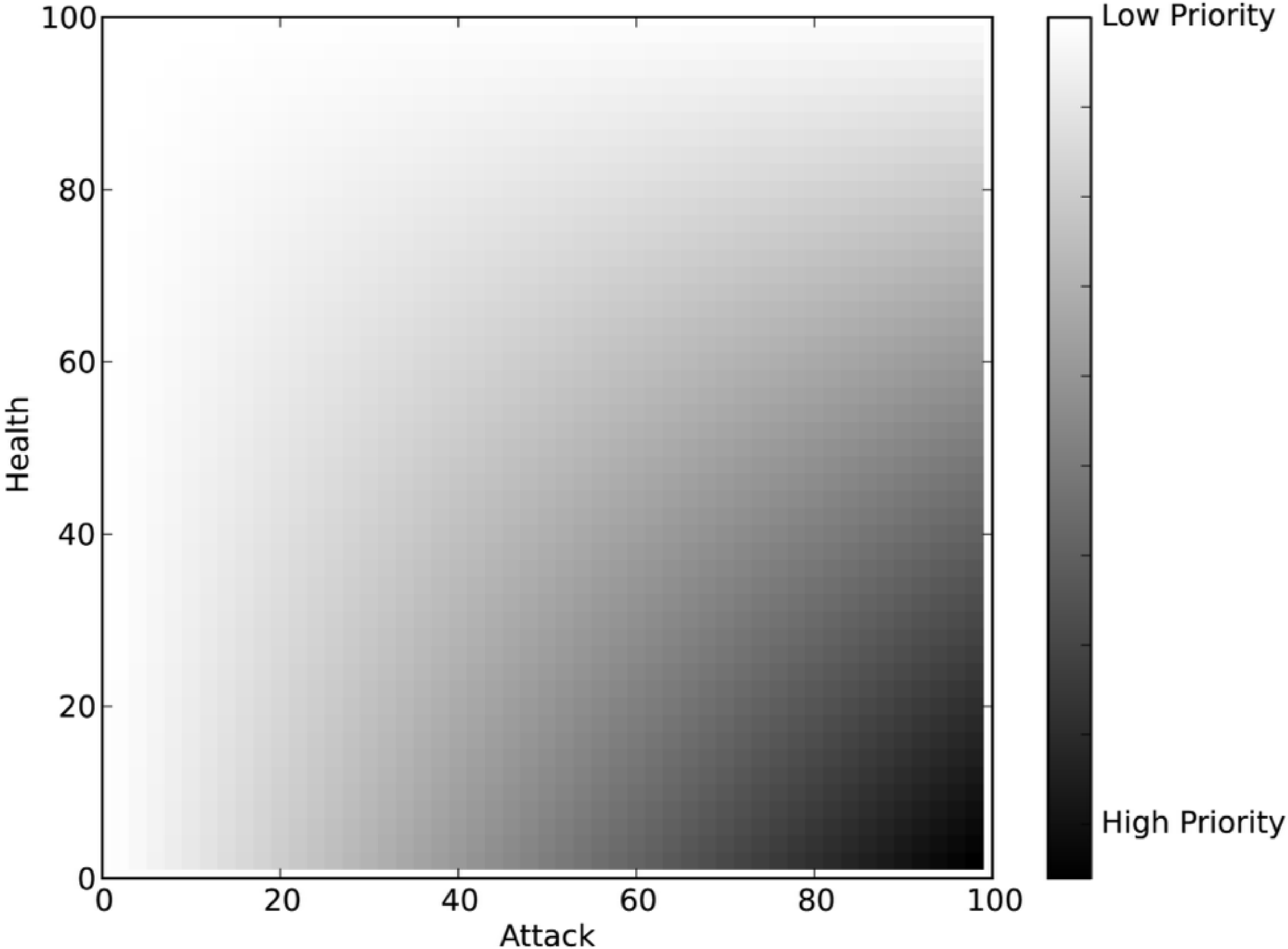
Highest Attack



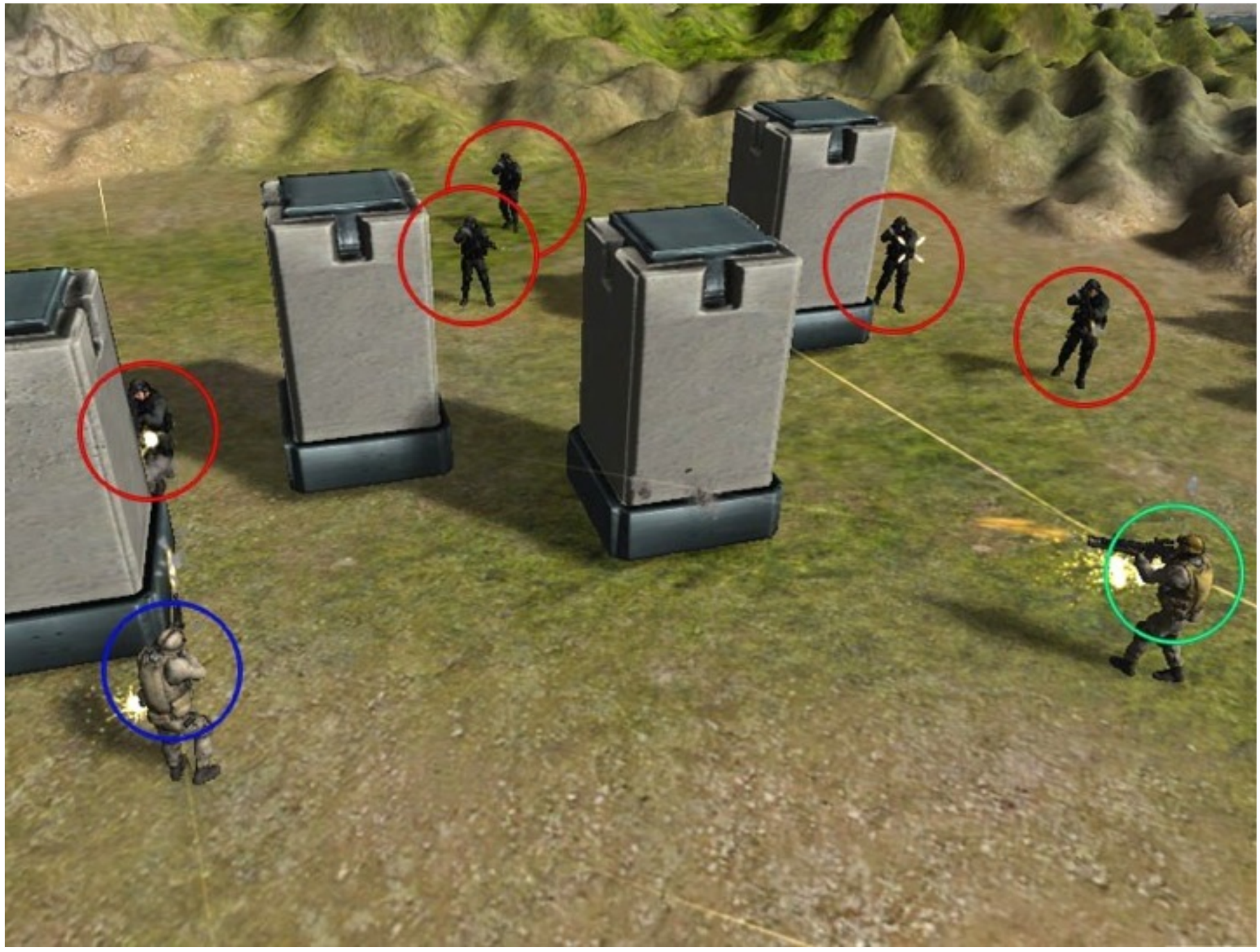
PSPACE-Hard [Furtak *et al.*]

Threat Ordering

- What is the threat of an enemy?
- Attack within respect of health
- The benefit of killing that enemy and not an other one


Low Priority
High Priority
Health
Attack
0
20
40
60
80
100

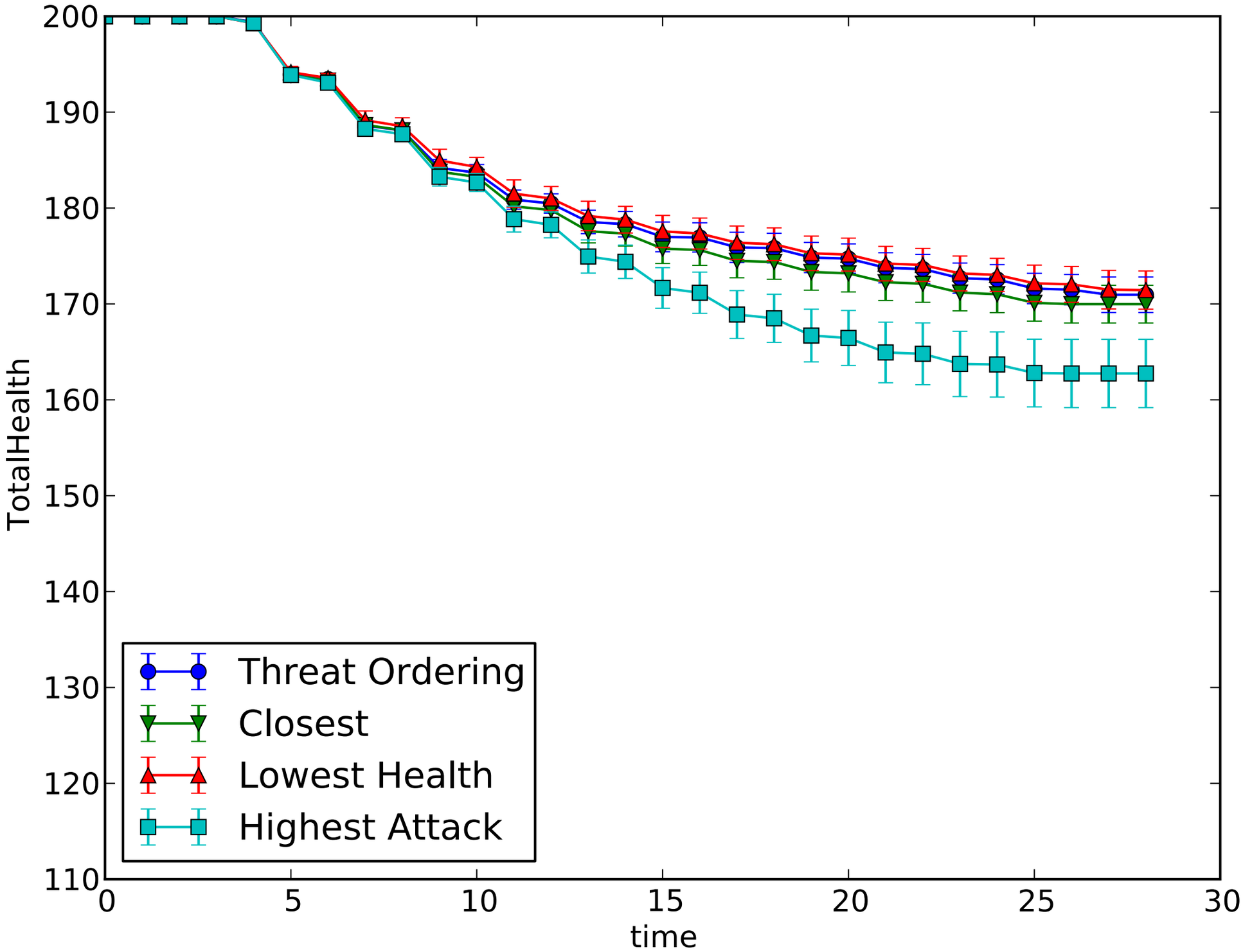
M enemies *vs.* *N* players



Strategies

- Threat ordering
- Closest
- Highest attack
- Lowest health

Tank level

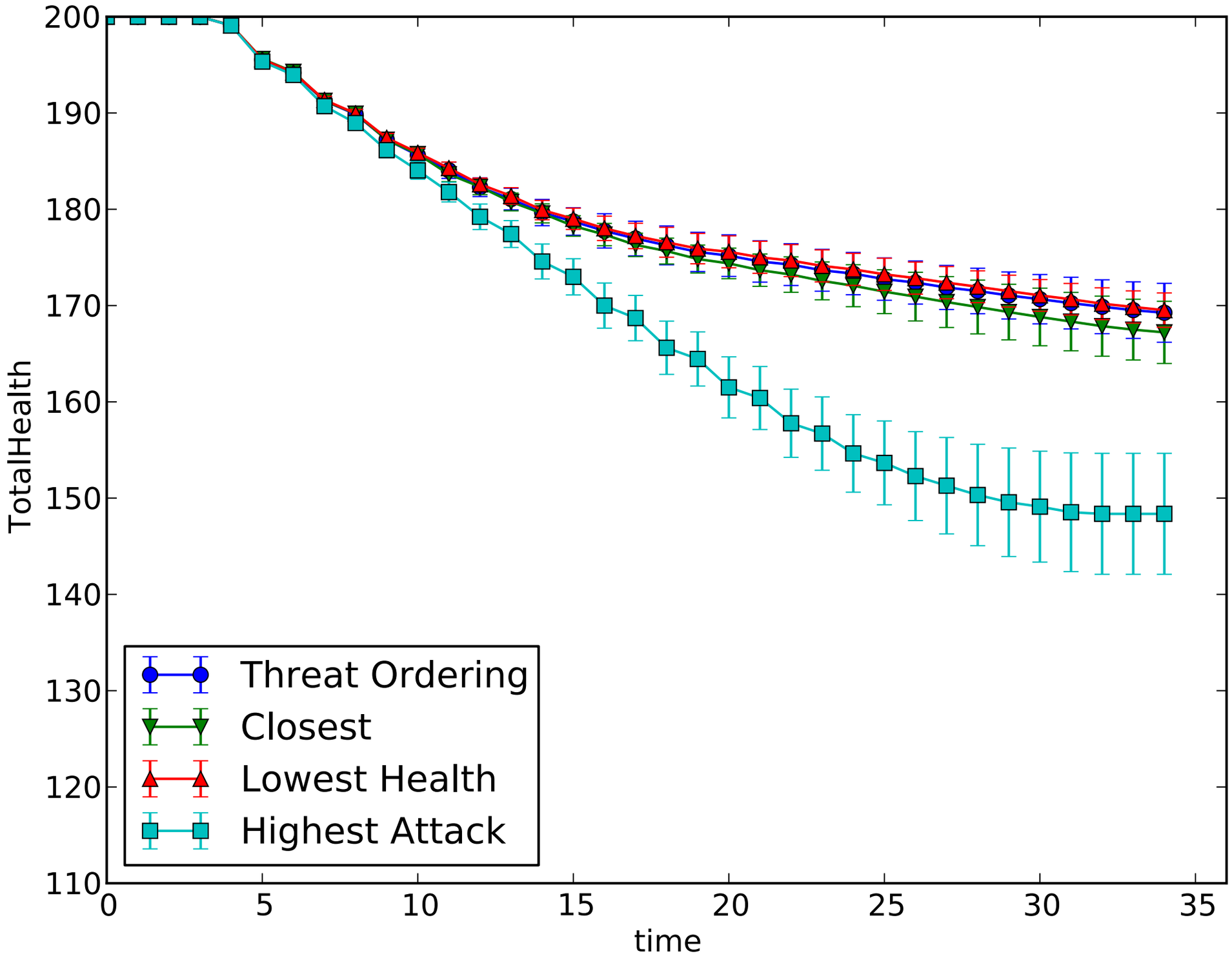

TotalHealth
200
190
180
170
160
150
140
130
120
110
0
5
10
15
20
25
30
time
Threat Ordering
Closest
Lowest Health
Highest Attack

Independent

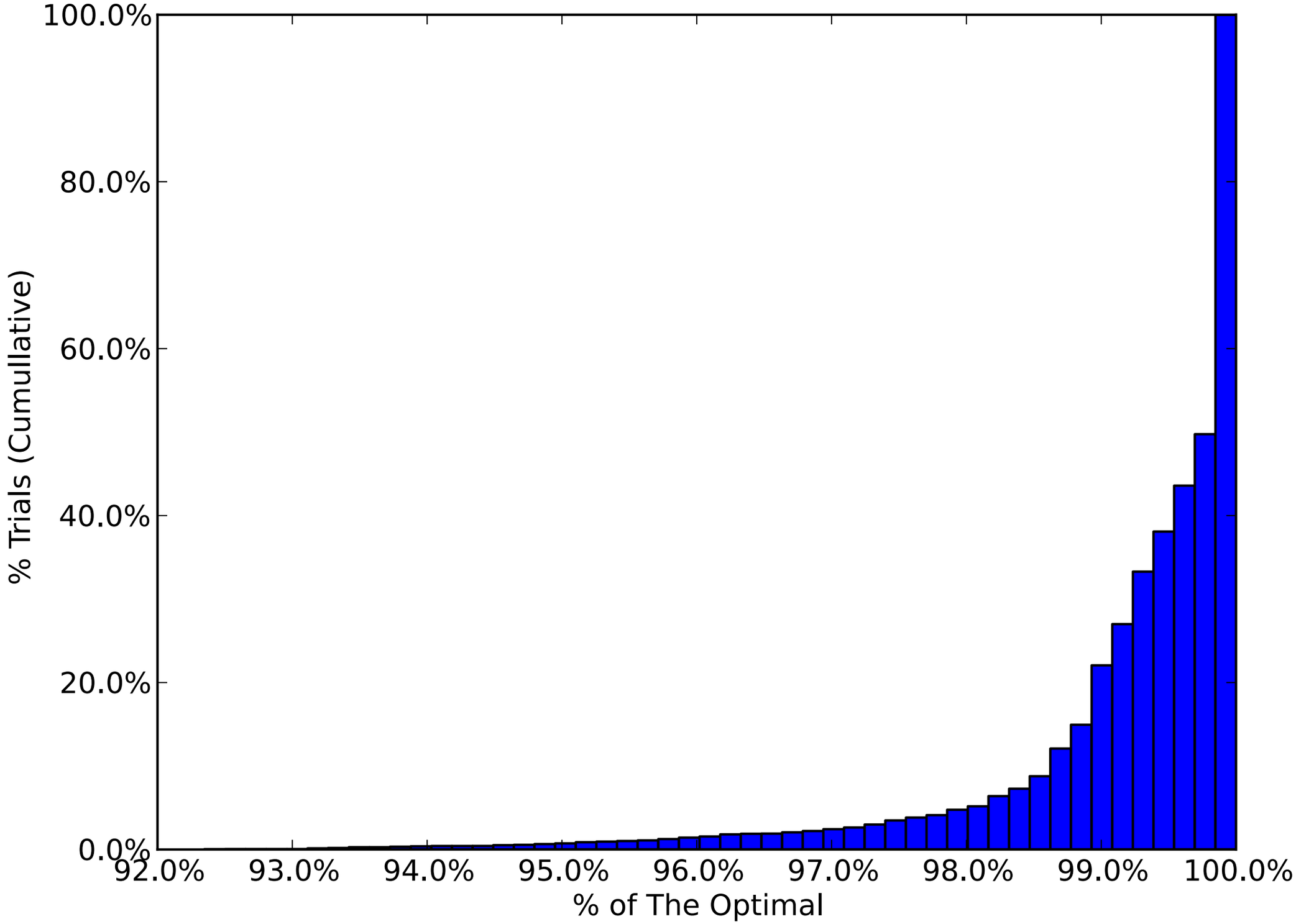
vs.

Mimicking

Tank level - mimic



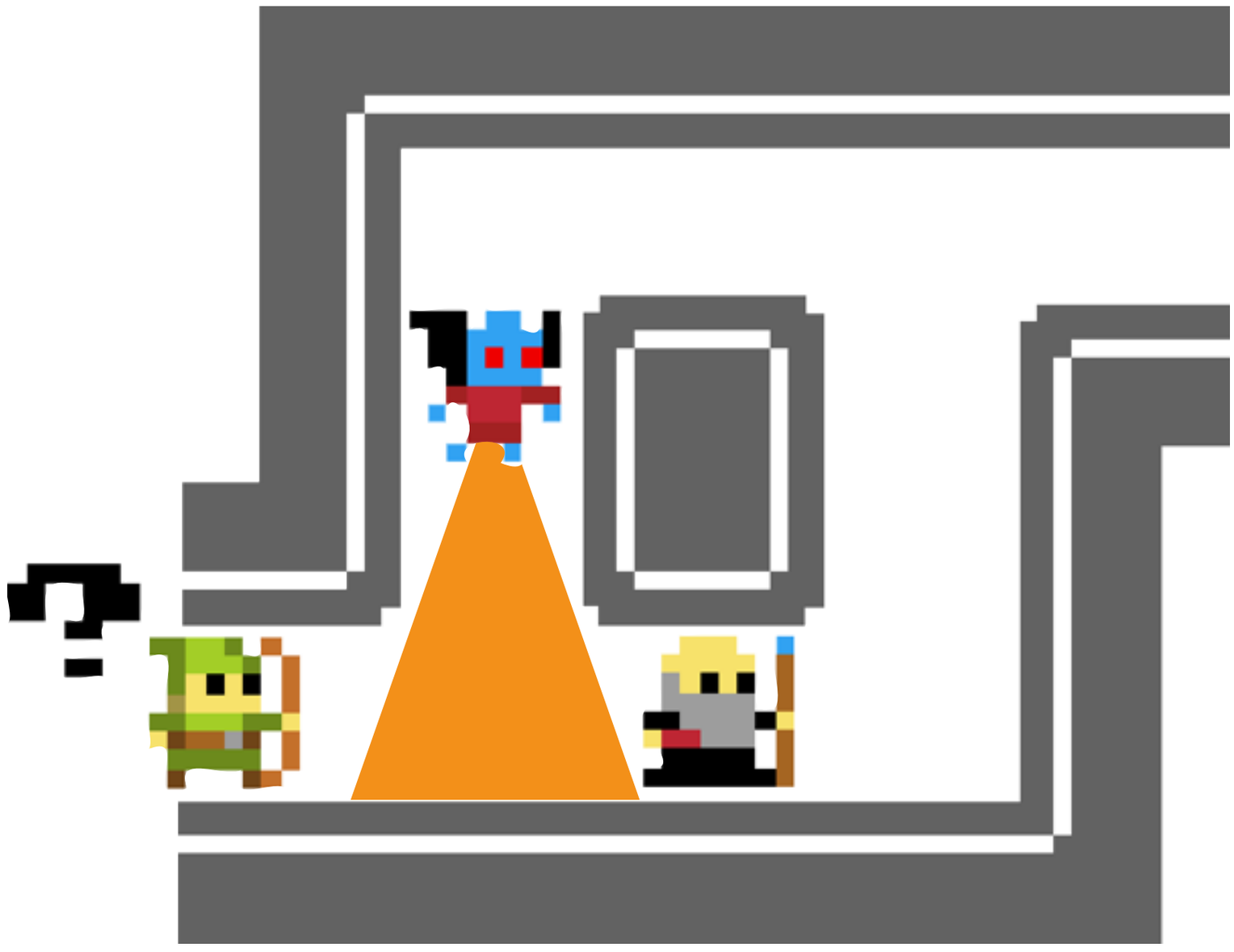
Heuristic *vs.* Optimal



Threat Ordering

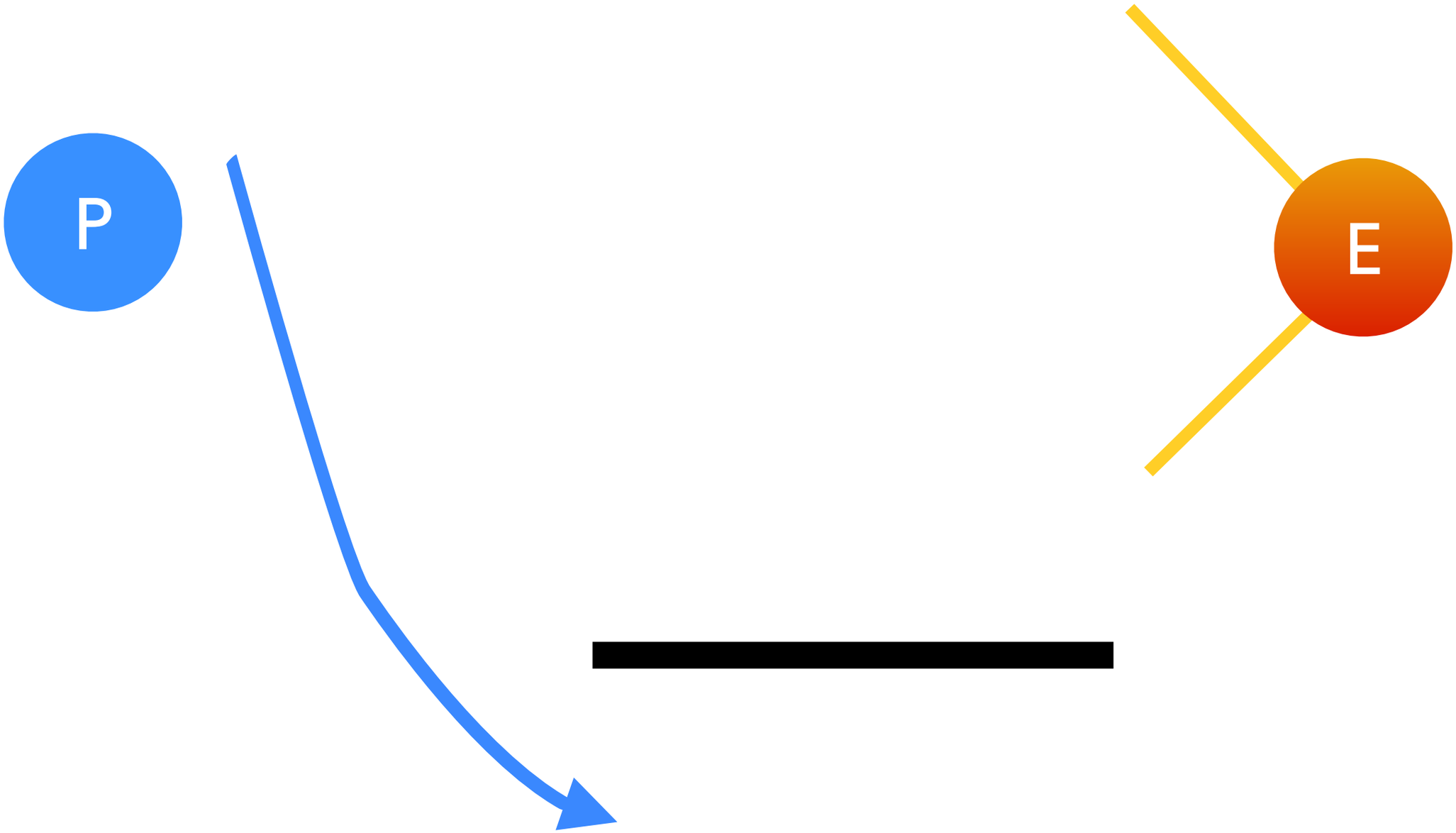
- Approximation of a hard problem
- Insights on the cost of bad strategies
- 50% time finds optimal and usually within 1% of the optimal

Stealth movement

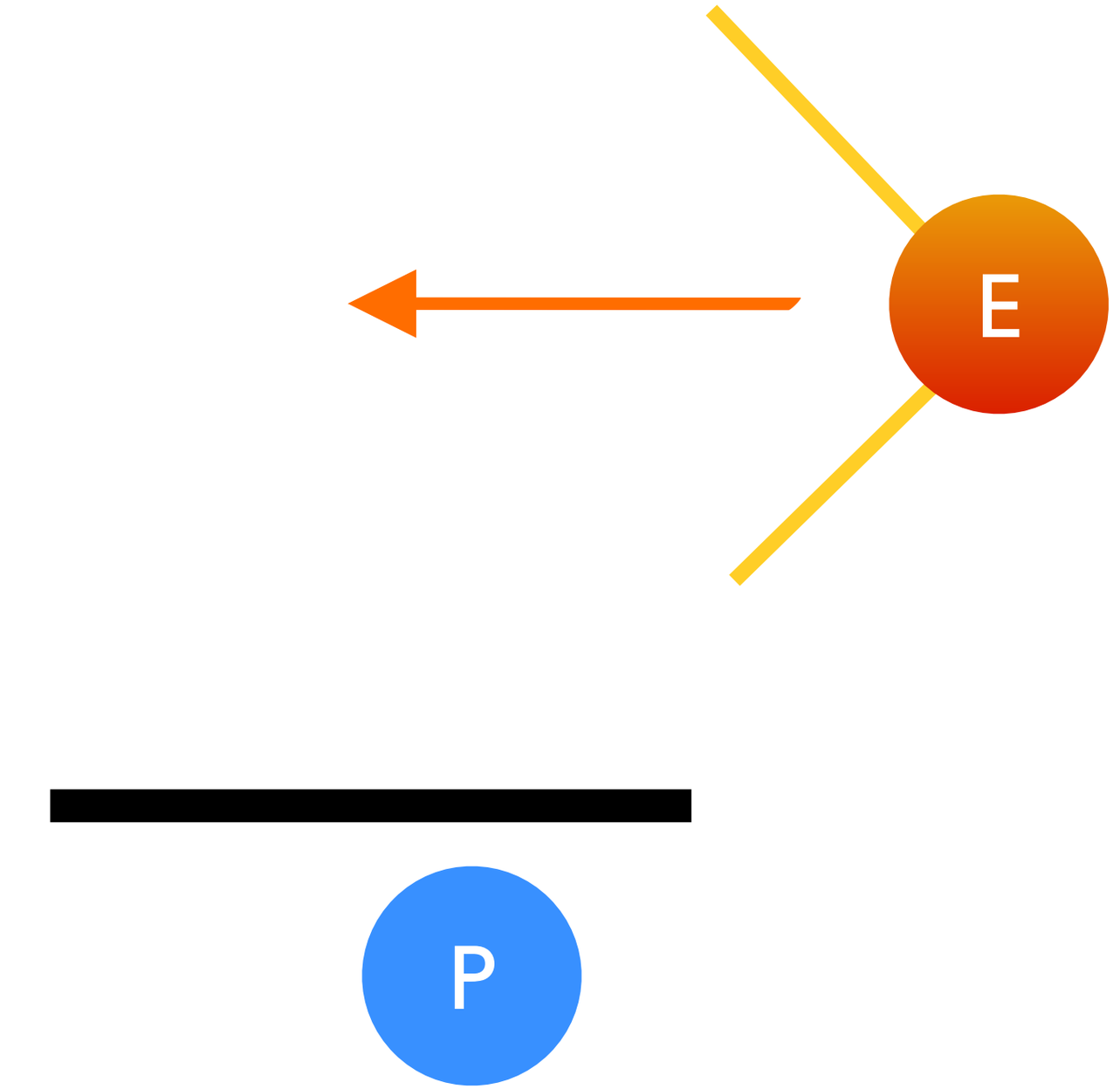


Sneaking

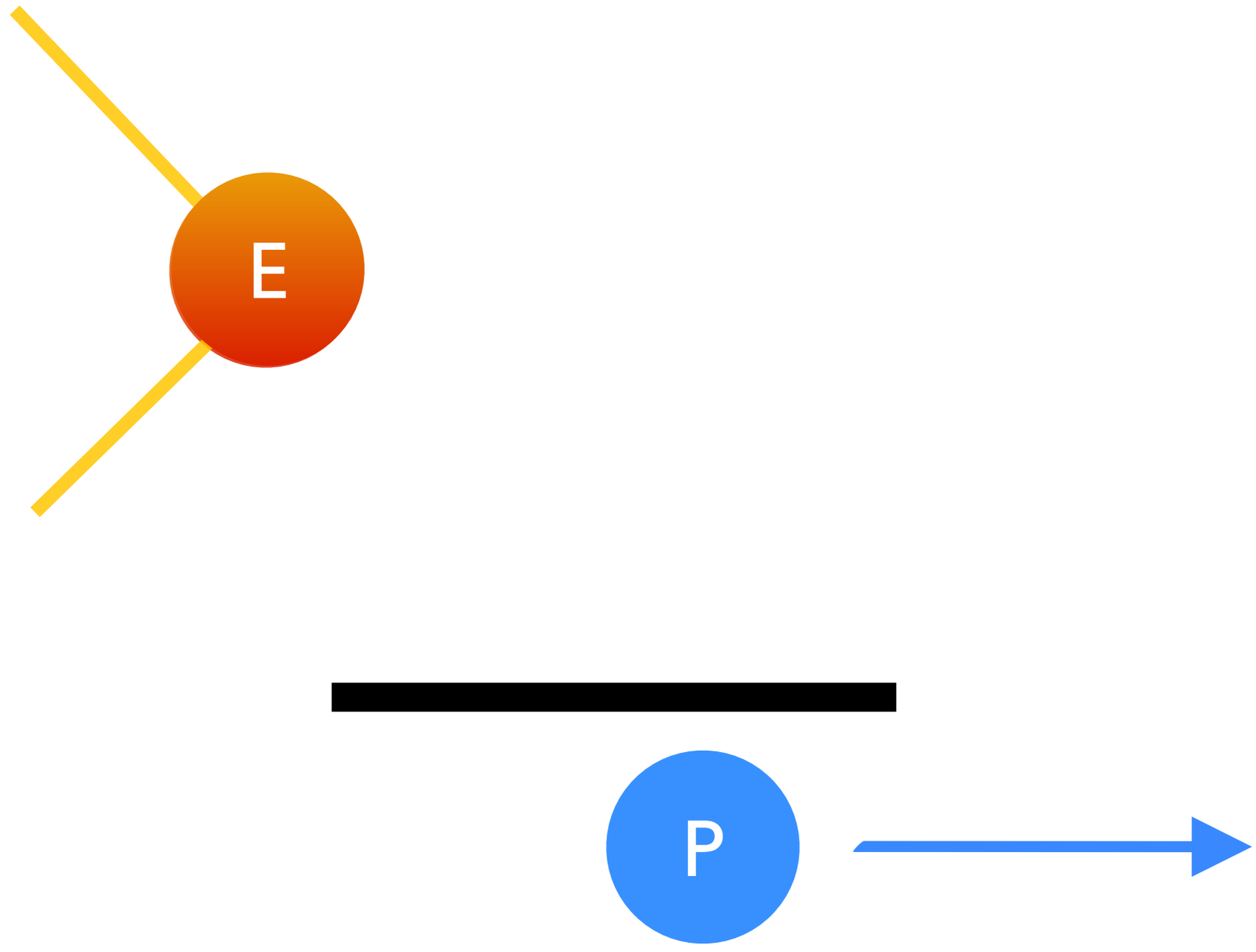
Sneaking



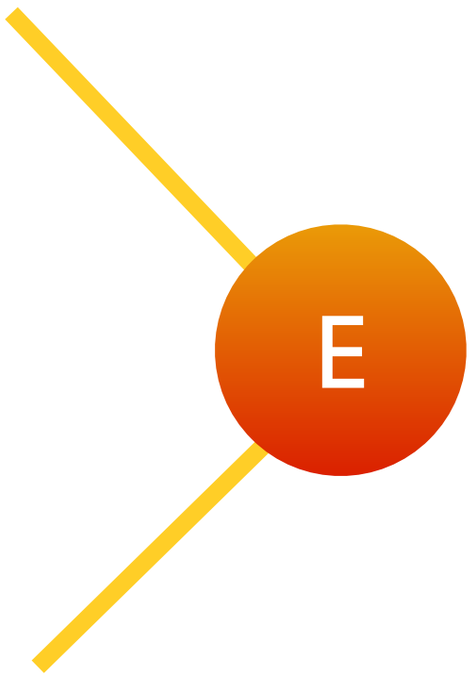
Sneaking



Sneaking



Sneaking



Can we compute an undetected path from A to B?

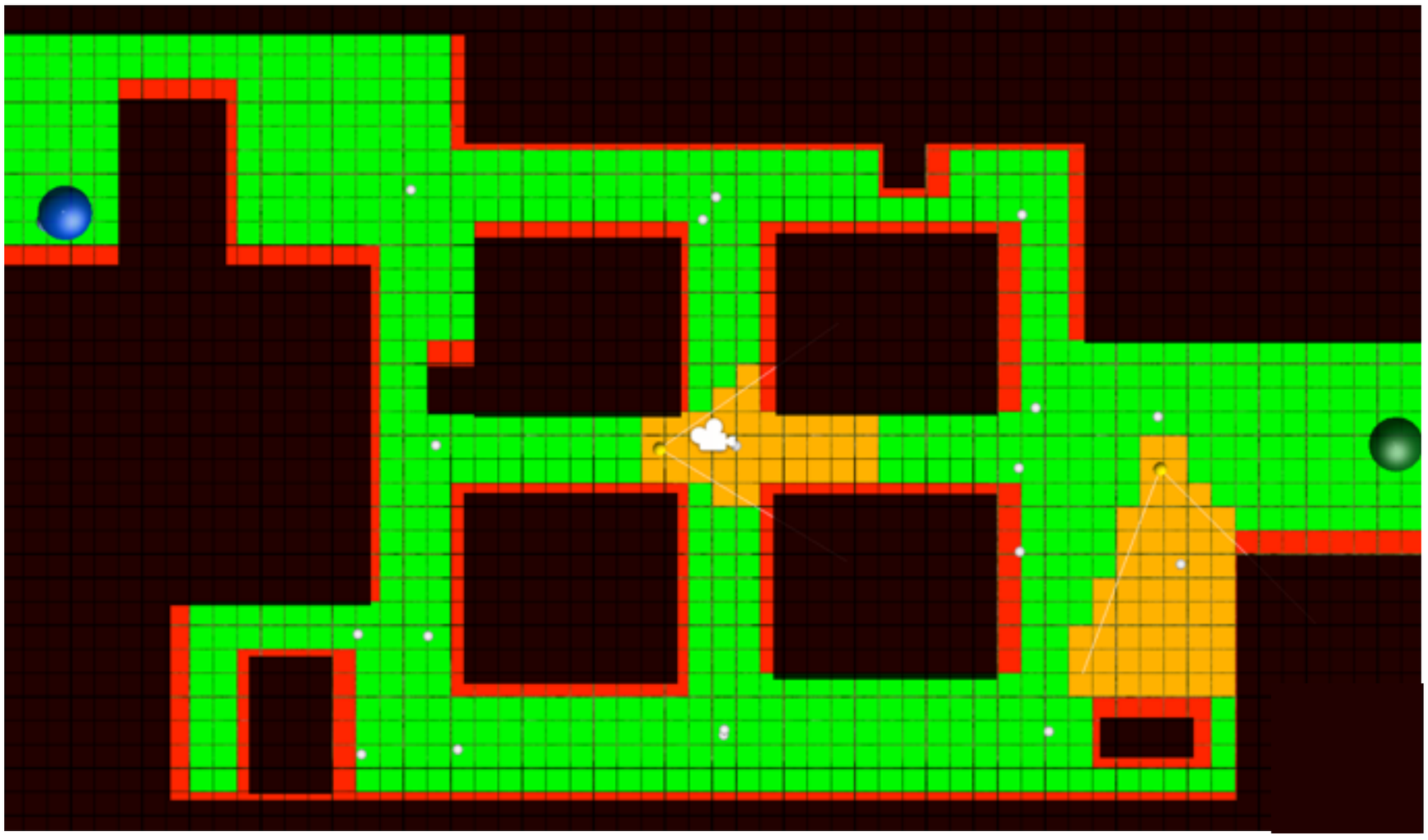
Assumptions

- Level geometry
- Enemies’ deterministic movement
- Cannot be detected
- Initial and goal position

Overview

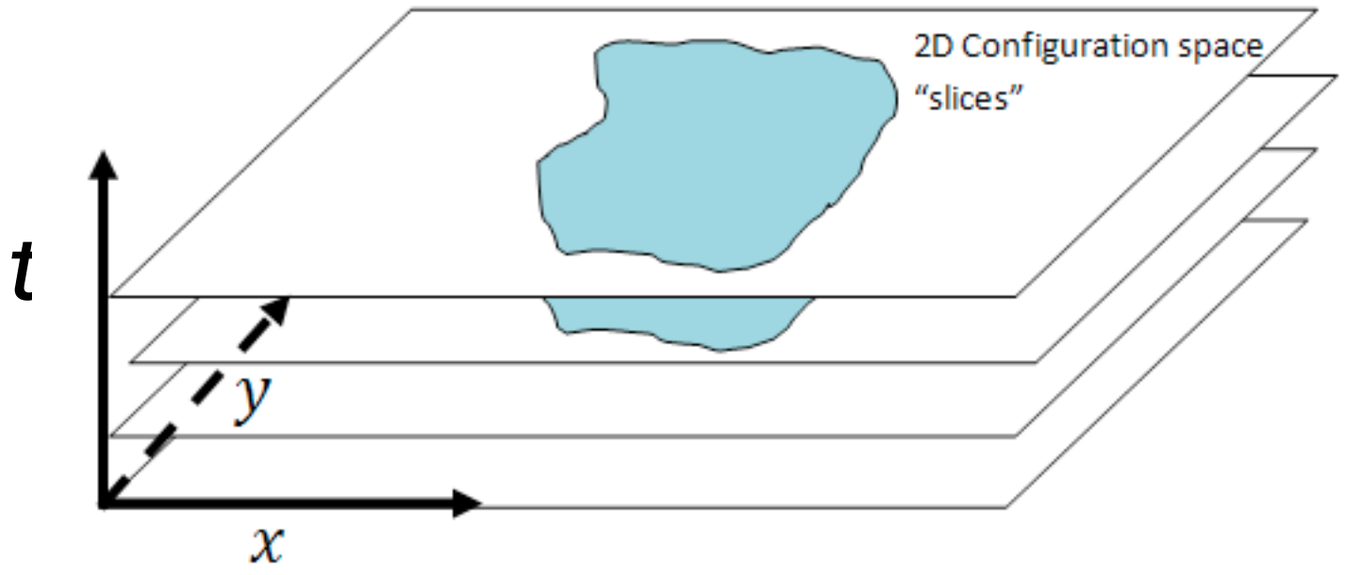
- Defining the state space
- Rapidly exploring Random Tree (RRT)
- Presenting results

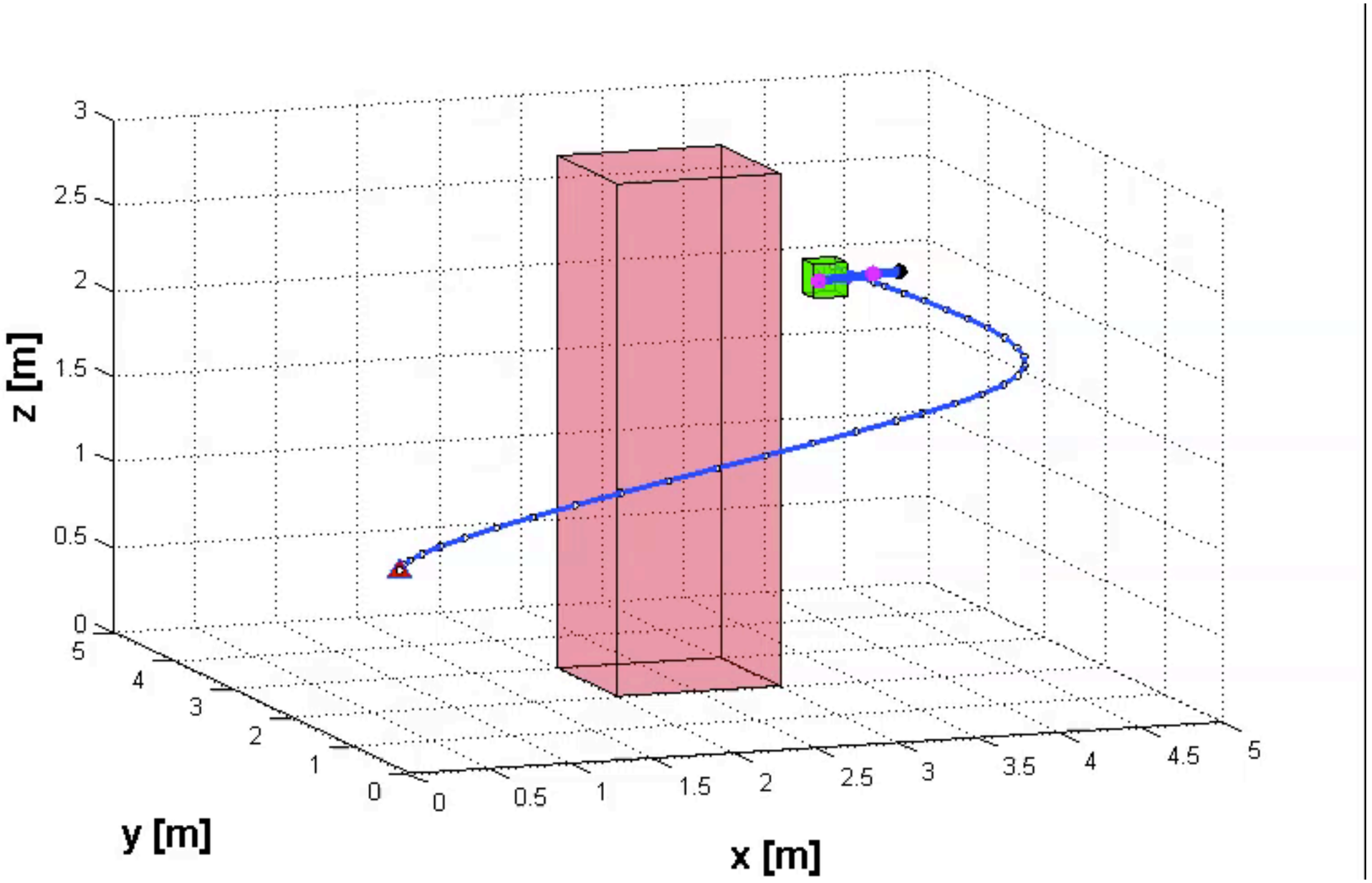
Discretized Space



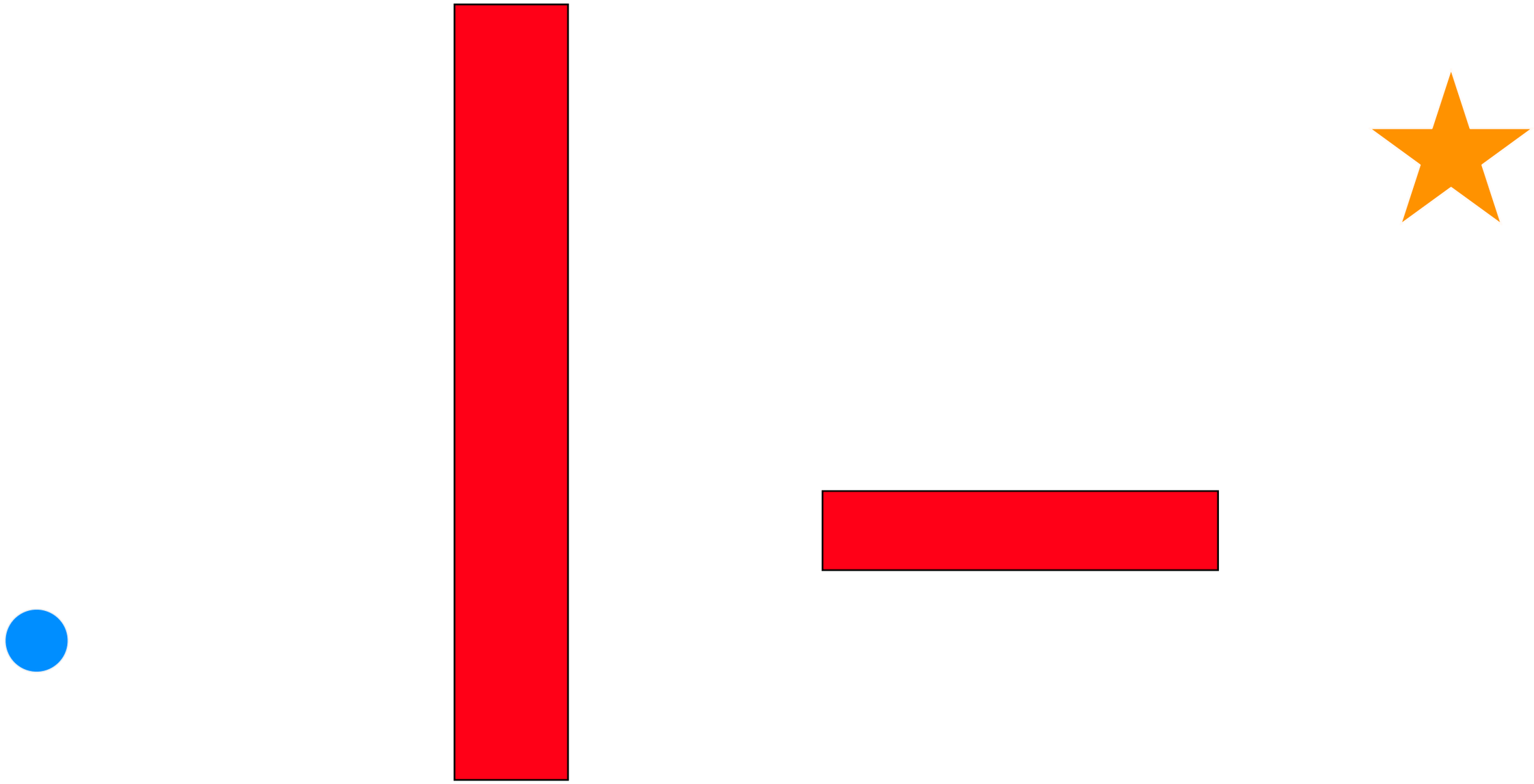
Obstacles Seen Walkable

Search Space

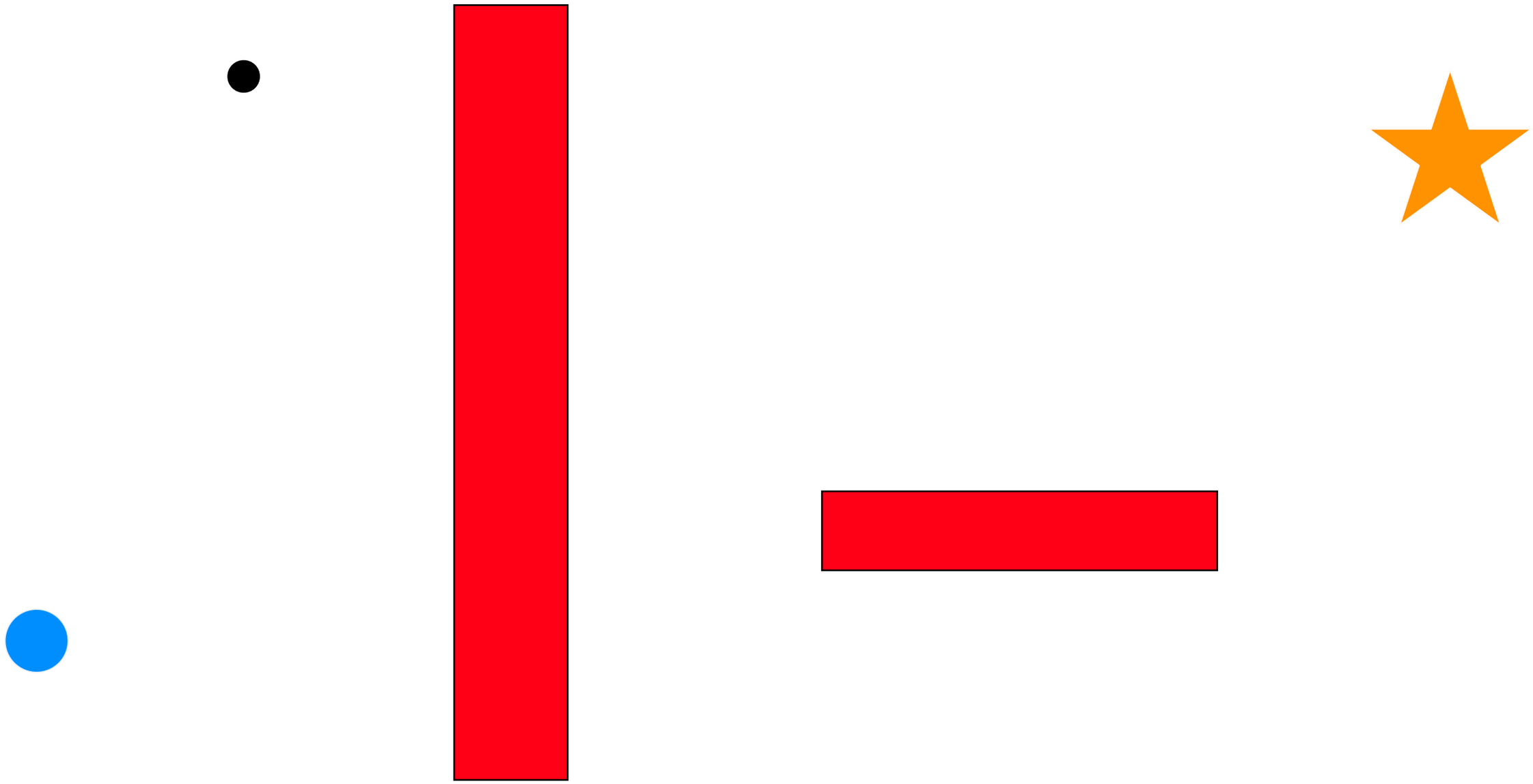



z [m]
3
2.5
2
1.5
1
0.5
0
y [m]
5
4
3
2
1
0
x [m]
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

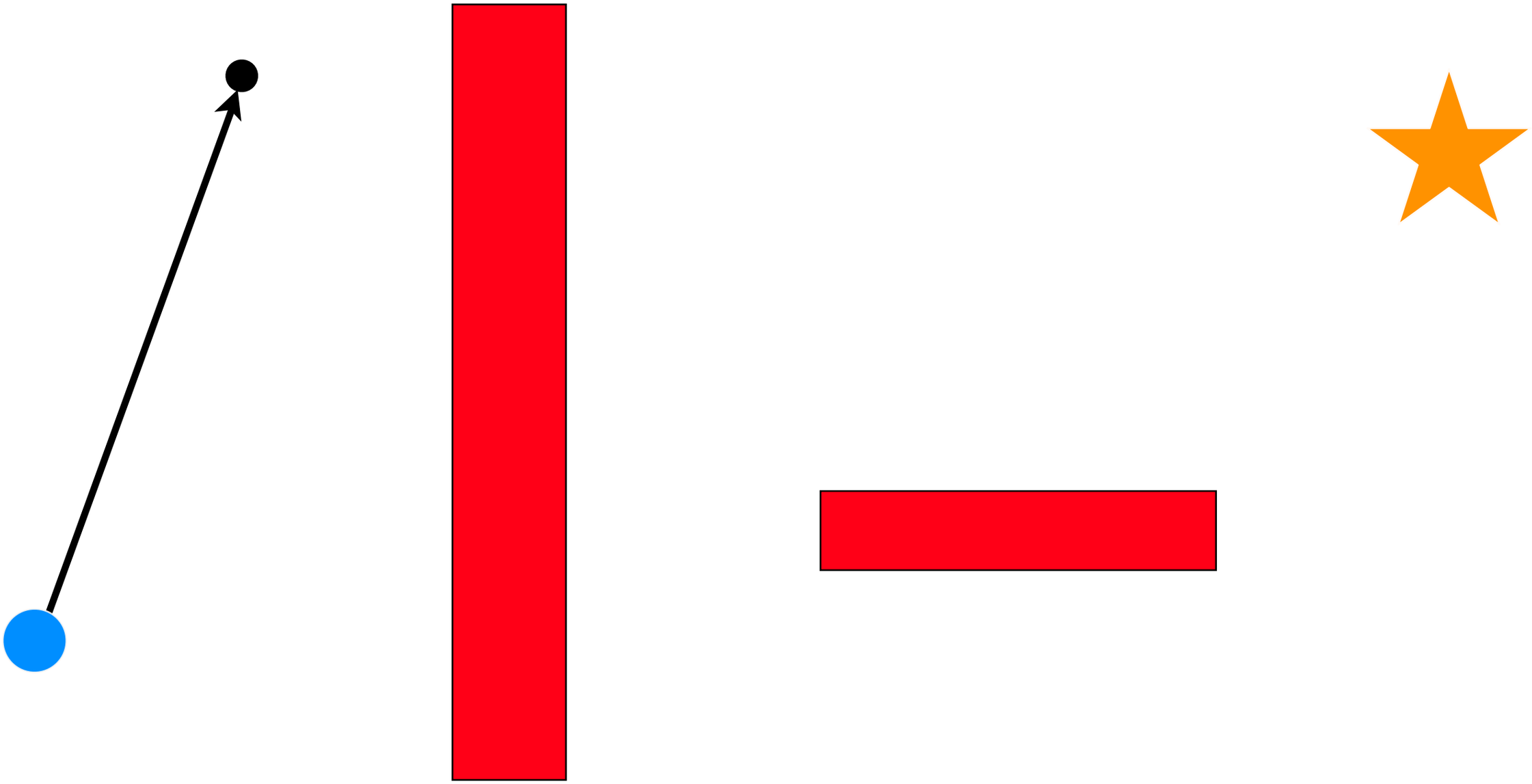
RRT



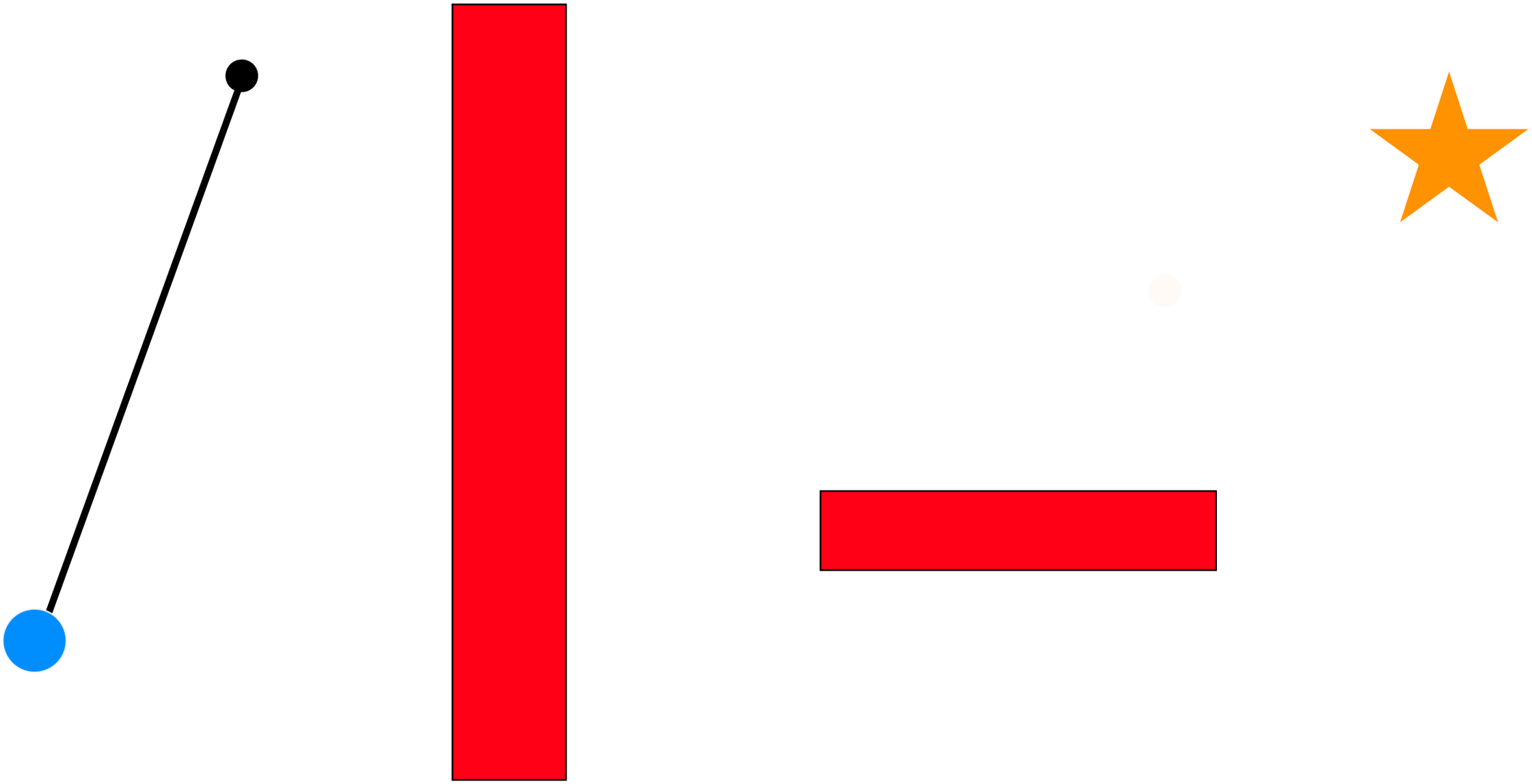
RRT



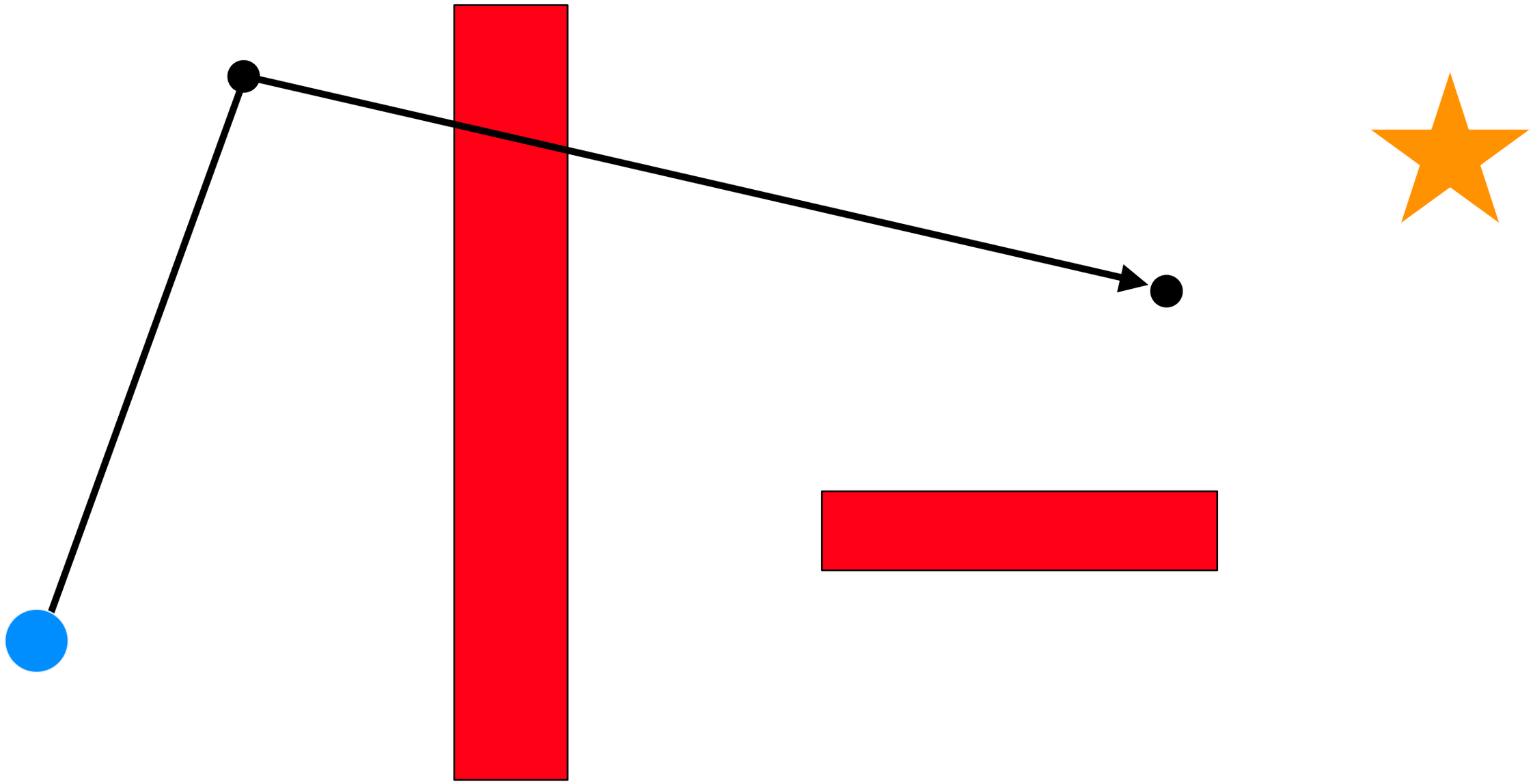
RRT



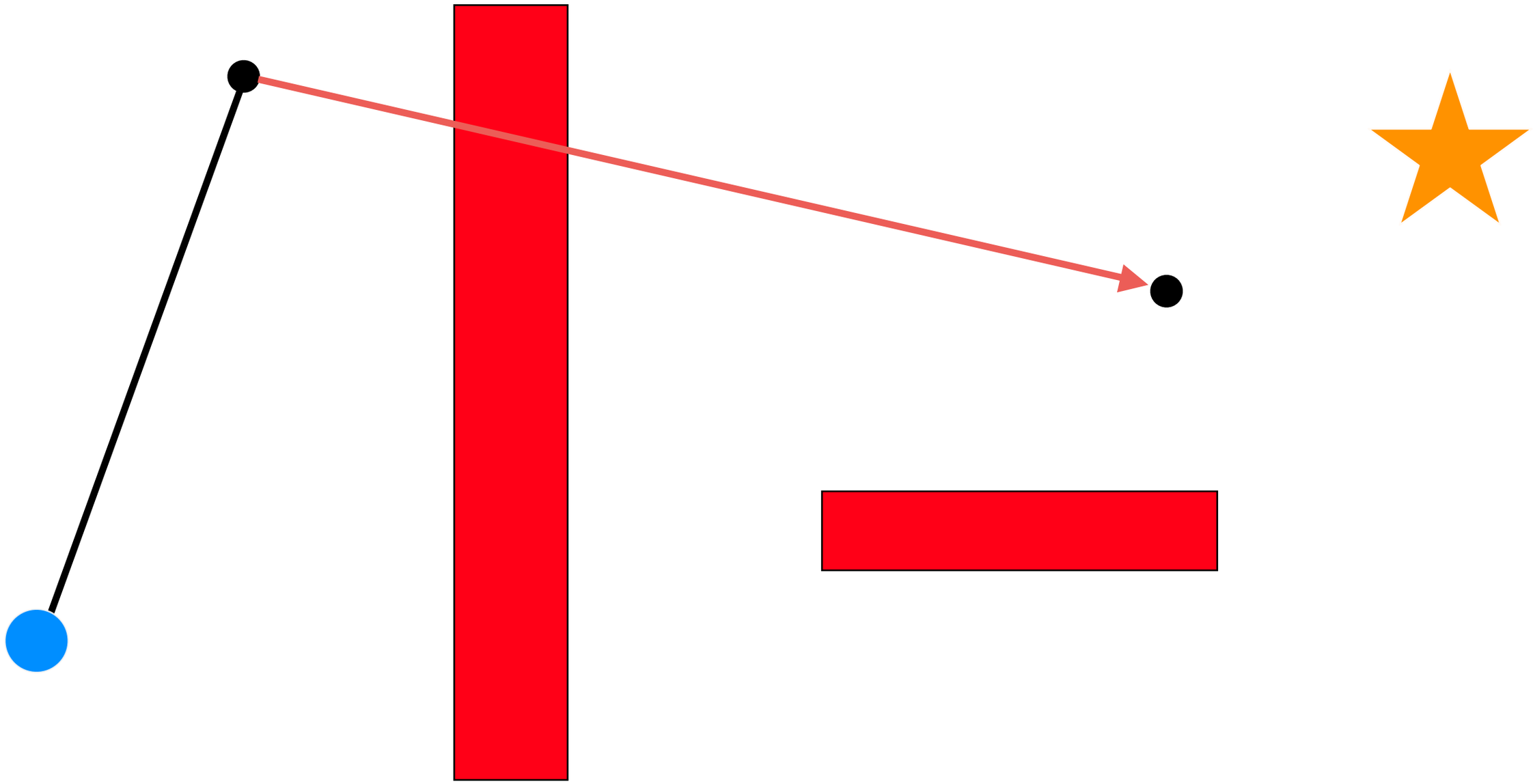
RRT



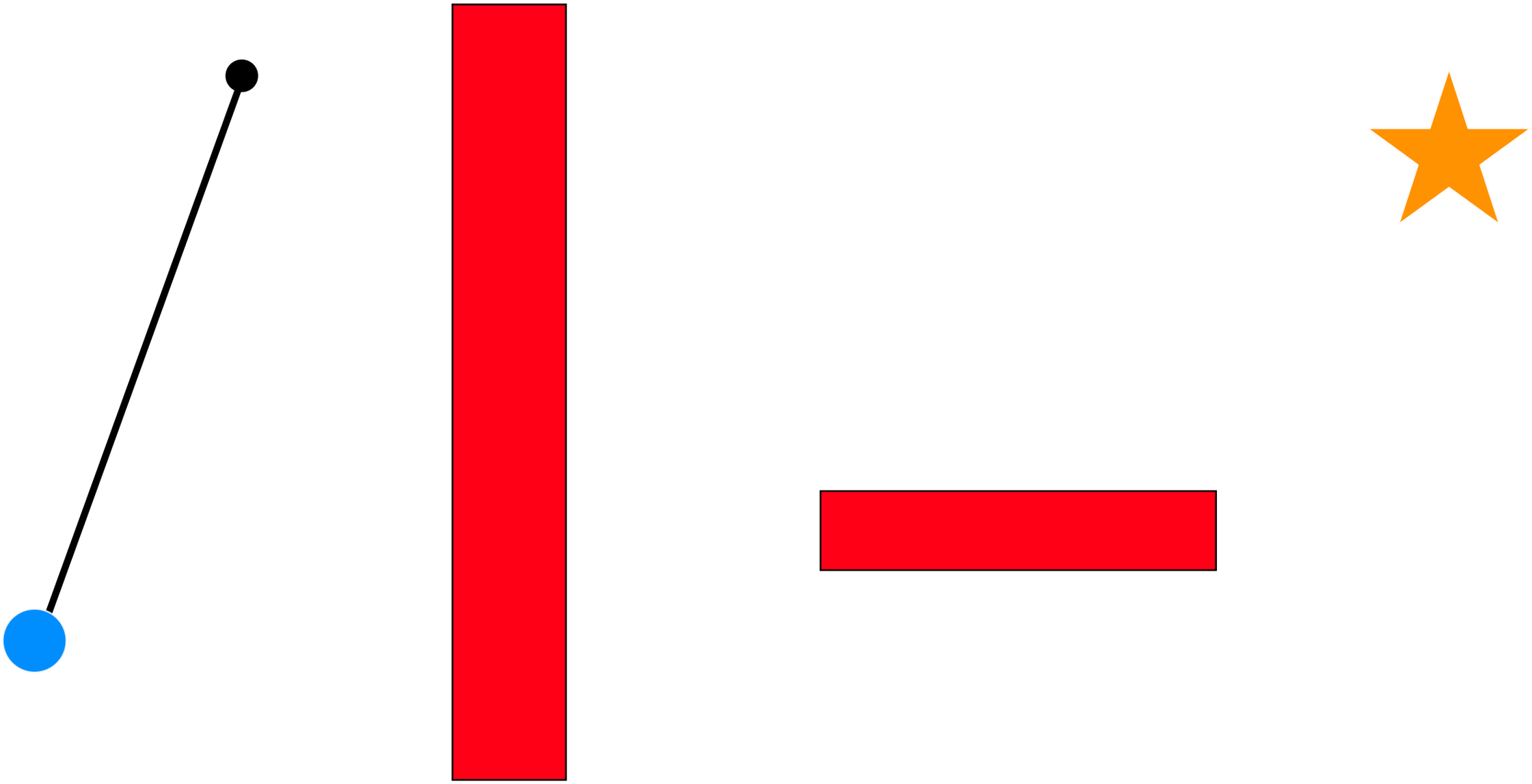
RRT



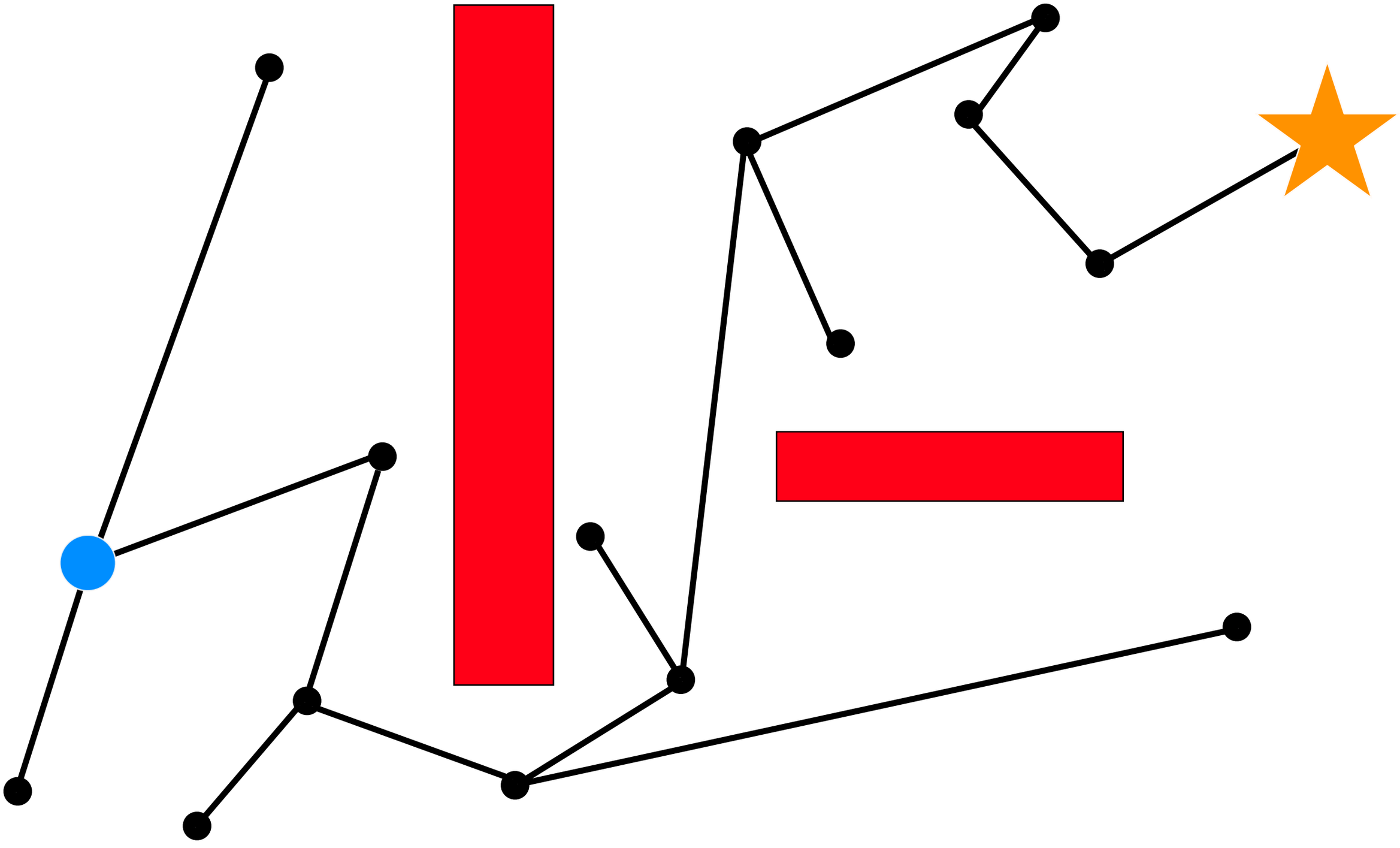
RRT



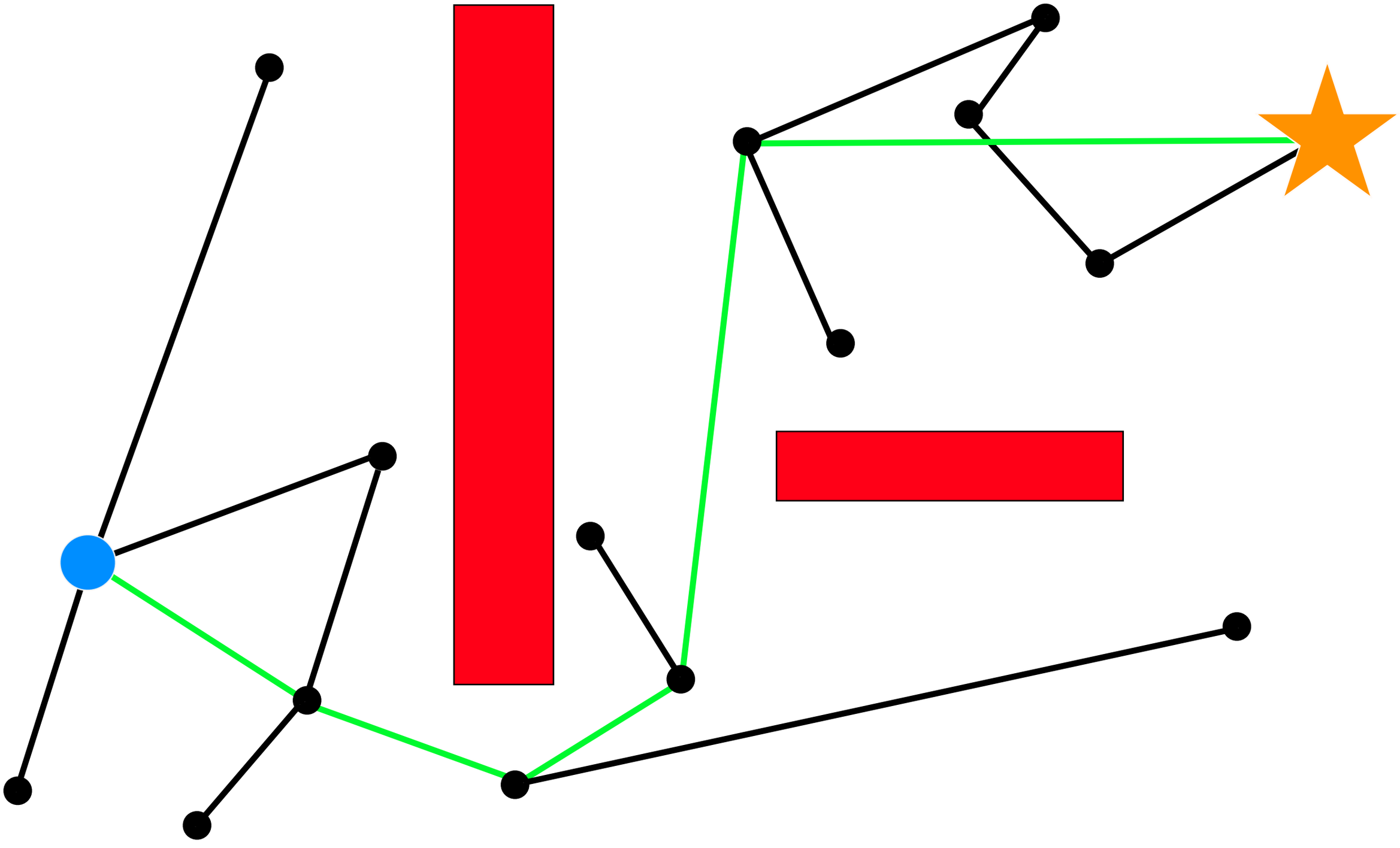
RRT



RRT



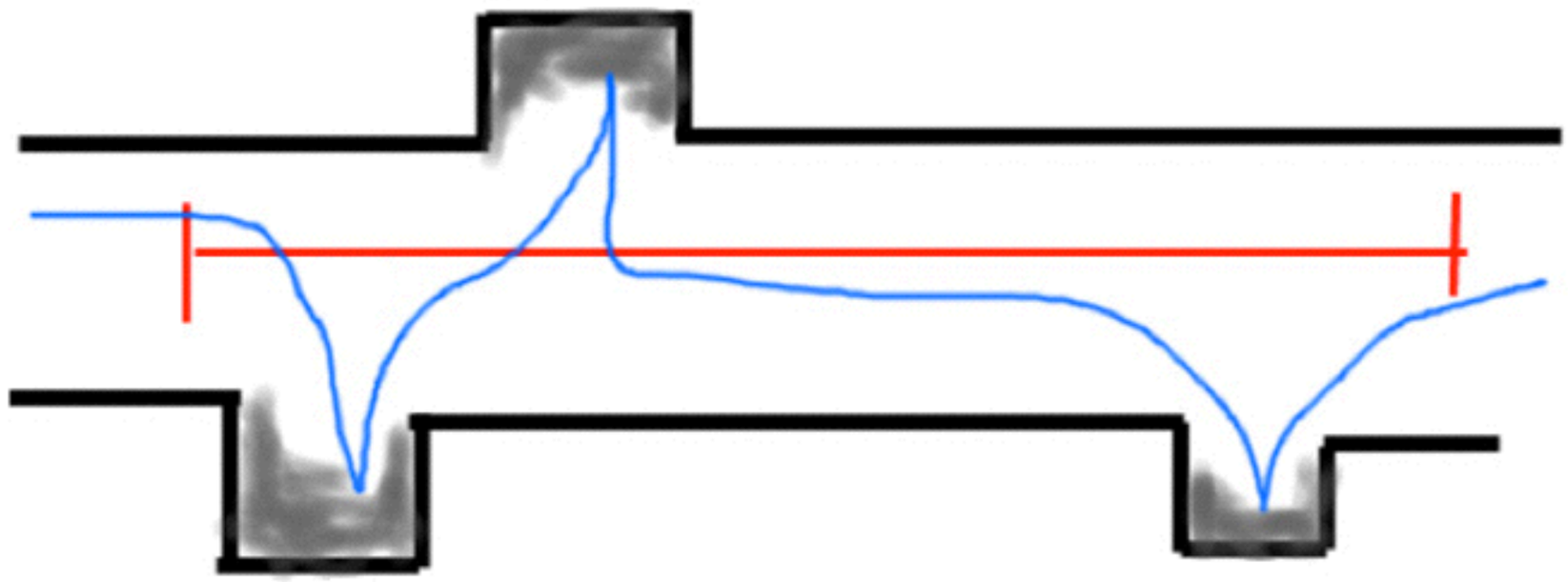
RRT



RRT

- Run multiple times
- Randomly exploring the space
- None optimal paths

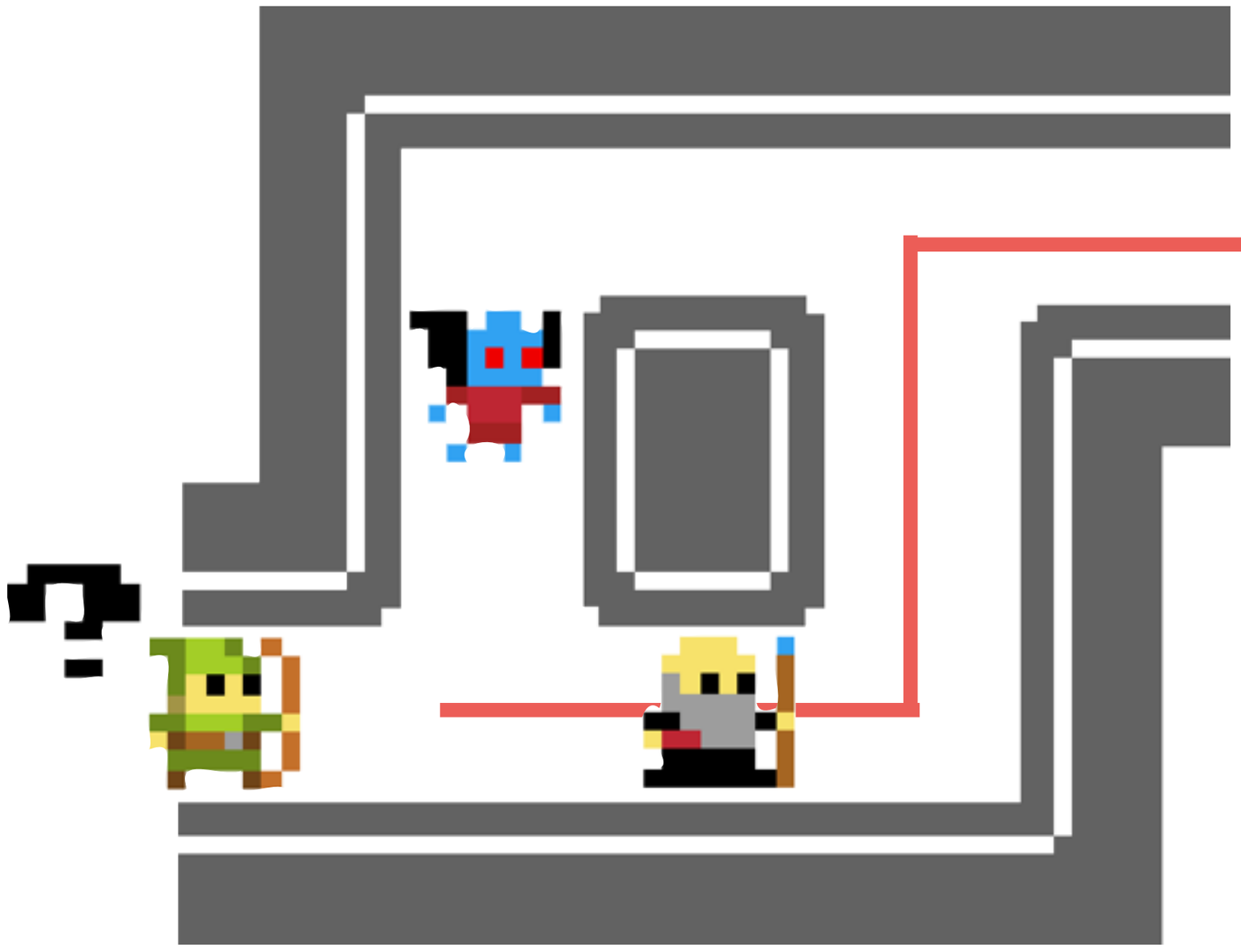
Clustering



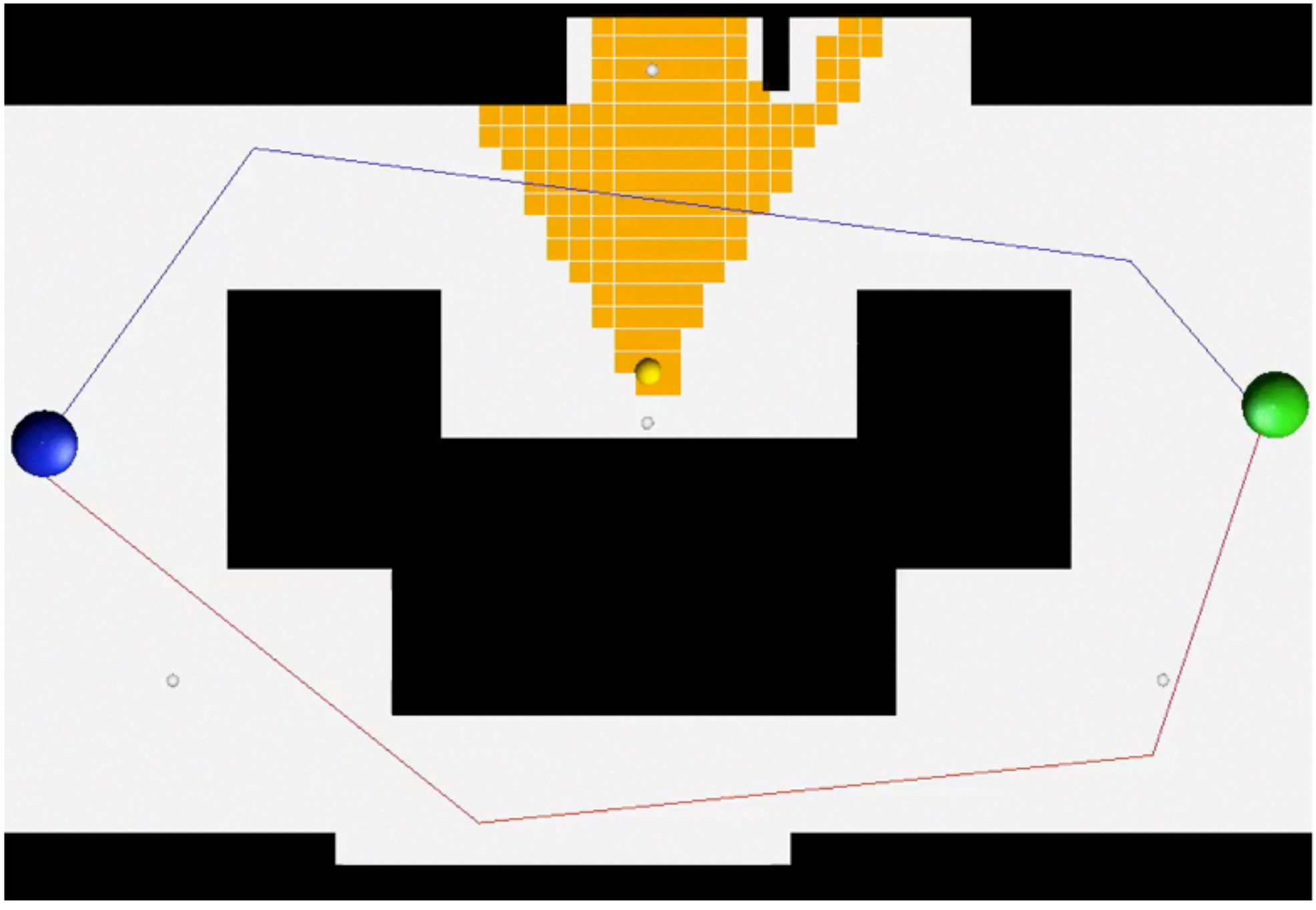
[Smith 06]

Quick Demo

Understanding the player



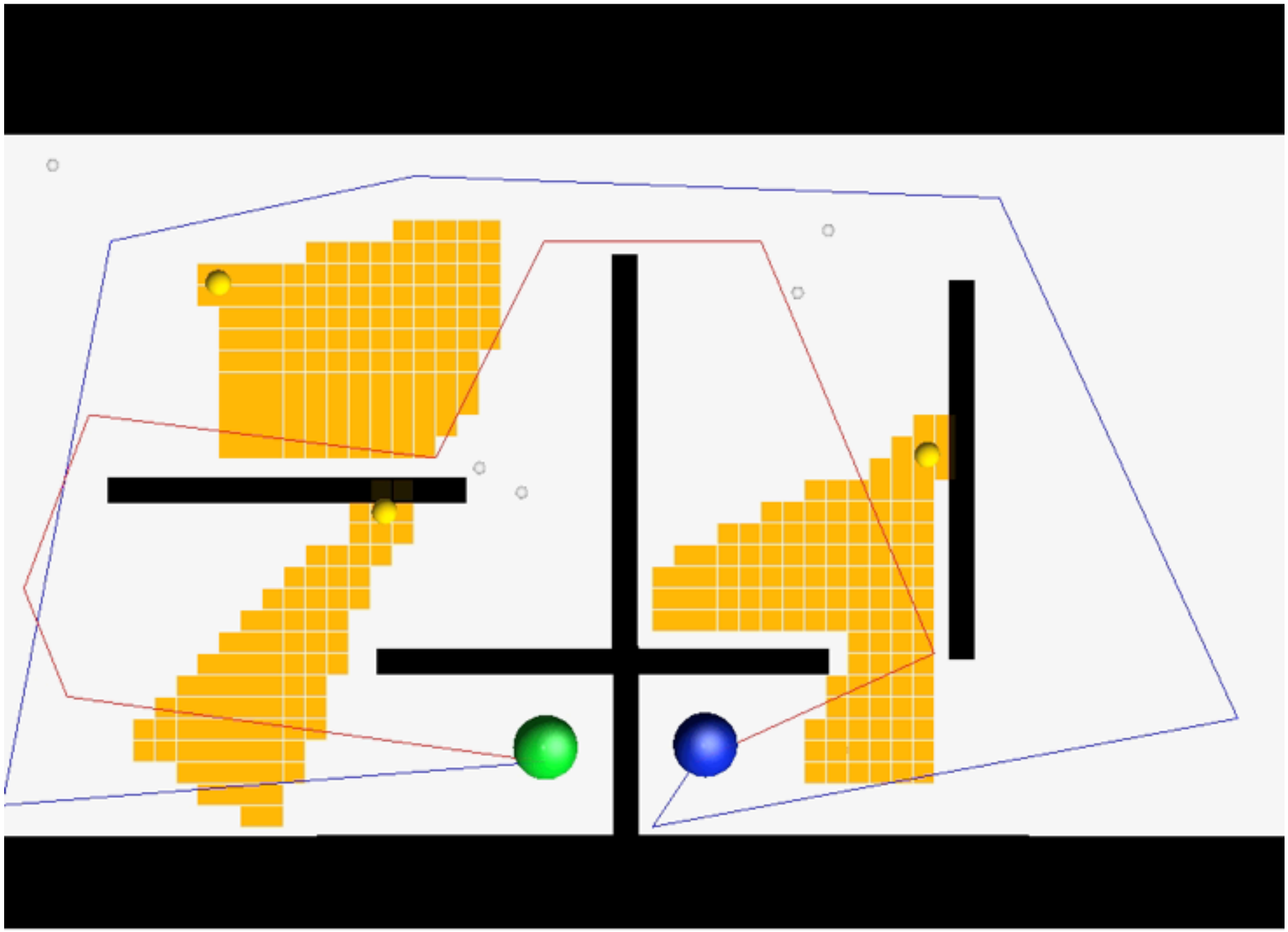
Which path is the safest?



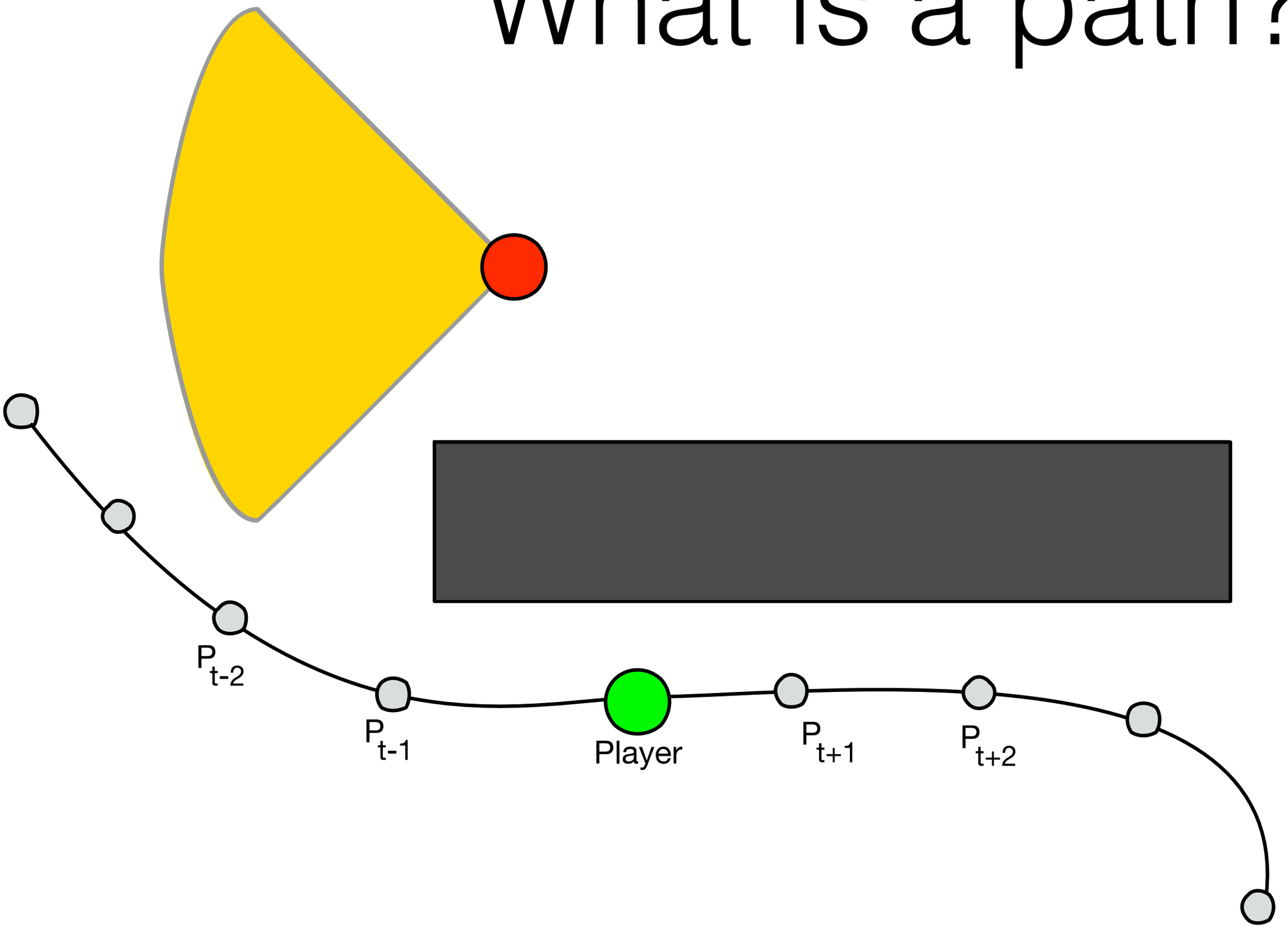
Defining risk

- Distance to the enemy
- Distance to the enemy's field of view
- Nearly seen
- Shortest path
- *etc.*

Which path is the safest?



What is a path?



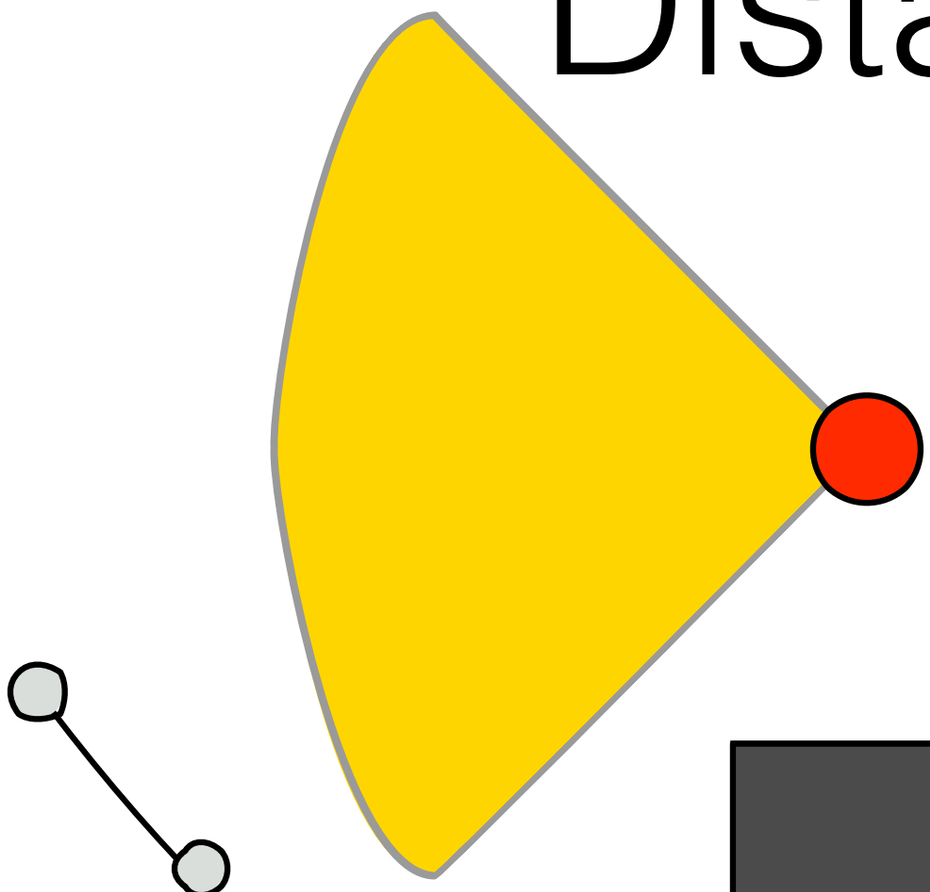
Metrics

Distance to the enemy (DIST)

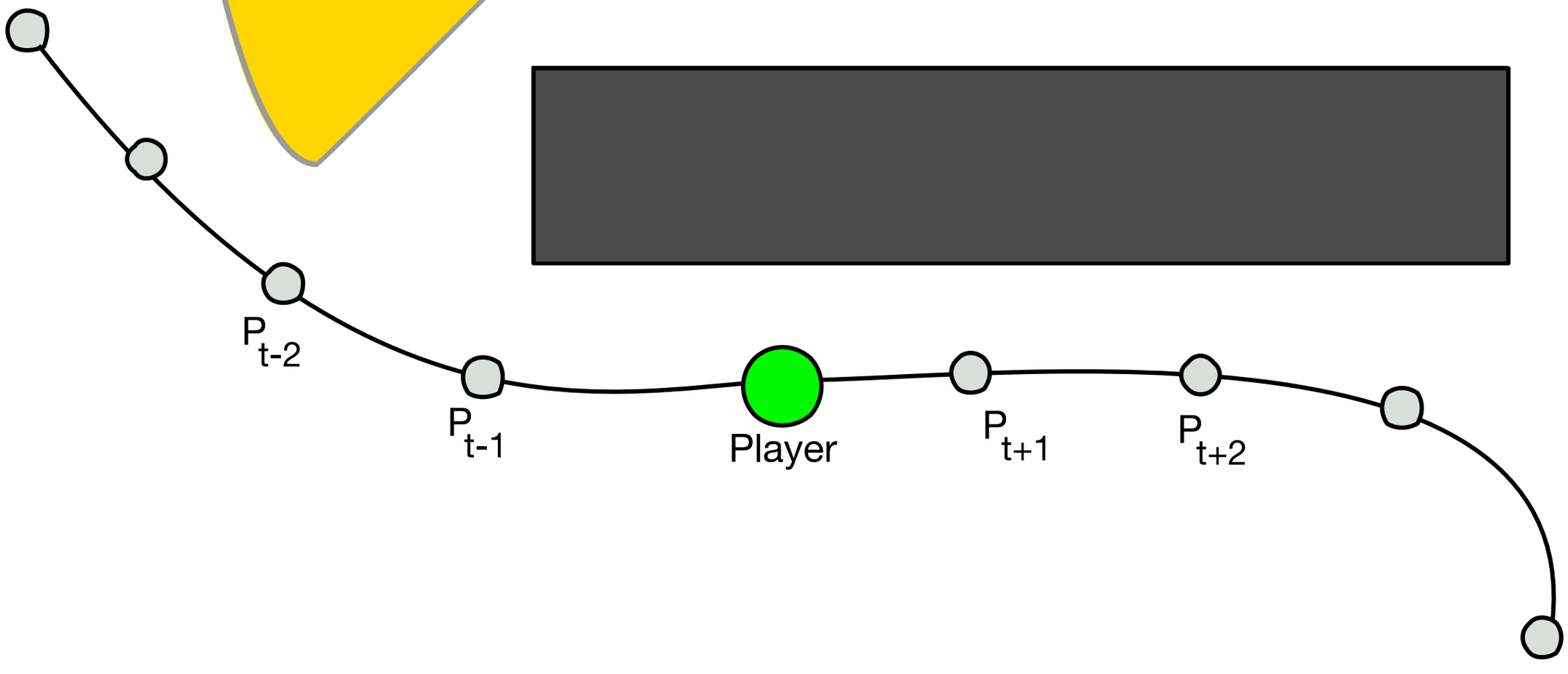
Line of sight cost (LOS)

Nearly missed (NM)

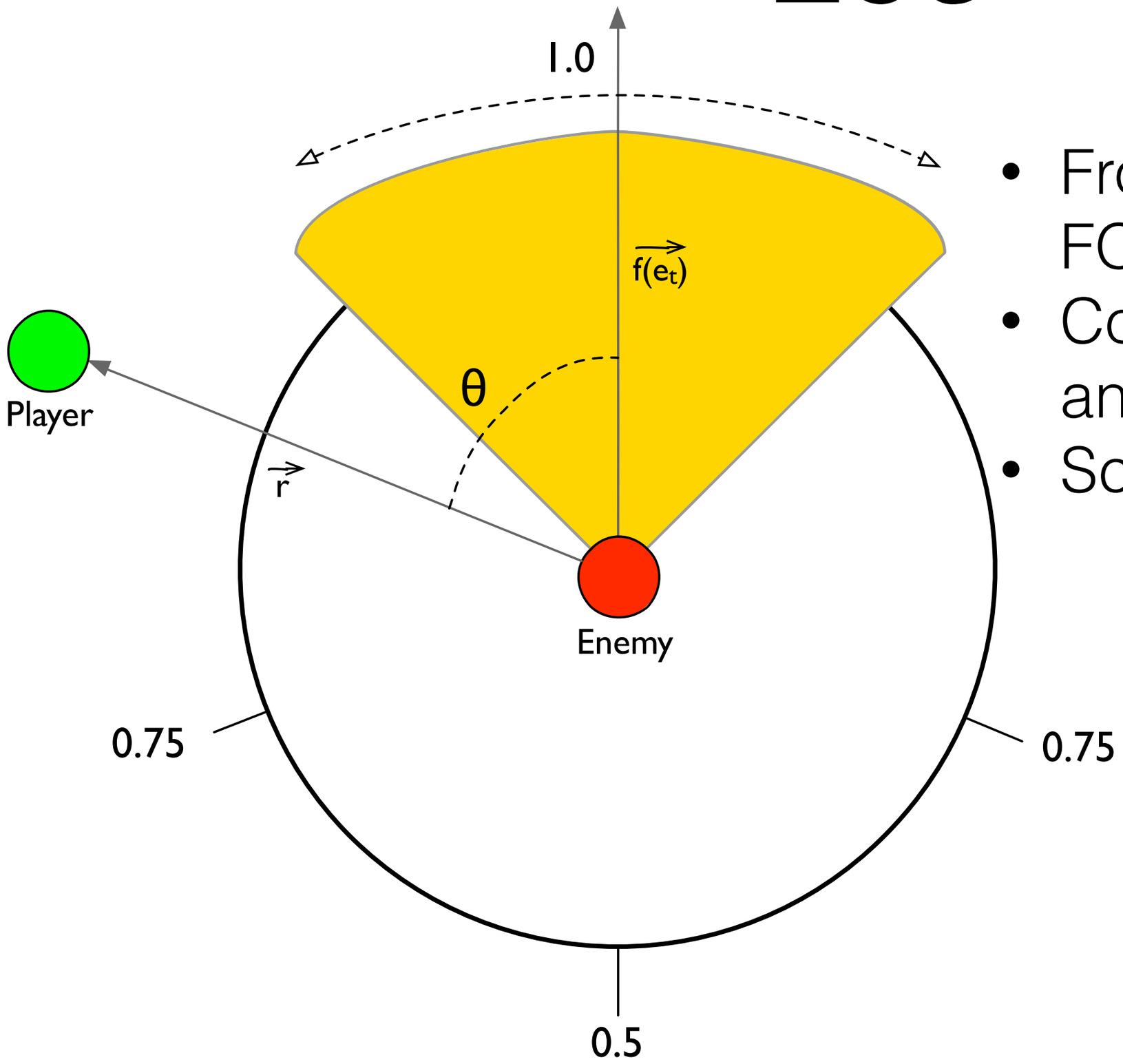
Distance (Dist)



- Scaled distance from player to enemy
- Summed over enemies
- Divided by length path

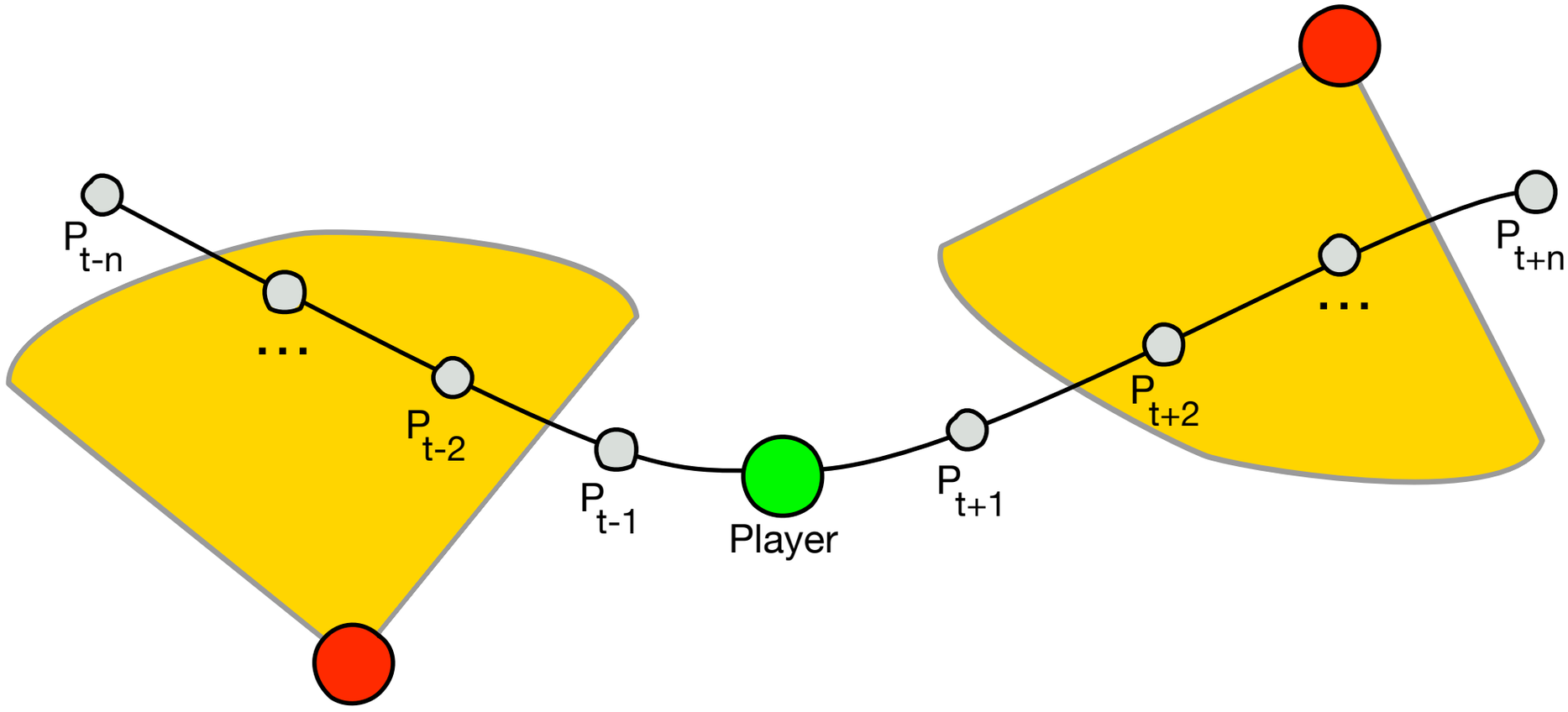


Los



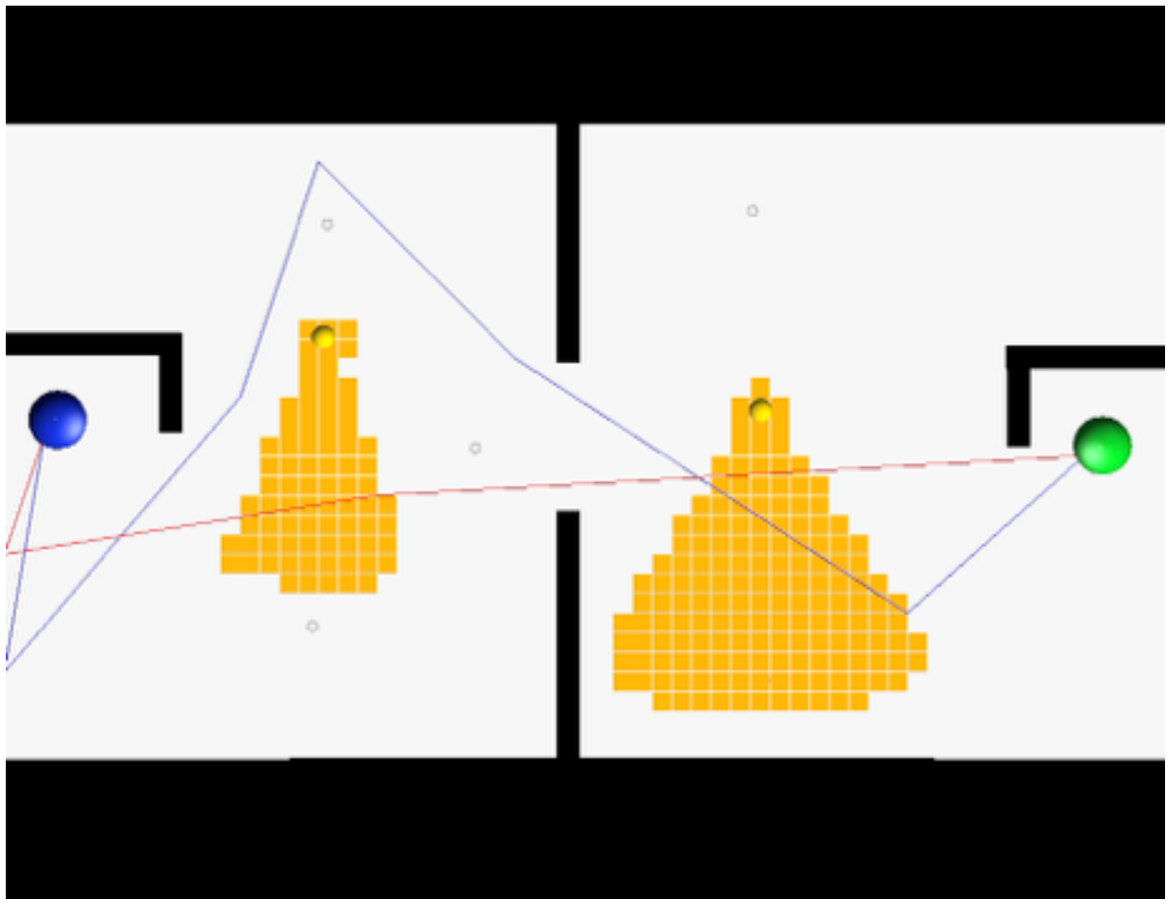
- From player to enemy's FOV.
- Cost function based on angle
- Scale to the distance

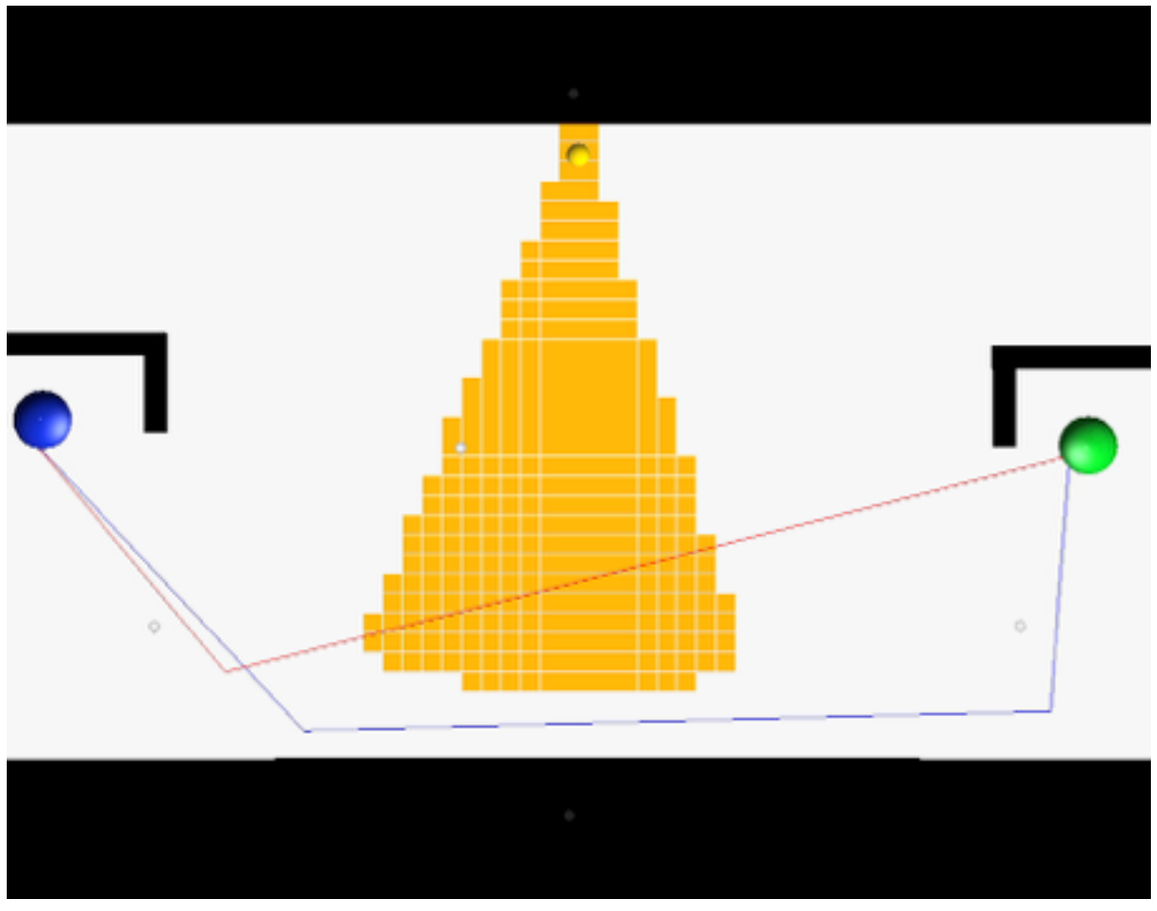
Nearly Missed



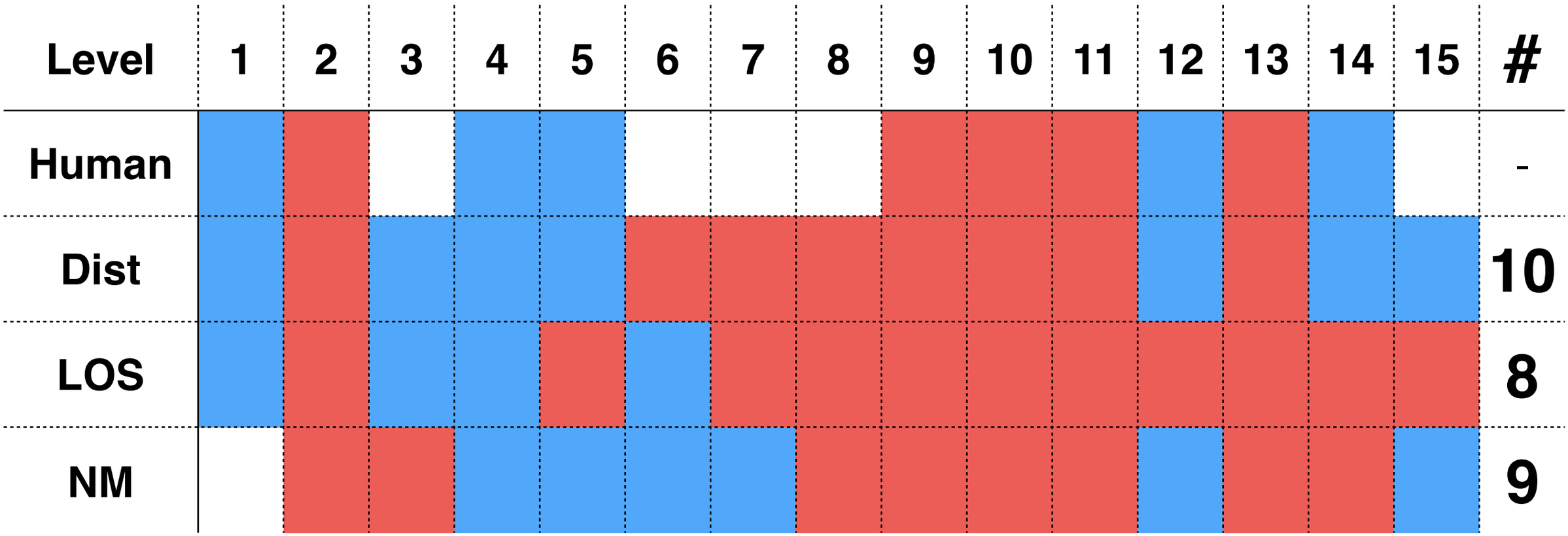
- Check the past and future positions
- Cost if seen based on time

Human study

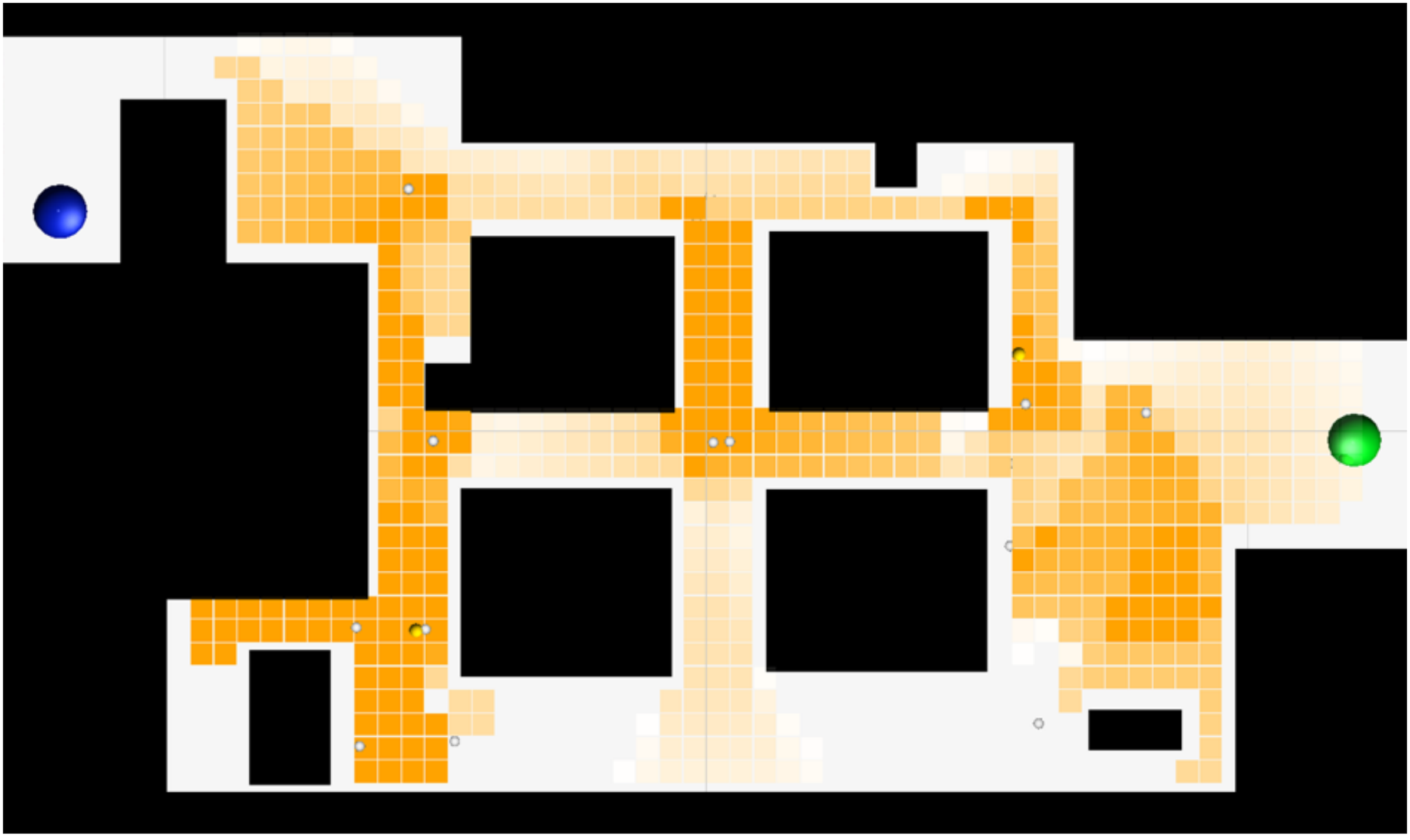




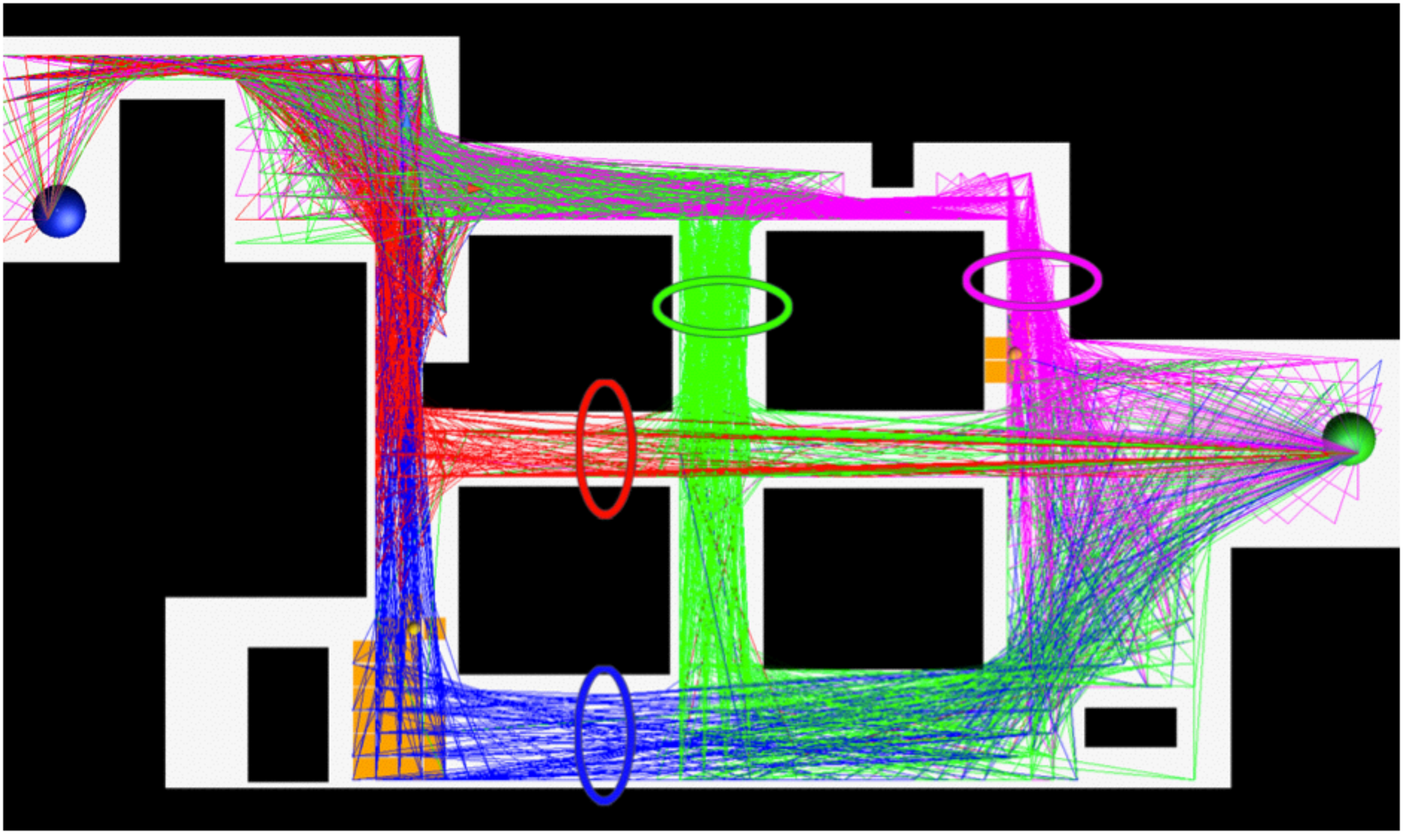
Results



Evaluating level difficulty



Evaluating level difficulty



Evaluating level difficulty

Metrics	Red		Blue		Green		Magenta	
	Avg	Med	Avg	Med	Avg	Med	Avg	Med
Dist ($\times 10^{-3}$)	0.6	0.2	3.7	0.9	1.8	1.0	0.2	0.9
LOS ($\times 10^{-2}$)	0.7	0.02	13.8	0.4	1.6	0.01	4.7	0.3
NM ($\times 10^{5}$)	2.0	1.6	2.8	2.4	2.5	1.9	1.9	0.7

Metrics

- Quantitative metrics to measure player's experience
- Metrics correlate with human perception of *risk*
- Help understand level design

So Far

- Companion makes better target choices
- Offline stealth path finding
- Understanding notions of stealth risk

Still to come

- Guard interactions planning

- Online stealth path finding for companion

Not presented

- Combat/stealth simulator
- Player simulator in the platformer domain
- Clustering similar paths
- Advance visualization of stealth space
- Automatically placing guards in a level

Special thanks

- Clark Verbrugge
- Pedro Andrade Torres
- Qihan Xu
- Christopher Dragert
- Nir Ricovitch
- Eugène Jancorda-Vadnais
- Alexander Borodovski
- Jonathan Campbell

References

- T. Furtak and M. Buro. On the complexity of two-player attrition games played on graphs. In AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, 2010.

- Randy Smith. Level Building for Stealth Gameplay. Online resource, 2009. www.roningamedeveloper.com/Materials.html

Thank you

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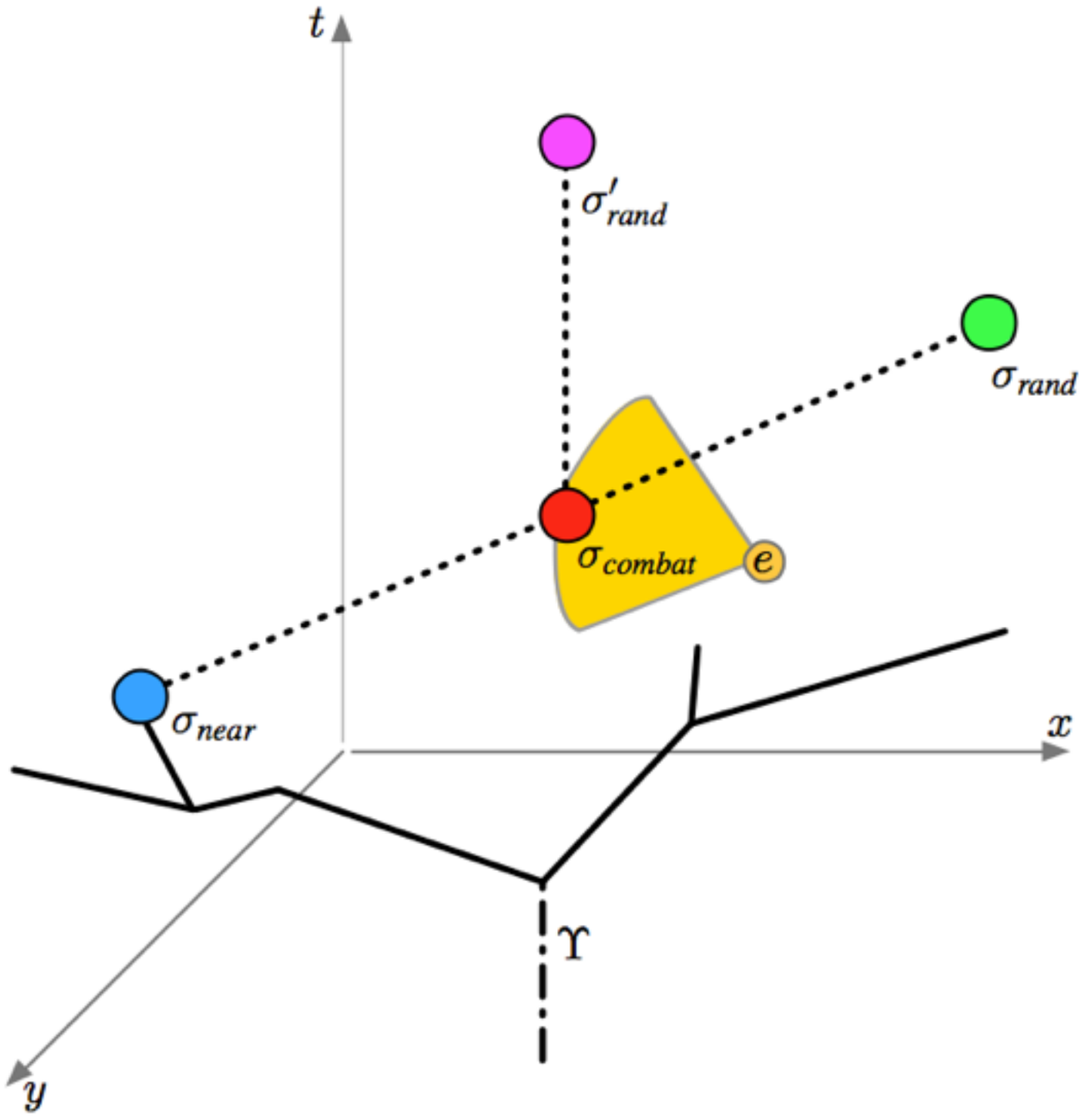
Adding combat



Threat ordering

$$\max_{e \in E} \left[e.a \cdot (E_h - e_h) \right]$$

Distance

$$\mathrm{Dist}(p) = \sum_{t=1}^{\mathrm{T}} \left[\sum_{e \in \mathrm{E}} \frac{1}{d^*(g(p,t), g(e,t))^3} \right]$$

Los

$$\mathrm{LOS}(p) = \frac{\sum_{t=1}^{\mathrm{T}} \left[\sum_{e \in \mathbf{E}} \frac{\mathrm{Cost}(\theta(g(p,t),g(e,t)))}{d^*(g(p,t),g(e,t))^3} \mathrm{Vis}(p,e,t) \right]}{L}$$

Nearly Missed

$$\text{Seen}(\alpha, \tau) = \begin{cases} 1 & \text{if } (\alpha_x, \alpha_y, \tau) \in \chi_{FOV} \\ 0 & \text{otherwise} \end{cases}$$

$$W^{-}(t, n) = \sum_{i=1}^{n} (n-i)^2 \cdot \text{Seen}\left(g(p, t-i), t\right)$$

$$W^{+}(t, m) = \sum_{i=1}^{m} (m-i)^2 \cdot \text{Seen}\left(g(p, t+i), t\right)$$

$$\text{NM}(\text{Path}) = \sum_{t=1}^{\text{T}} \left(W^{-}(t, n) + W^{+}(t, m)\right)$$