COMP250: Artificial Intelligence

3: Game Theory and Planning

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Game theory

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- Important applications in economics, ecology and social sciences as well as AI

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- If **both betray each other**, both get an F

Payoff matrix

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	A silent	A betray
B silent	A: 50 B: 50	A: 70 B: -100
B betray	A: -100 B: 70	A: 0 B: 0

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... and Bob's thought process is the same!

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- If all players are **rational** (in the sense of wanting to maximising payoff), they should converge upon a Nash equilibrium

Does every game have a Nash equilibrium?

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	A rock	A paper	A scissors
B rock	A: 0 B: 0	A: +1 B: -1	A: -1 B: +1
B paper	A: -1 B: +1	A: 0 B: 0	A: +1 B: -1
B scissors	A: +1 B: -1	A: -1 B: +1	A: 0 B: 0

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  - If I choose paper, you'll choose scissors, so I should choose rock, but then you'll choose paper, so I'll choose scissors, so you'll choose rock, so I choose paper...

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- The optimum strategy is to be **unpredictable**
- Choose rock with probability $\frac{1}{3}$, paper with probability $\frac{1}{3}$, scissors with probability $\frac{1}{3}$

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- If we allow mixed strategies, **every game has at least one Nash equilibrium**

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- Example:
  - If the guesses are 30, 40 and 80...
  - ... then the mean is $\frac{30+40+80}{3} = 50$...
  - ... so the winning guess is 30, as this is closest to $\frac{2}{3} \times 50 = 33.333$

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- ... and so on ad infinitum

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- ... and so on ad infinitum
- So the only **rational** guess is 0, as every rational player should guess 0 and $\frac{2}{3}$ of 0 is 0

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- However it's important to remember that **humans aren't always rational**
- E.g. in guess $\frac{2}{3}$, if enough players deviate from the rational guess of 0, then 0 is no longer the best guess!

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- Problem: find a sequence of actions that leads to the goal

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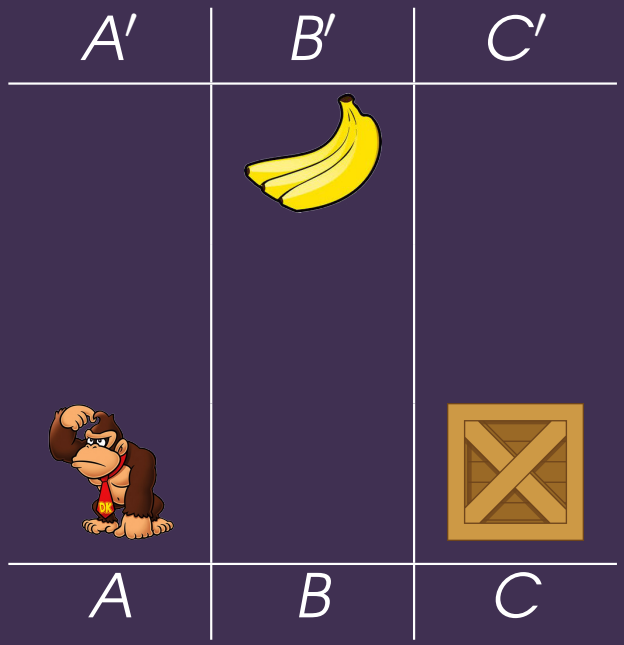
    - Postconditions (specifying what predicates are made true or false by this action)

STRIPS example



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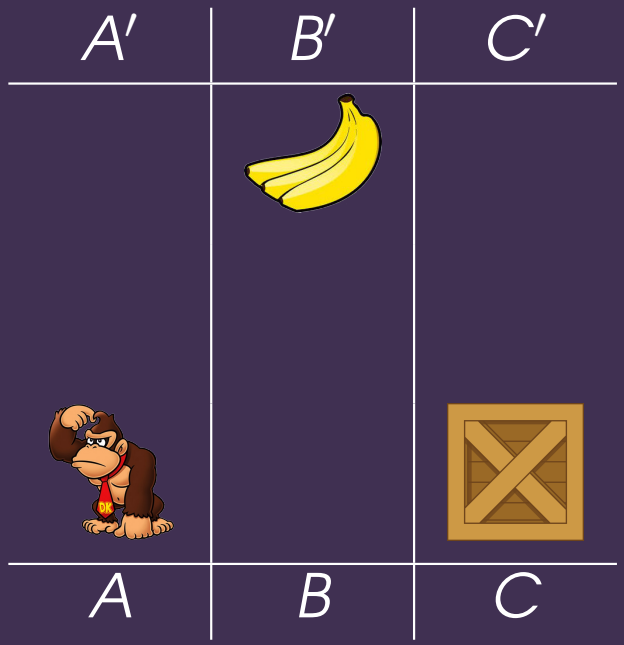
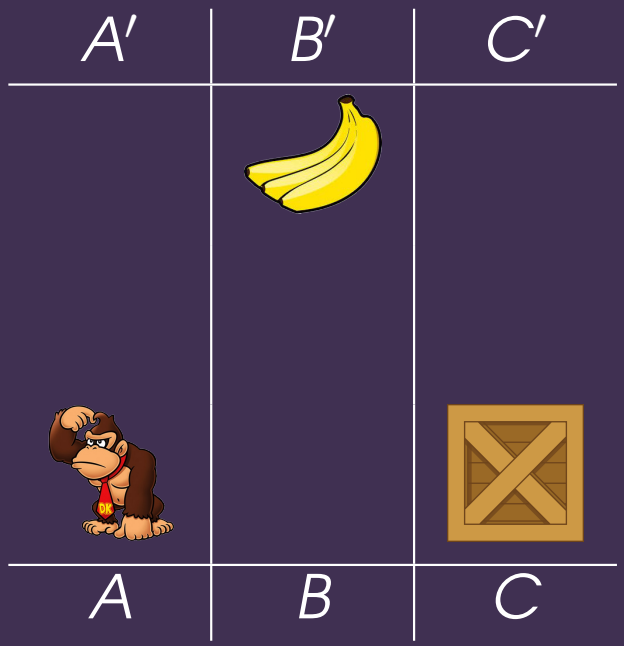


Initial state:

```
At(A),
BoxAt(C),
BananasAt(B')
```

STRIPS example



Initial state:

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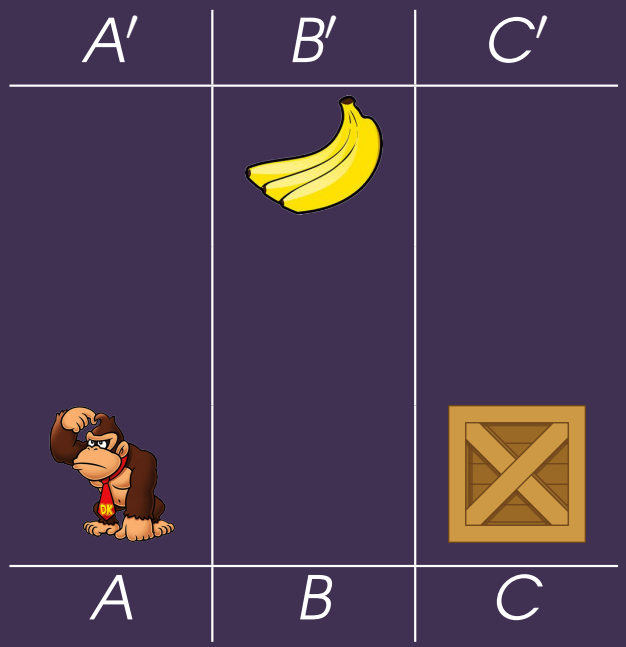
```

Goal:

```
HasBananas
```

STRIPS example — Actions




```
Move(x, y)
  Pre:  At(x)
  Post: !At(x), At(y)

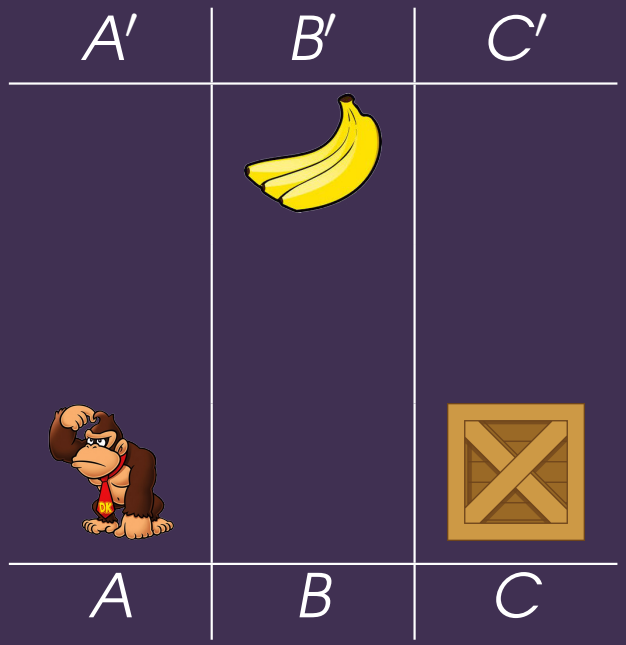
ClimbUp(x)
  Pre:  At(x), BoxAt(x)
  Post: !At(x), At(x')

ClimbDown(x')
  Pre:  At(x'), BoxAt(x)
  Post: !At(x'), At(x)

PushBox(x, y)
  Pre:  At(x), BoxAt(x)
  Post: !At(x), At(y),
        !BoxAt(x), BoxAt(y)

TakeBananas(x)
  Pre:  At(x), BananasAt(x)
  Post: !BananasAt(x), HasBananas
```

STRIPS example — Solution



State:

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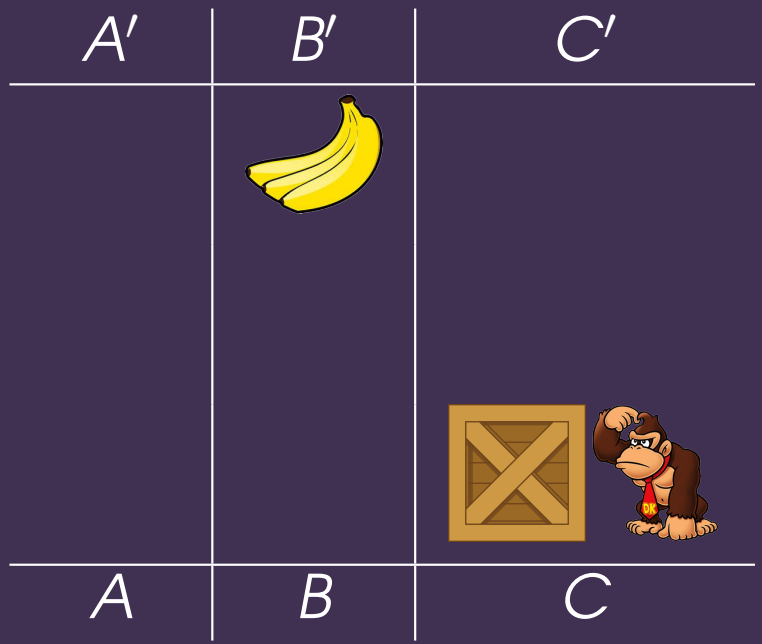


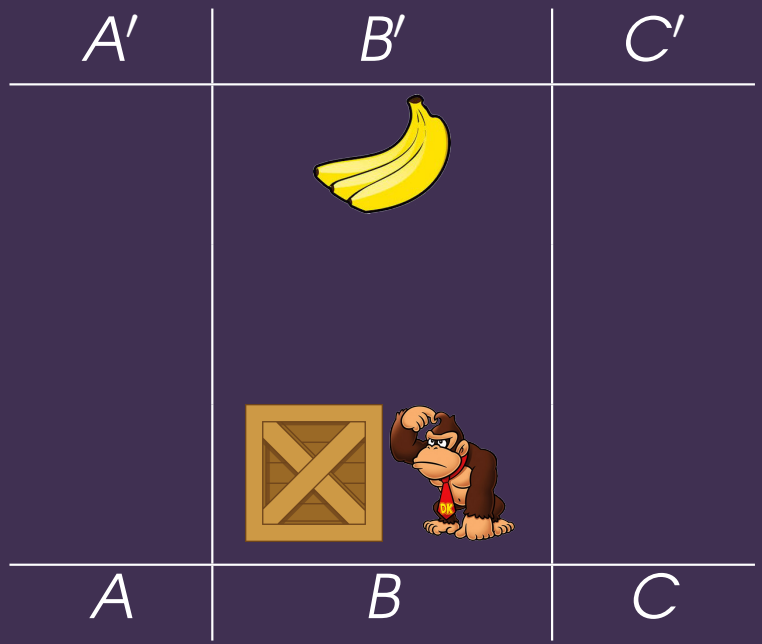
Action:

```
Move(A, C)
```

State:

```
At(C),
BoxAt(C),
BananasAt(B')
```

STRIPS example — Solution



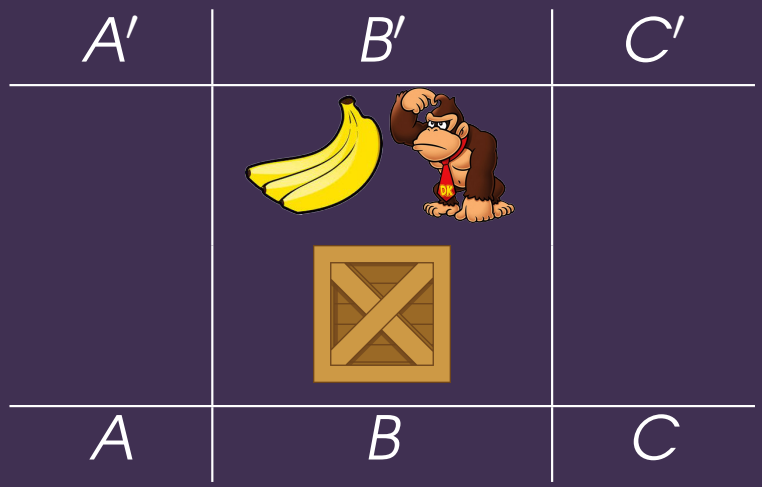
Action:

```
PushBox(C, B)
```

State:

```
At(B),
BoxAt(B),
BananasAt(B')
```

STRIPS example — Solution



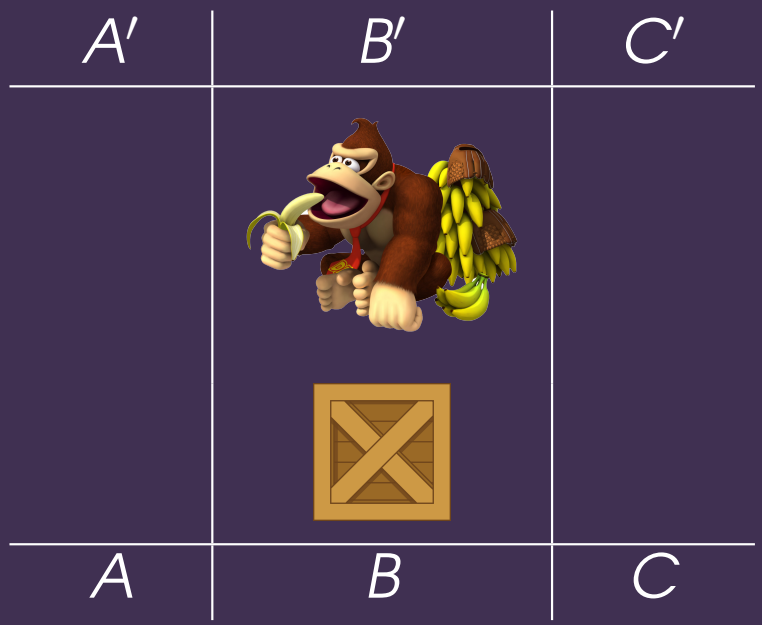
Action:

```
ClimbUp(B)
```

State:

```
At(B′),
BoxAt(B),
BananasAt(B′)
```

STRIPS example — Solution



Action:

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TakeBananas(B')
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- We can construct a **state-action graph**
  - Nodes: environment states
  - Edges: actions
- We can then **search** this graph to find the optimum path from the current state to a goal state

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  - A* (if we have a suitable **heuristic**)

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- A modified version of STRIPS specifically for real-time planning in video games

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  - Multiple goals with differing **priority**
  - Goals are like in STRIPS — sets of predicates that the agent wants to satisfy
- Each agent also has a set of **actions**
  - Like in STRIPS — actions have preconditions and postconditions
  - Unlike STRIPS, each action also has a **cost**

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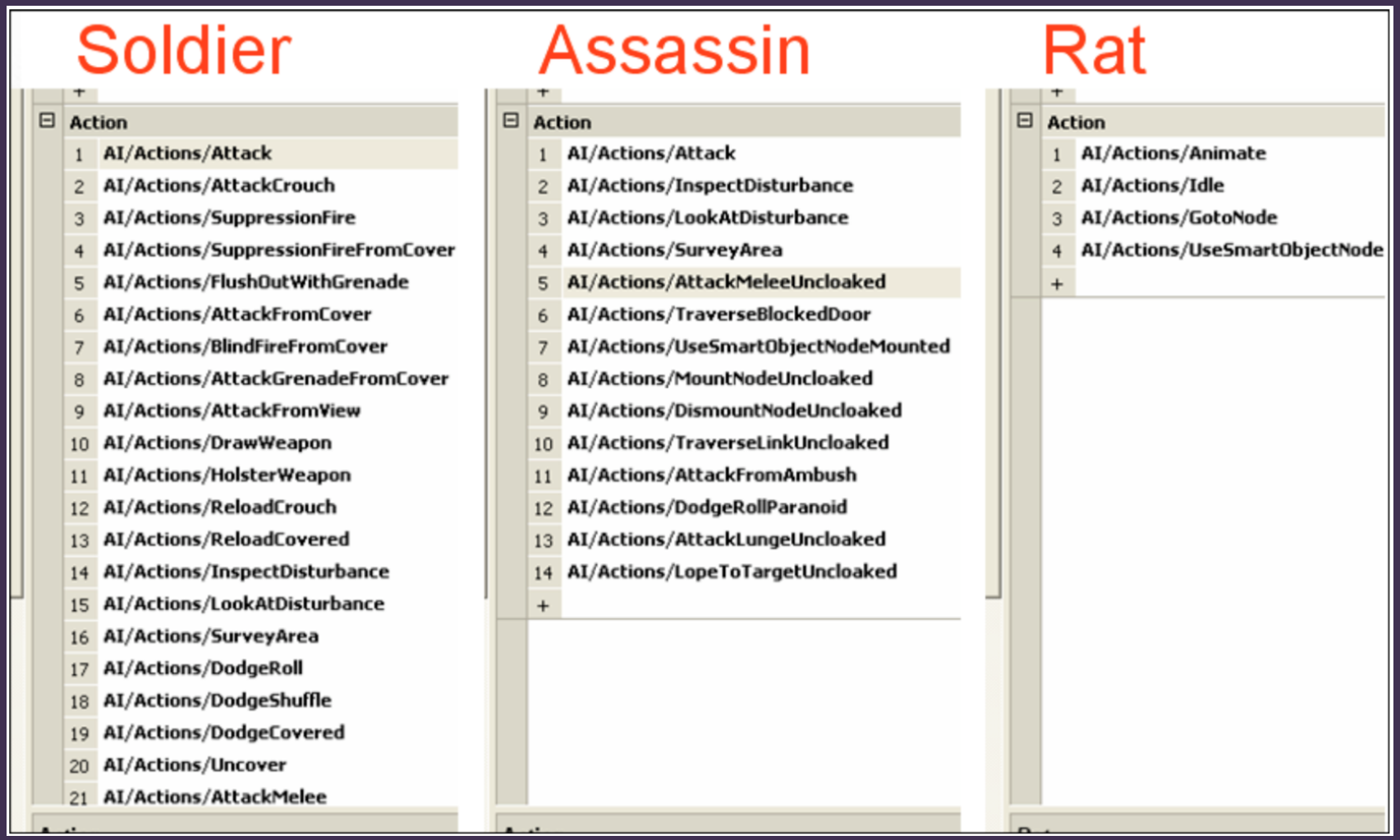
- This will result in those agents achieving those goals in **different ways**
- NB this doesn't have to be explicitly coded — it **emerges** from the GOAP system
- E.g. this was used by the F.E.A.R. team to quickly add new enemy types

Action sets


Soldier
Action
1 AI/Actions/Attack
2 AI/Actions/AttackCrouch
3 AI/Actions/SuppressionFire
4 AI/Actions/SuppressionFireFromCover
5 AI/Actions/FlushOutWithGrenade
6 AI/Actions/AttackFromCover
7 AI/Actions/BlindFireFromCover
8 AI/Actions/AttackGrenadeFromCover
9 AI/Actions/AttackFromView
10 AI/Actions/DrawWeapon
11 AI/Actions/HolsterWeapon
12 AI/Actions/ReloadCrouch
13 AI/Actions/ReloadCovered
14 AI/Actions/InspectDisturbance
15 AI/Actions/LookAtDisturbance
16 AI/Actions/SurveyArea
17 AI/Actions/DodgeRoll
18 AI/Actions/DodgeShuffle
19 AI/Actions/DodgeCovered
20 AI/Actions/Uncover
21 AI/Actions/AttackMelee
Assassin
Action
1 AI/Actions/Attack
2 AI/Actions/InspectDisturbance
3 AI/Actions/LookAtDisturbance
4 AI/Actions/SurveyArea
5 AI/Actions/AttackMeleeUncloaked
6 AI/Actions/TraverseBlockedDoor
7 AI/Actions/UseSmartObjectNodeMounted
8 AI/Actions/MountNodeUncloaked
9 AI/Actions/DismountNodeUncloaked
10 AI/Actions/TraverseLinkUncloaked
11 AI/Actions/AttackFromAmbush
12 AI/Actions/DodgeRollParanoid
13 AI/Actions/AttackLungeUncloaked
14 AI/Actions/LopeToTargetUncloaked
Rat
Action
1 AI/Actions/Animate
2 AI/Actions/Idle
3 AI/Actions/GotoNode
4 AI/Actions/UseSmartObjectNode

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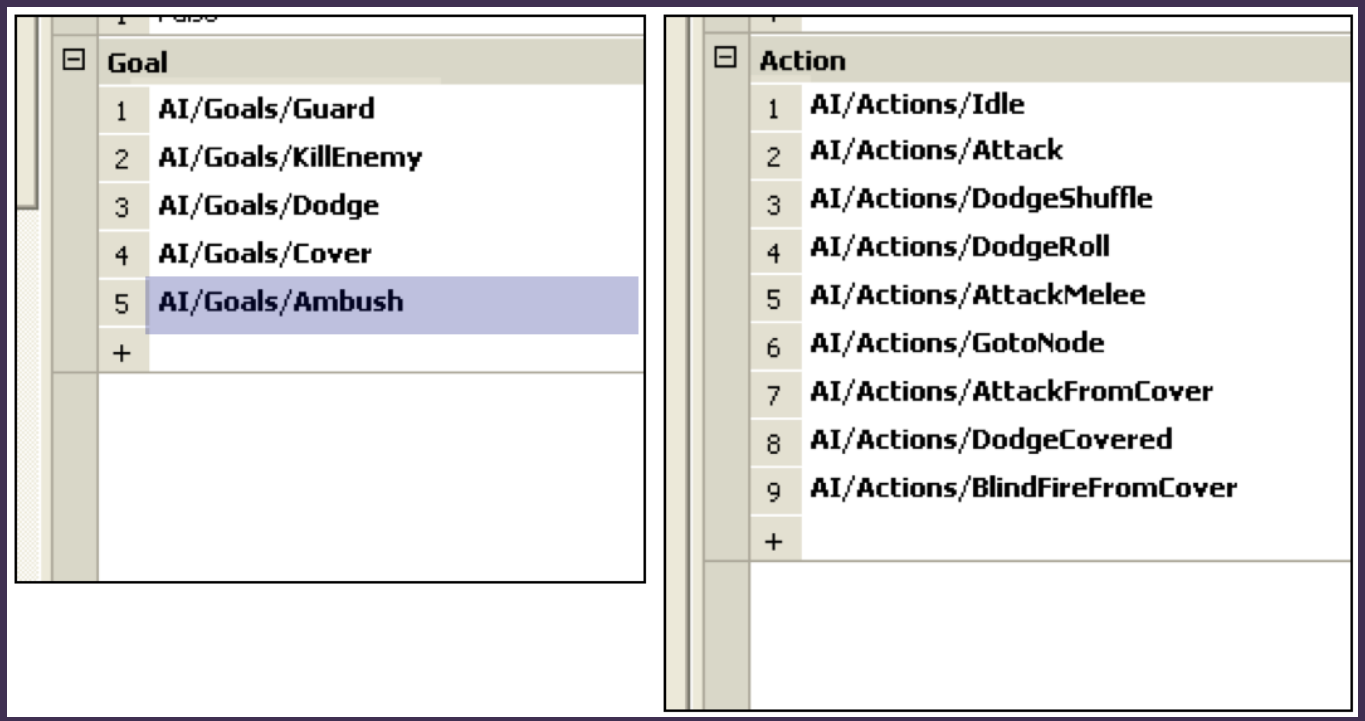
- E.g. enemy AI in F.E.A.R.:



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- Most implementations also allow for **programmatic** preconditions (e.g. calling the pathfinding system to check availability of a path)

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- If the plan is interrupted or fails then the agent can **replan**

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- GOAP can be classified as **computational intelligence**