UIT2504 Artificial Intelligence

Search and Non-determinism

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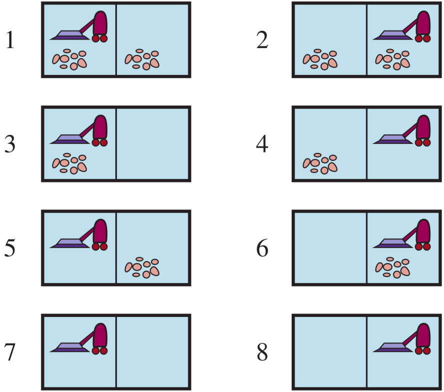
- So, the agent is in one belief state and by performing an action moves to another belief state

Vacuum World Revisited



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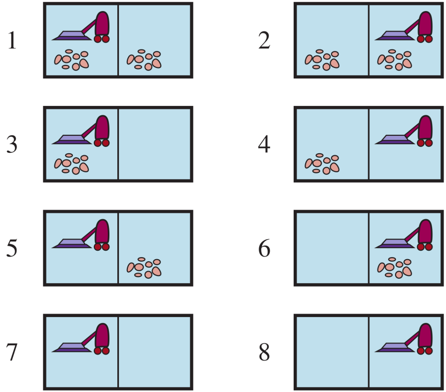

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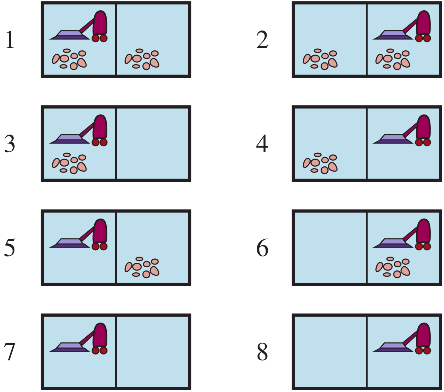
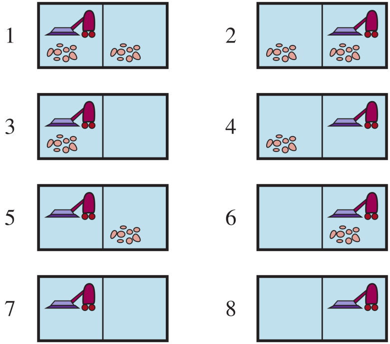


- Consider three possible actions — *Right*, *Left*, and *Suck*
- If the environment is simple, and the initial state is 1, then any search technique can be used to find a goal state (7 or 8) — [*Suck*, *Right*, *Suck*]

Erratic Vacuum World



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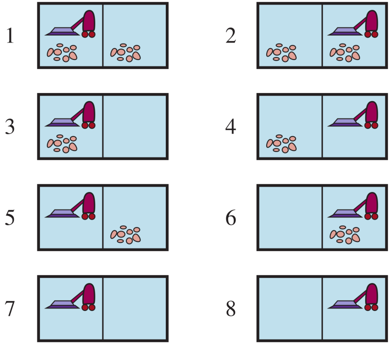

- Suppose, we introduce nondeterminism through erratic behavior of the *Suck* action:
  - When applied to a dirty square the action cleans the square and sometimes cleans up dirt in the adjacent square too
  - When applied to a clean square the action sometimes deposits dirt on the carpet

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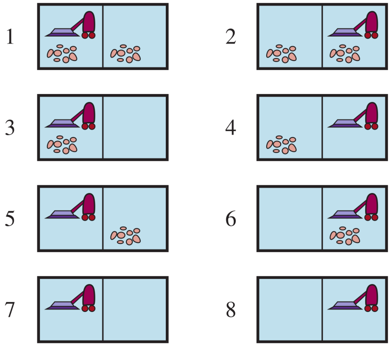

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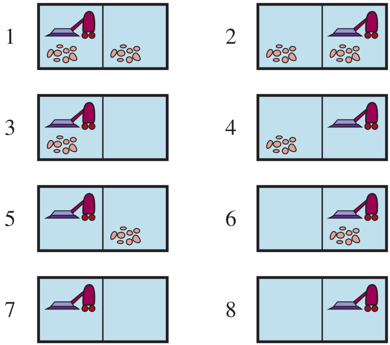

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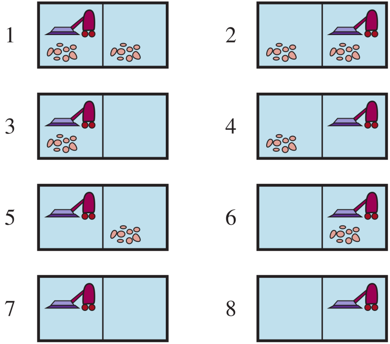

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- $RESULTS(1, Suck) = \{5, 7\}$

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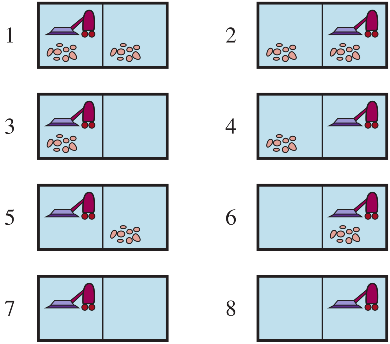

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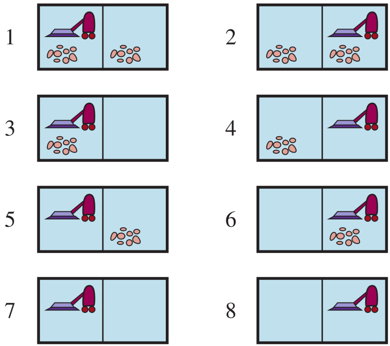

- Suppose, we start from state 1, what may be a solution? Is it a sequence of action?

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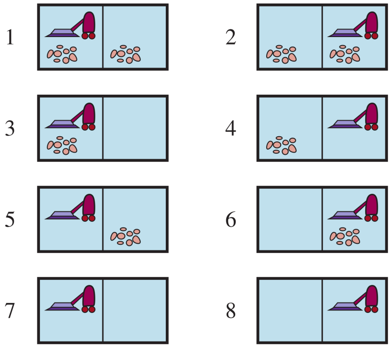
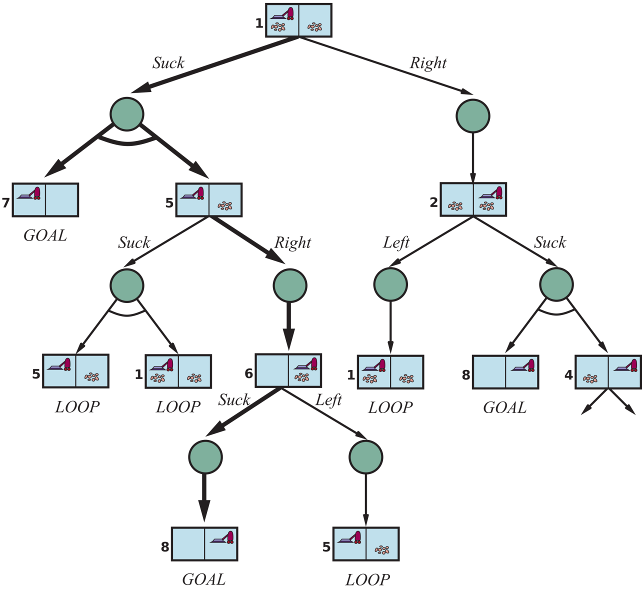


- Suppose, we start from state 1, what may be a solution? Is it a sequence of action?
- The solution now is a tree! It is called as a condition plan (also known as a contingency plan or a strategy)

$$[\mathit{Suck}, \textbf{if } \mathit{State} = 5 \textbf{ then } [\mathit{Right}, \mathit{Suck}] \textbf{ else } []]$$

AND–OR Search Trees



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Solution in a AND–OR Tree

- As we can see, solution is no more a path in the search tree
- Solution is a subtree that
  - has a goal node at each leaf
  - specifies one action at each of its OR nodes
  - includes every outcome branch at each of its AND nodes

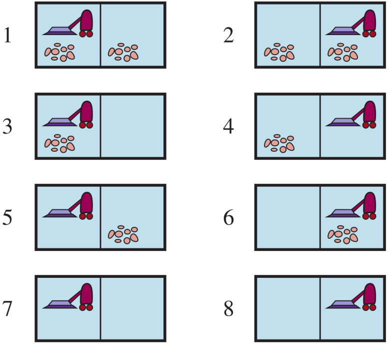
AND–OR Search Algorithm

function AND-OR-SEARCH(*problem*) **returns** a conditional plan, or *failure*
  return OR-SEARCH(*problem*, *problem*.INITIAL, [ ])

function OR-SEARCH(*problem*, *state*, *path*) **returns** *a conditional plan, or failure*
  if *problem*.IS-GOAL(*state*) **then return** the empty plan
  if IS-CYCLE(*path*) **then return** *failure*
  for each *action* **in** *problem*.ACTIONS(*state*) **do**
    plan ← AND-SEARCH(*problem*, RESULTS(*state*, *action*), [*state*] + *path*])
    if *plan* ≠ *failure* **then return** [*action*] + *plan*]
  return *failure*

function AND-SEARCH(*problem*, *states*, *path*) **returns** *a conditional plan, or failure*
  for each s_i **in** *states* **do**
    $plan_i$ ← OR-SEARCH(*problem*, s_i, *path*)
    if $plan_i$ = *failure* **then return** *failure*
  return [**if** s_1 **then** $plan_1$ **else if** s_2 **then** $plan_2$ **else** $\ldots$ **if** s_{n-1} **then** $plan_{n-1}$ **else** $plan_n$]

Slippery Vacuum World



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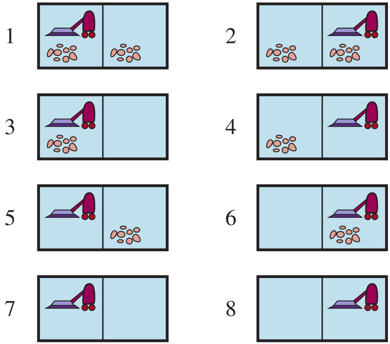

- Consider a different variation of the conventional vacuum world problem — movement actions sometimes fail, leaving the agent in the same location
- This can be captured by appropriately modifying the transition model

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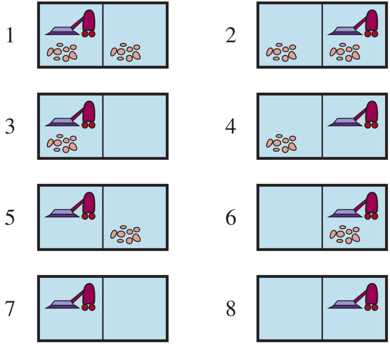

- Consider a different variation of the conventional vacuum world problem — movement actions sometimes fail, leaving the agent in the same location
- This can be captured by appropriately modifying the transition model
- $RESULTS(1, Right) = \{1, 2\}$, $RESULTS(2, Left) = \{1, 2\}$, and so on

Cyclic Plans

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- This idea works if the driving mechanism is just slippery and works otherwise. The plan does not work if the agent can never move right

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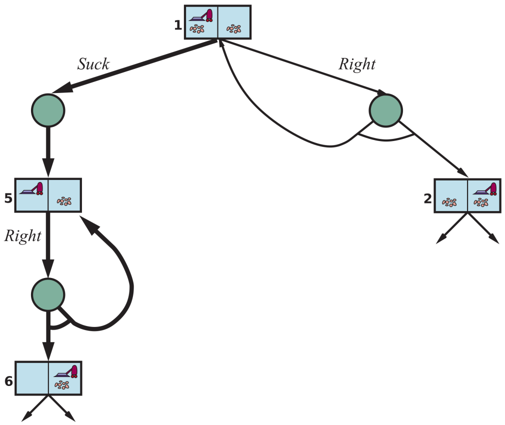

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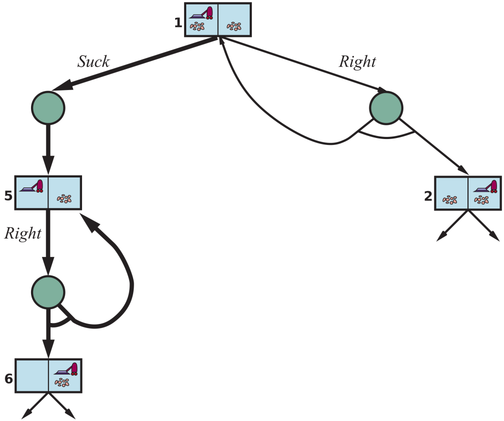

- Solution is a “tree” with possible loops, where every leaf is a goal state and that a leaf is reachable from every point in the plan

Questions?

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- Depending on what has been rolled, a player, say Black, has certain choices of actions but can not think ahead as nobody knows what will be the result of White's dice roll
- The game tree is similar to the AND-OR tree, but basic probability knowledge can be used

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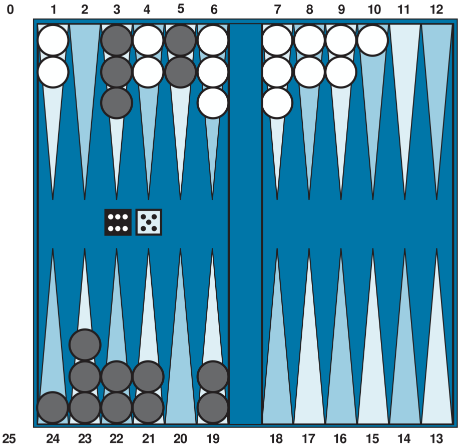

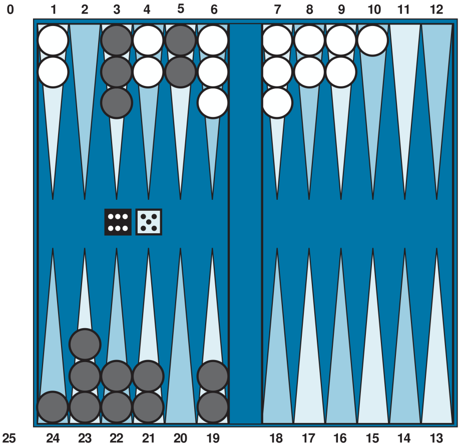

- Black, which moves clockwise from 0 to 25, has four possible moves for this roll of dice (6-5): (5–11, 5–10), (5–11, 19–24), (5–10, 10–16), (5–11, 11–16)

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- We make a weighted sum of utility values of all the children to get the expected utility of a chance node

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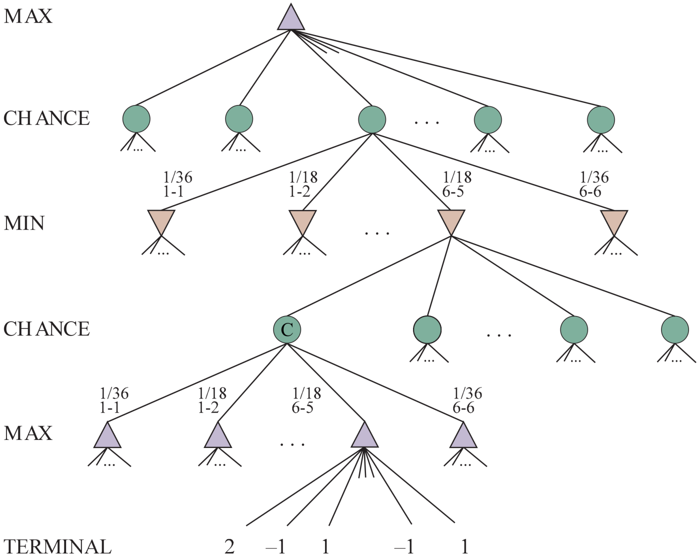

Expectiminimax

- Now, the idea of minimax value for deterministic games can be generalized to the expectiminimax value as follows:

  EXPECTIMINIMAX(s) =

$$\begin{cases} Utility(s, MAX) & \text{if IS\_TERMINAL}(s) \\ max_a EMINIMAX(RESULT(s, a)) & \text{if TO\_MOVE}(s) = \text{MAX} \\ min_a EMINIMAX(RESULT(s, a)) & \text{if TO\_MOVE}(s) = \text{MIN} \\ \Sigma_r P(r) EMINIMAX(RESULT(s, r)) & \text{if TO\_MOVE}(s) = \text{CHANCE} \end{cases}$$

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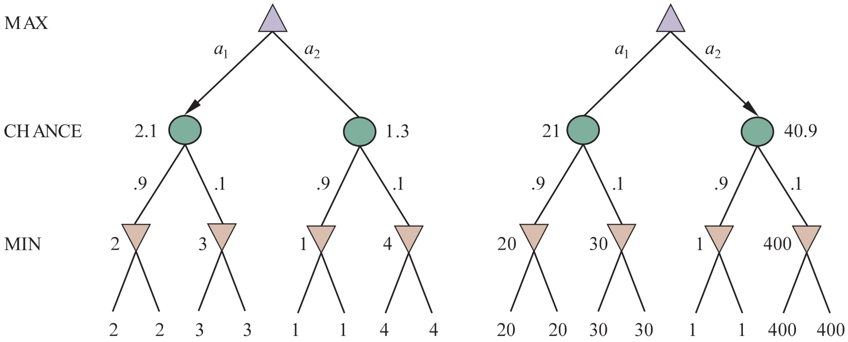

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- Consider a game where 5 dices are rolled! The branching factor is too high. A Type B strategy of forward pruning may be applied
- Monte Carlo Tree Search is definitely possible as we can always take a random outcome for a dice roll!

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