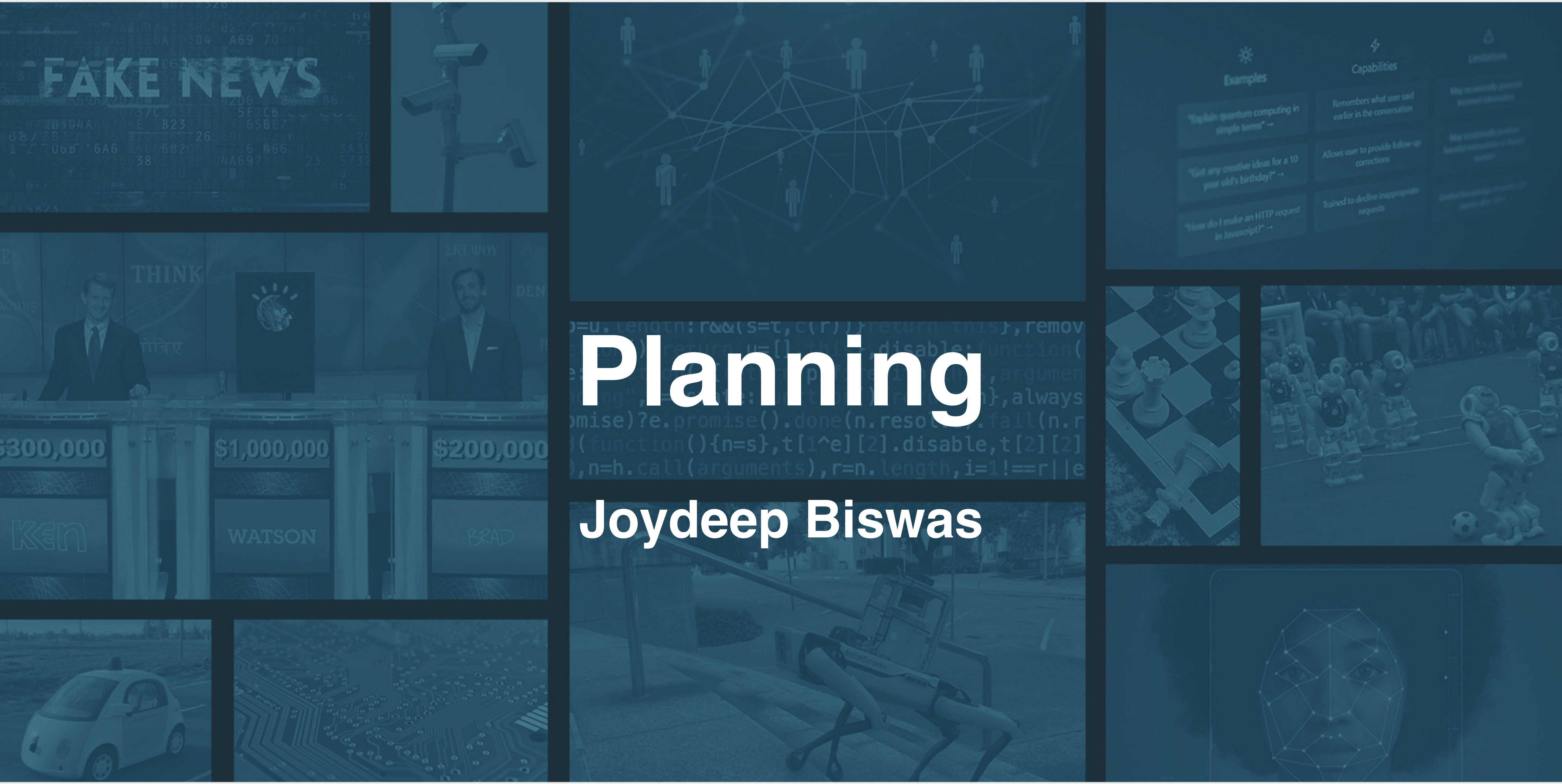


Planning

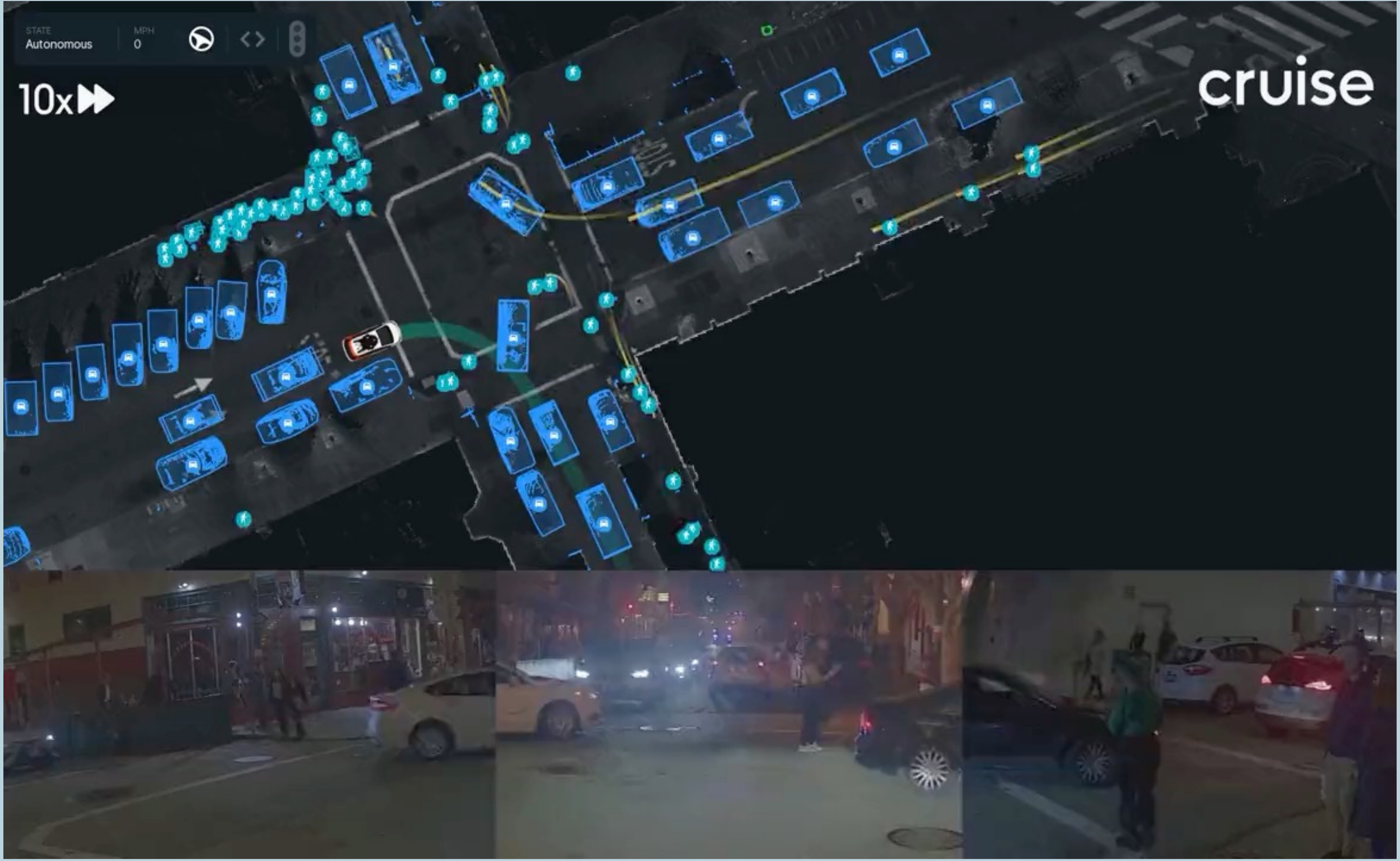
Joydeep Biswas

Liberal Arts development studio LAITS

TEXAS

What’s common between…

Friends, S5E16, “The One with the Cop”



“Twin Peaks”, North Beach on St. Patrick’s day
https://twitter.com/kvogt/status/1641123102858919953

FAKE NEWS
THINK
$300,000
$1,000,000
$200,000
WATSON
Examples
Capabilities

Planning!

The Planning Problem

Given:

1. An ***initial state*** of the world
2. A set of ***available actions***, their requirements, and their effects
3. A ***goal state***
4. [Optionally] ***Costs*** associated with each action

Compute:

A ***valid sequence of actions*** (the ***plan***) that starts from the initial state and terminates at the goal state [with fewest actions / minimum cost]

A Toy Planning Domain: Blocks World

Objects in the world:

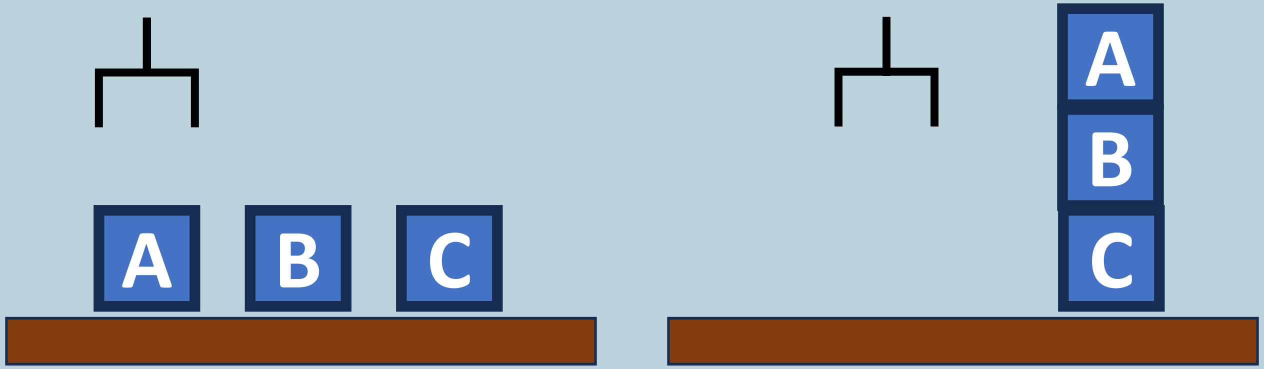
- Blocks A, B, C
- Table
- Robot gripper

Actions:

- Pick up a block (if gripper empty)
- Put down a block (when holding one)
    - On another block
    - On the table

Assumptions:

- No errors in picking / placing blocks
- Table has ample space for all blocks
- Horizontal positions are irrelevant



The Planning Problem *Applied To Blocks World*

Given:

1. An ***initial state*** of the world ***=> The initial state of the blocks***
2. A set of ***available actions***, their requirements, and their effects ***=> pick(block), place(block, location)***
3. A ***goal state*** ***=> Final state of blocks***

Compute:

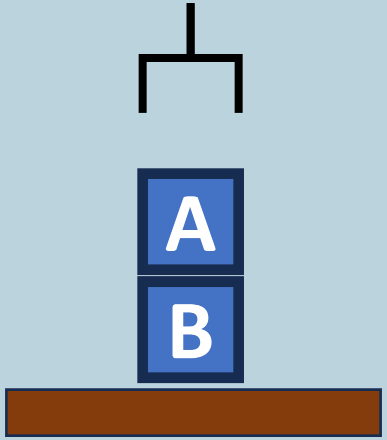
A ***valid sequence of actions*** that starts from the initial state and terminates at the goal state with fewest actions ***=> Plan = sequence of pick(.), place(.)…***

Planning Via Search

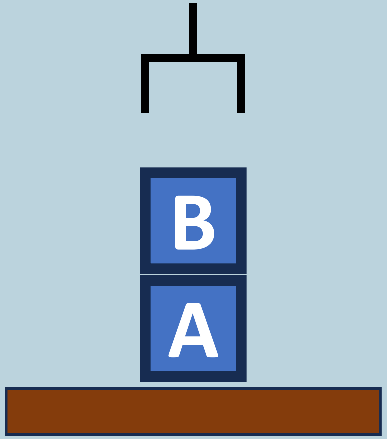
Starting from initial state:

1. Enumerate all possible actions available, and the resulting states
2. Check if goal state reached
3. If not, for every possible outcome, repeat step 1 for all new states

Planning In Blocks World By Search

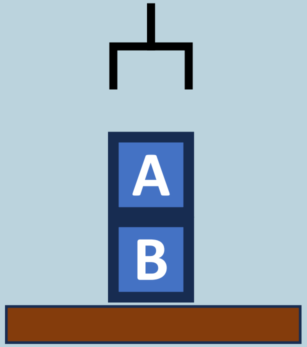


Initial State

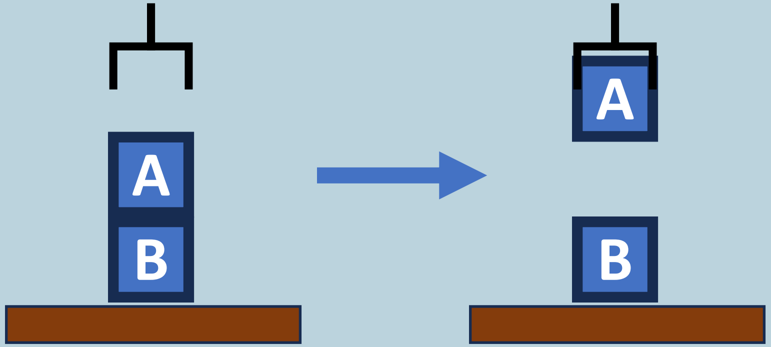


Goal State

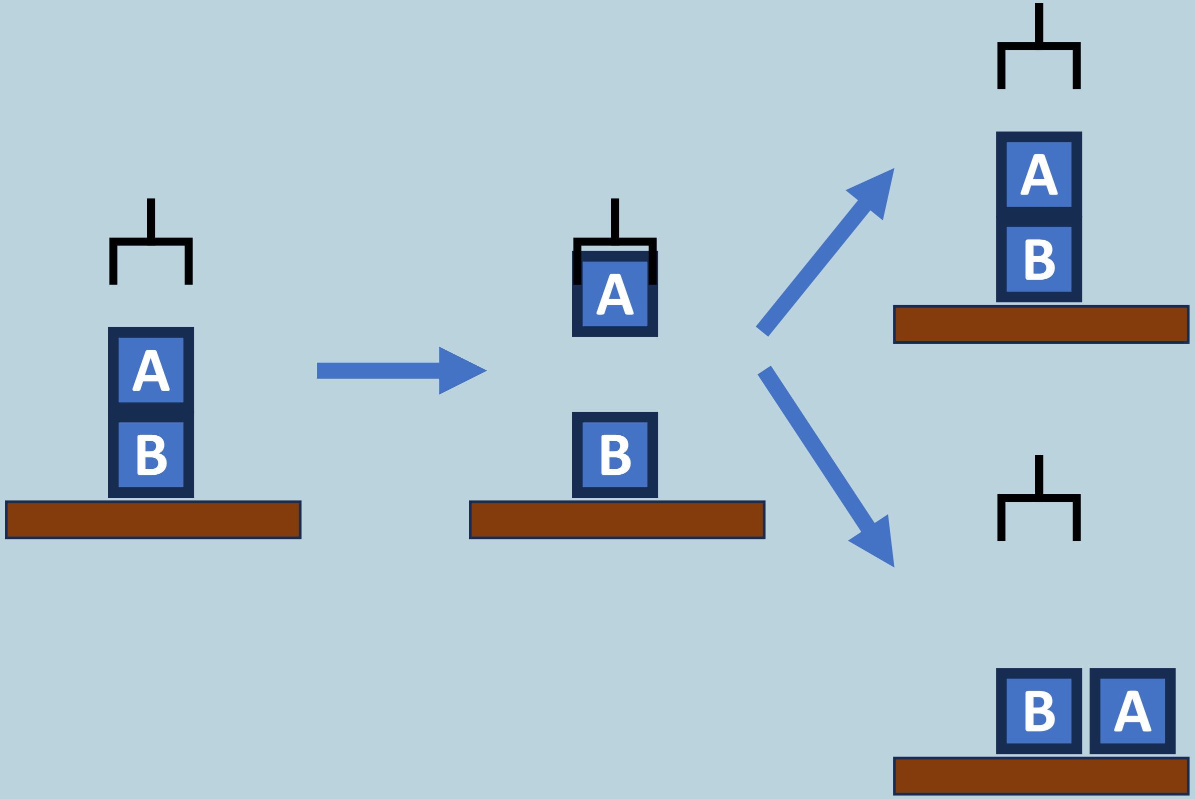
Planning In Blocks World By Search



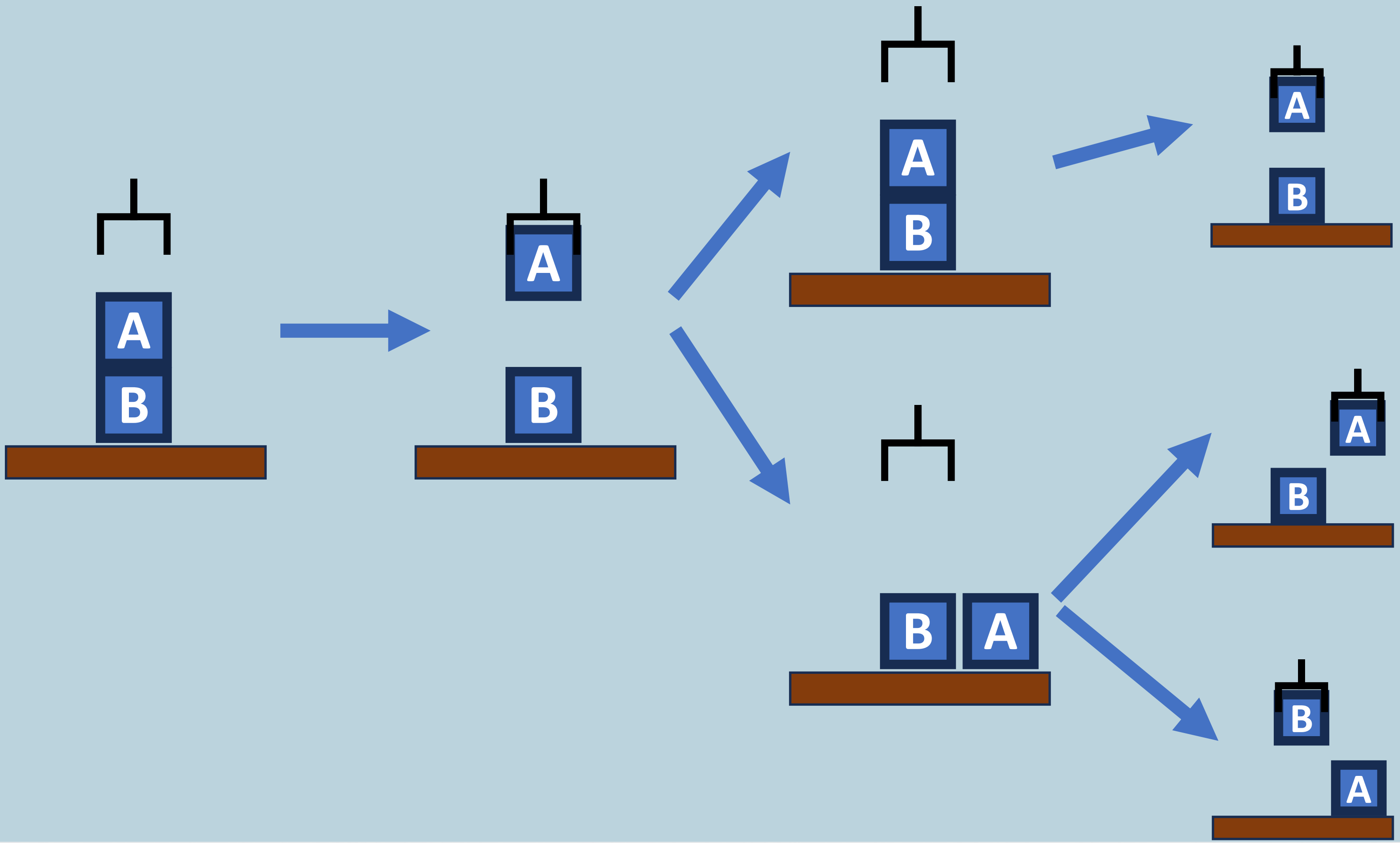
Planning In Blocks World By Search



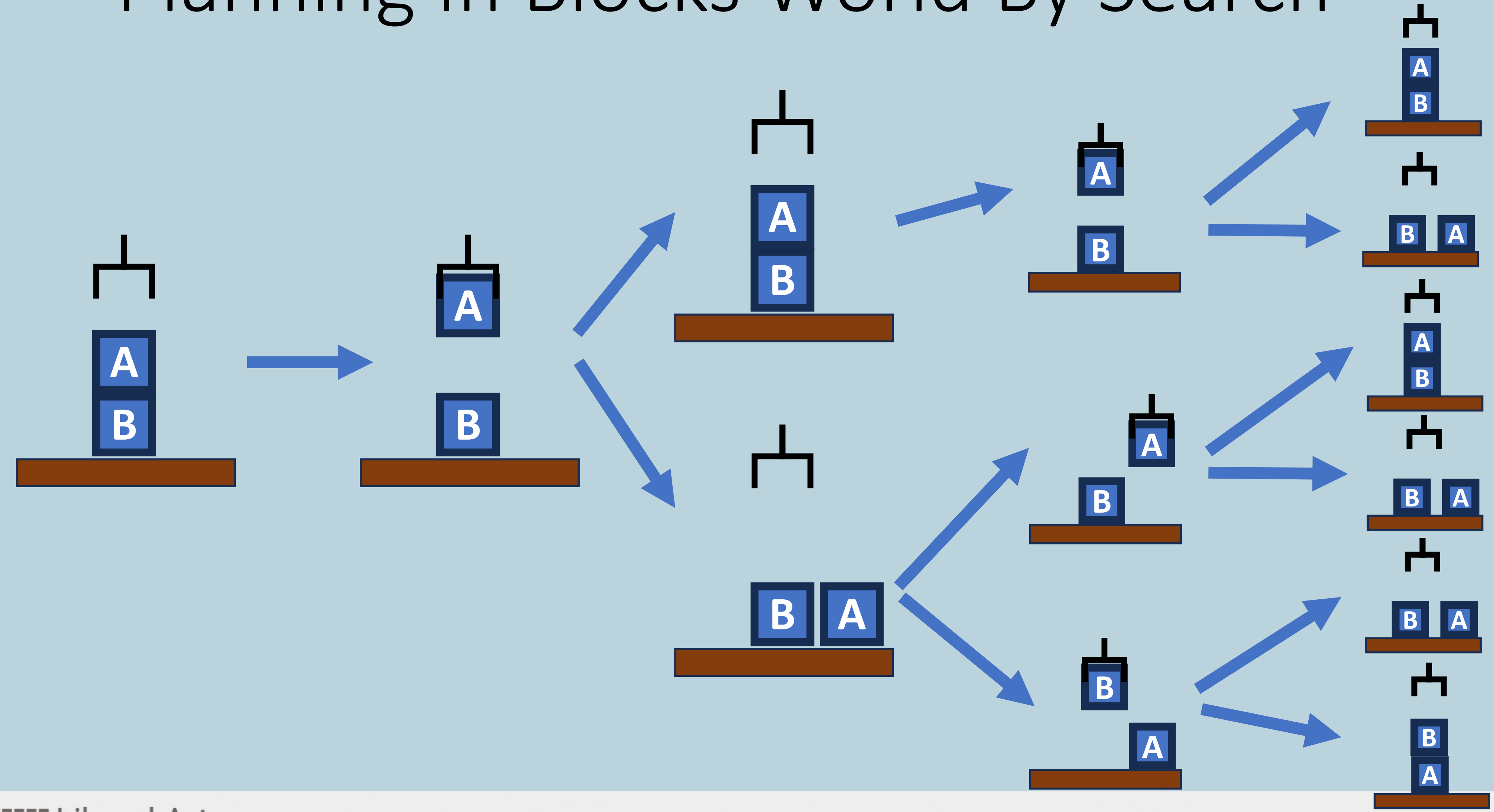
Planning In Blocks World By Search



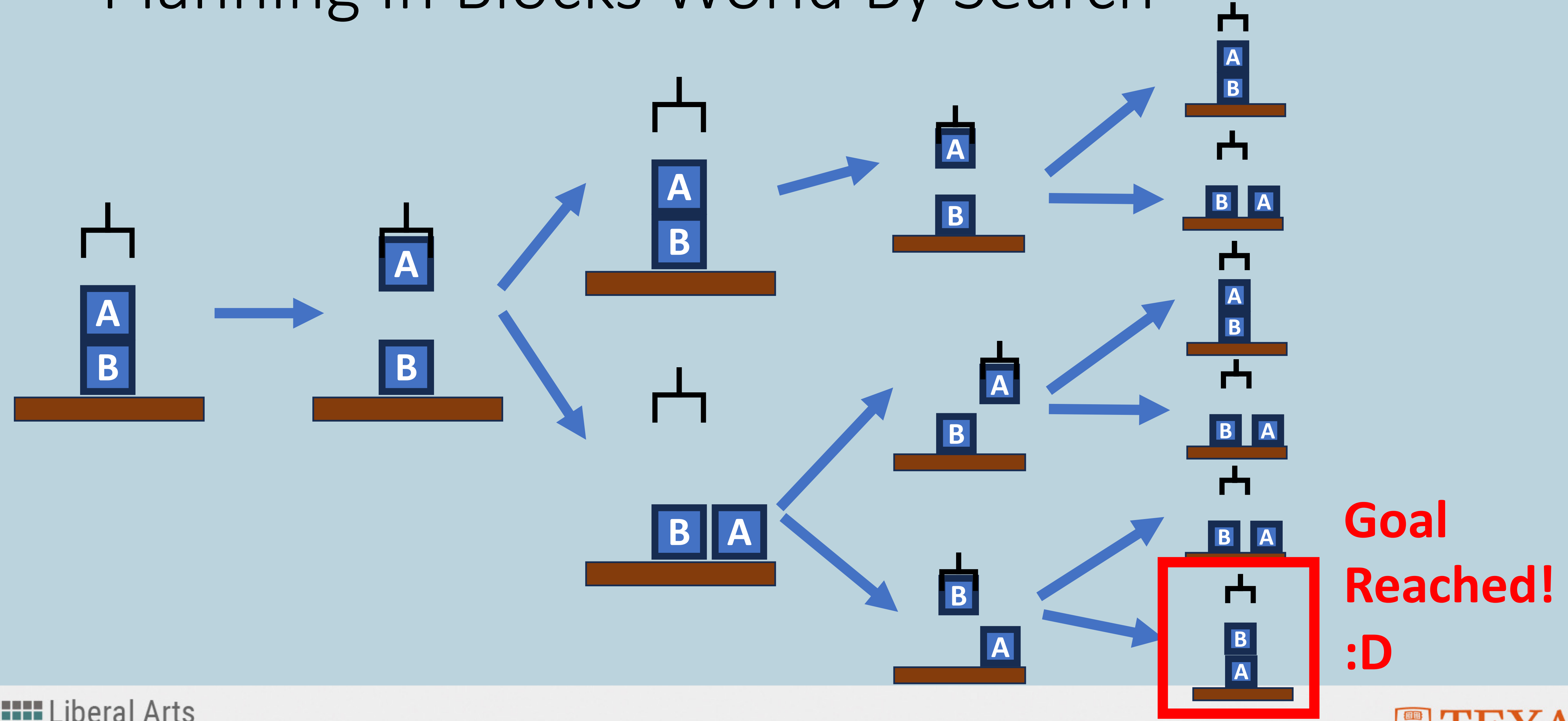
Planning In Blocks World By Search



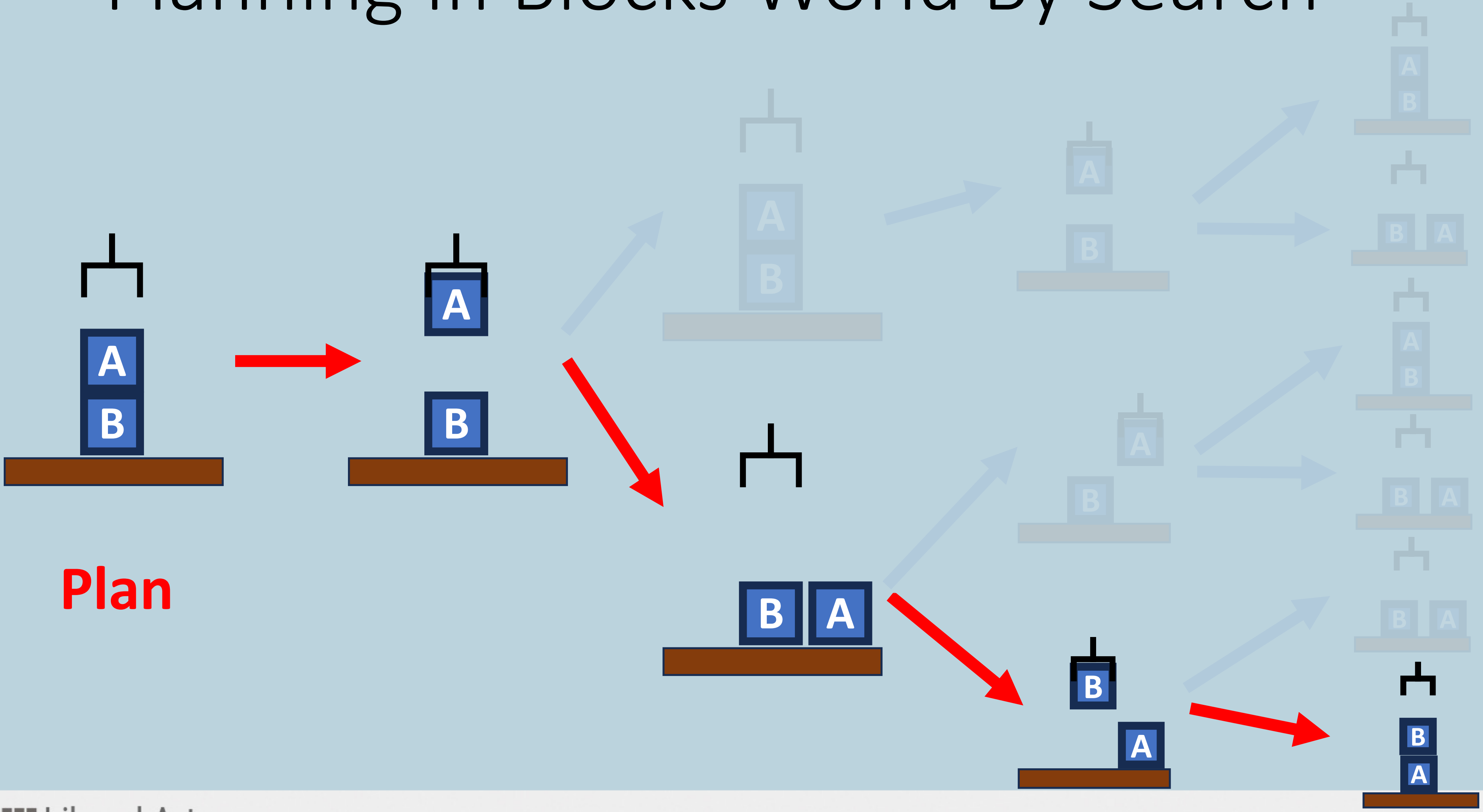
Planning In Blocks World By Search



Planning In Blocks World By Search



Planning In Blocks World By Search



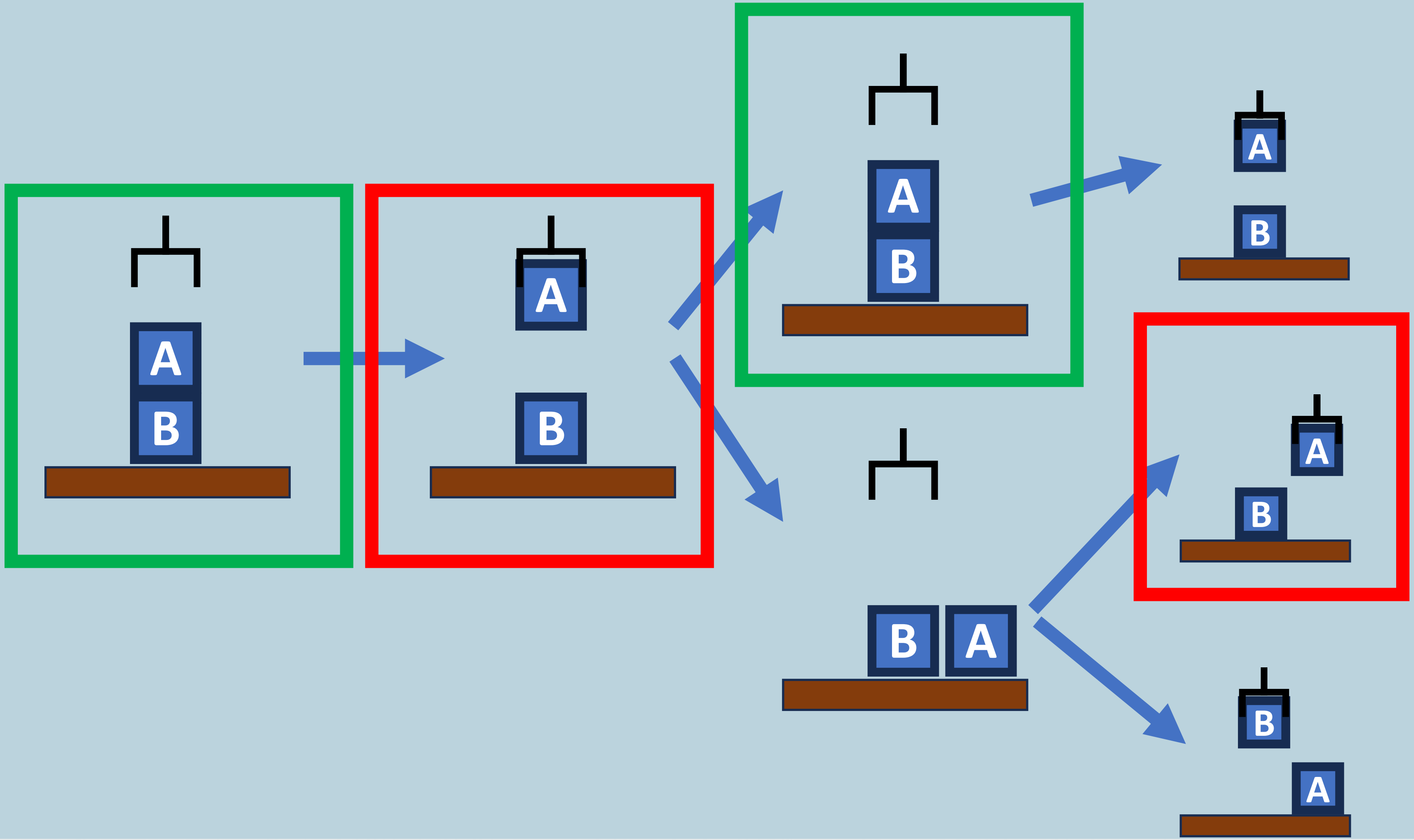
Plan

Problems With Search-Based Planning

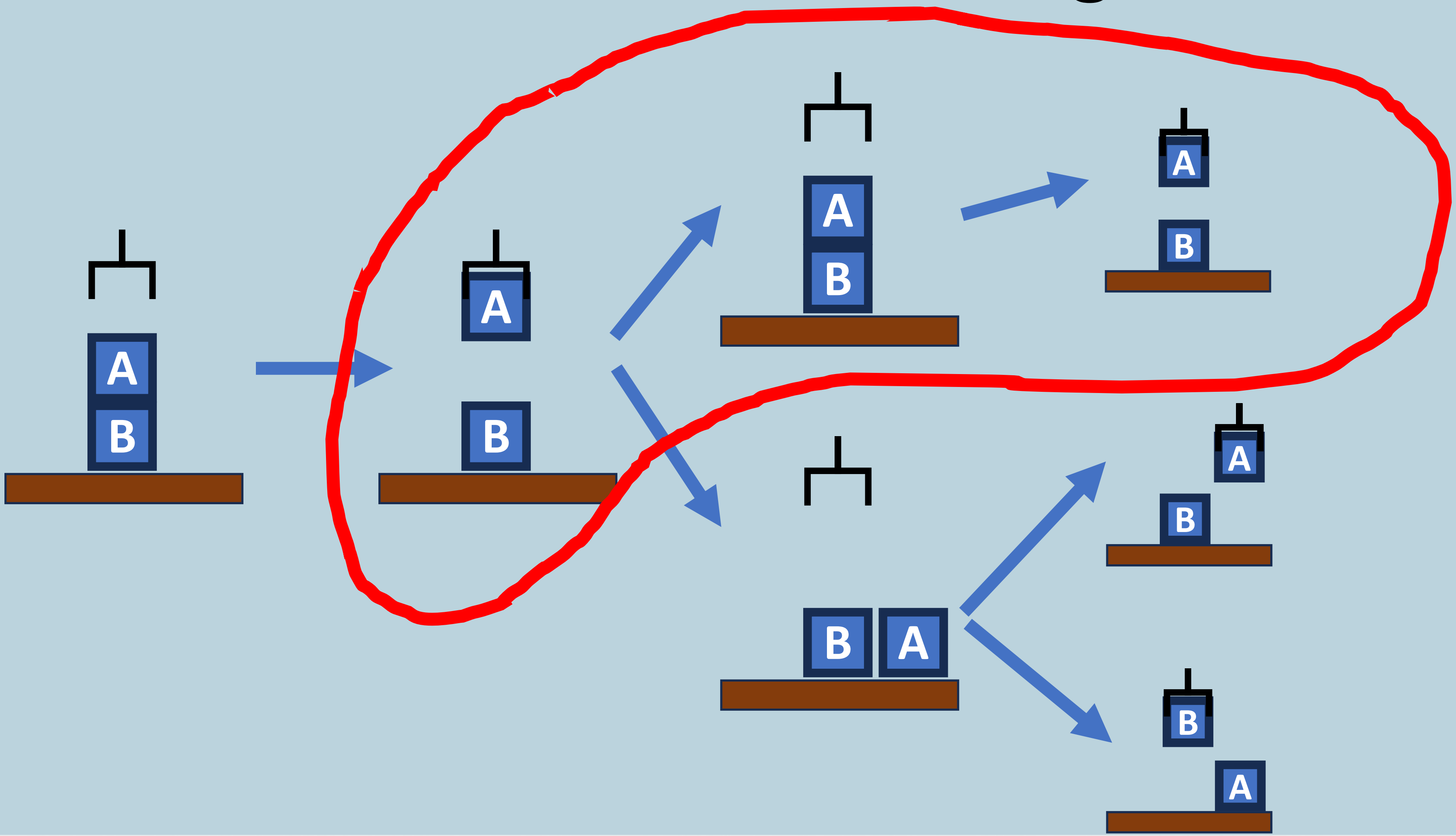
Many real-world problems quickly become intractable

- Too many action options
- Too many branching options
- Unable to enumerate till goal reached

Pruning: Eliminate Duplicated Sub-Trees



Moves That Make No Progress



Enter: Heuristics

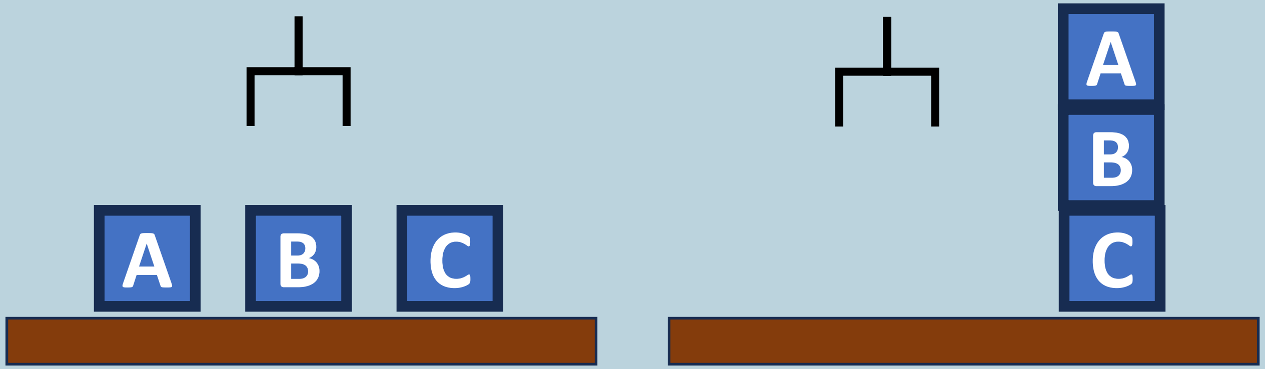
A planning heuristic is an (optimistic) estimate of how close a state is to the goal.

One way to use heuristics with planning (there are others):

Prioritize taking actions that have better heuristic scores

Example Heuristic

- Optimism: Assume goal conditions are independently achievable
- Heuristic value: How many goal conditions are met



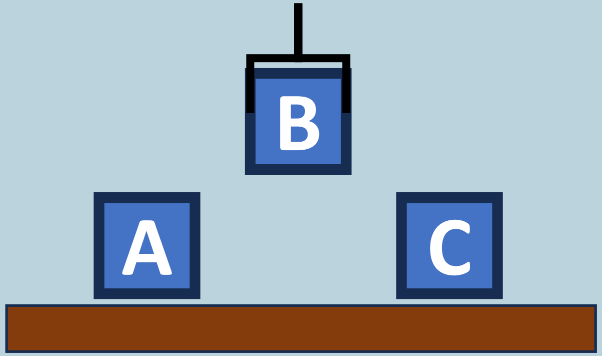
Initial:

- A on Table
- B on Table
- C on Table

Goal:

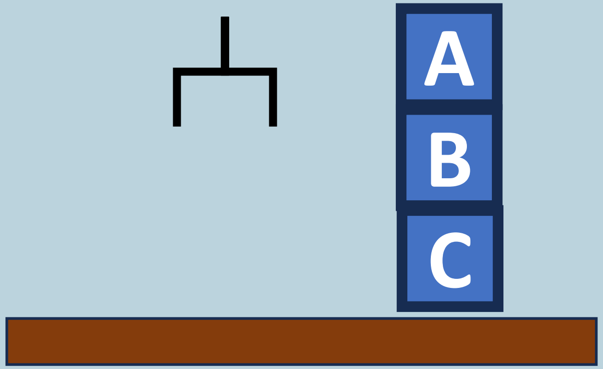
- A on B
- B on C
- C on Table

Heuristic In Action



Sub-Goals Satisfied: 1

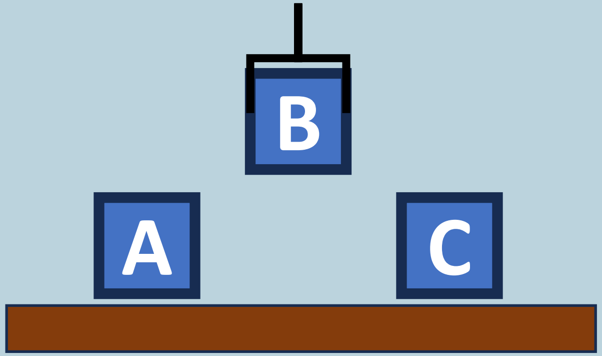
- ~~A on B~~
- ~~B on C~~
- C on Table



Goal:

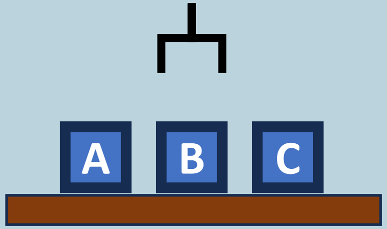
- A on B
- B on C
- C on Table

Heuristic In Action



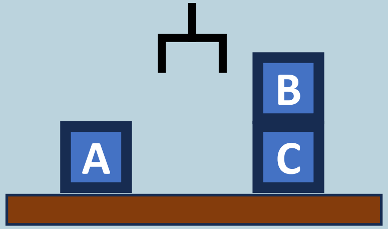
Sub-Goals Satisfied: 1

- ~~A on B~~
- ~~B on C~~
- C on Table



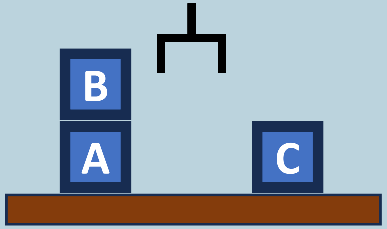
Sub-Goals Satisfied: 1

- ~~A on B~~
- ~~B on C~~
- C on Table



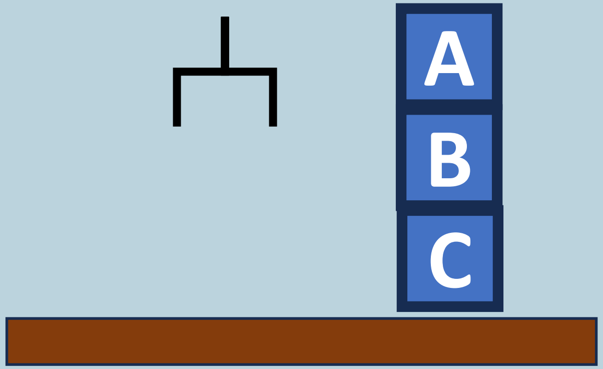
Sub-Goals Satisfied: 2

- ~~A on B~~
- B on C
- C on Table



Sub-Goals Satisfied: 1

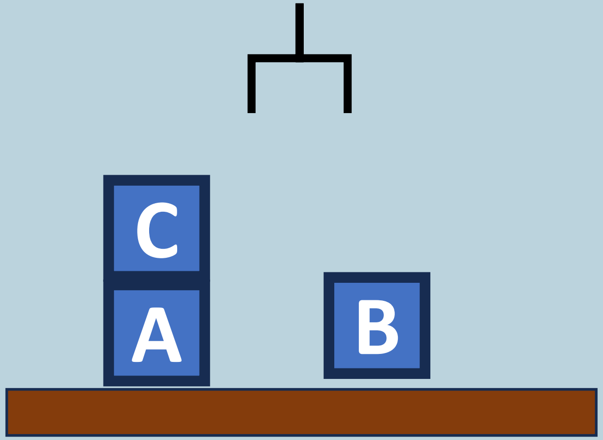
- ~~A on B~~
- ~~B on C~~
- C on Table



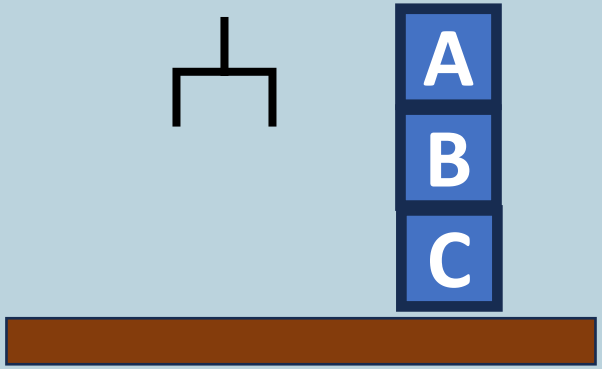
Goal:

- A on B
- B on C
- C on Table

Warning: Here Be Dragons…



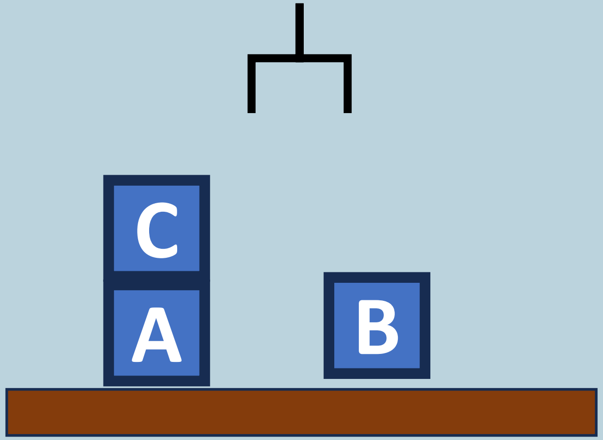
Initial State



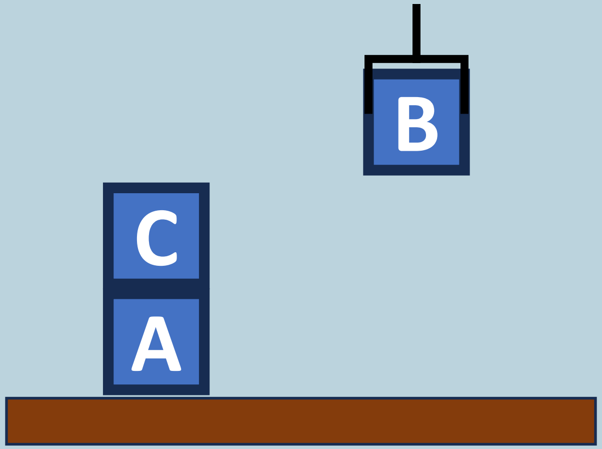
Goal:

- **A on B**
- **B on C**
- **C on Table**

Warning: Here Be Dragons…



Initial State

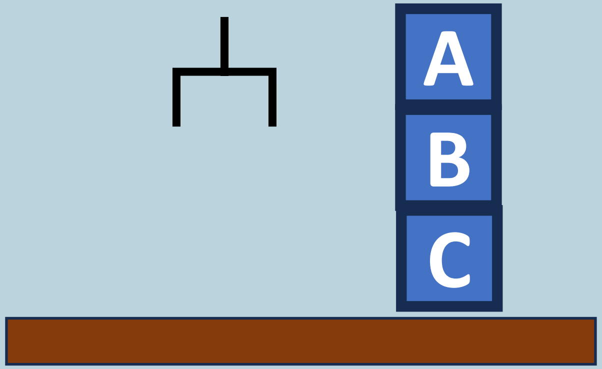


Intermediate…

Sub-Goals Satisfied:

- ~~A on B~~
- ~~B on C~~
- ~~C on Table~~

What happens next if we use our heuristic to pick the next move?



Goal:

- A on B
- B on C
- C on Table