CS161 Discussion 2

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Lisp practice

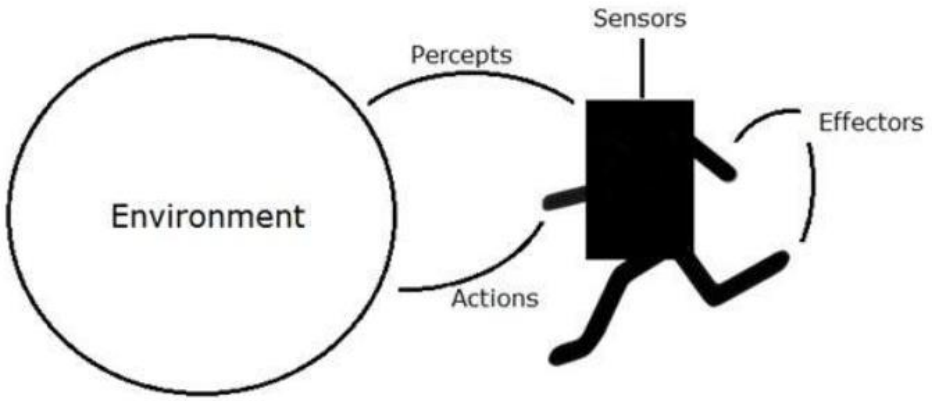
- if a list is increasing

Check if a list is increasing

```
(defun is_increasing (lst)
  (if (null (second lst))
      t
      (and (< (first lst)
              (second lst))
           (is_increasing (cdr lst)))))
```

Agents

An agent ***perceives*** its ***environment*** through ***sensors*** and ***acts*** upon it through ***actuators***



Agents

- **Rational agents**:
  - Choose actions that maximize the *expected* utility
  - Example 1: have a goal and a cost
    - Reach the goal with the lowest cost
  - Example 2: have numerical utilities, rewards, etc.
    - Take actions that maximize total reward over time
      - Reinforcement learning

Agents

- **Reflex agents**:
  - Action based on current percept of the environment (and maybe memory)
  - Does not consider future consequence of actions
  - If-else condition-action: What the world is like now => behave this way

Example

- Agent: Mail sorting robot
- Environment: Conveyor belt of letters
- Rule: city=Los Angeles -> put letter to California bag

Search Problem

A search problem consists of

- Initial State
- A state space $S = \{s_1, s_2, \dots s_d\}$
- Actions: a set of possible actions
- Successor function (transition model): $F(s_t, a_t) = s_{t+1}$, sometimes with a path cost function
- Goal test : determine if solution is achieved.

A solution:

a sequence of actions that transform the initial state to a goal state

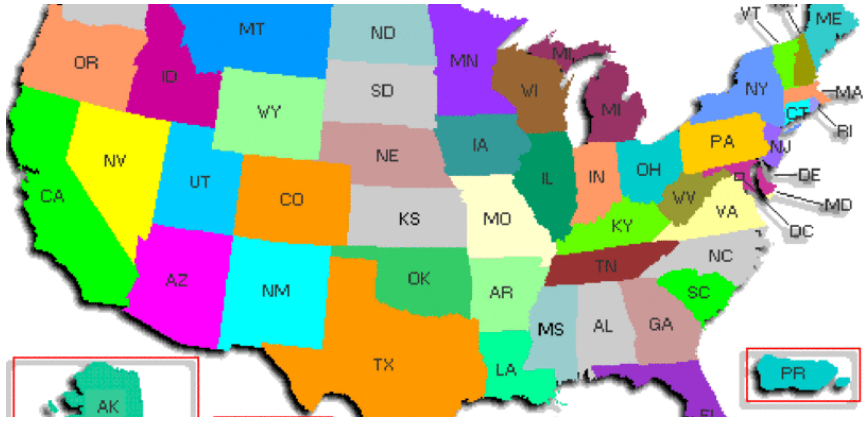
Problem formulation:

the process of deciding what actions and states to consider, given a goal.

Search Problem – Example - Travel from CA to MA

- **Initial State**: CA
- **State space**: 50 states in U.S.
- **Actions**: go to adjacent state. cost=distance
  - For example, Actions(CA)= {Go(OR), Go(AZ), Go(Nevada)}
- **Successor function** (transition model)
  - RESULT(In(CA), Go(AZ)) = In(AZ)
- **Goal test**:
  - state == MA?
- **Path cost function**

- Solution ?



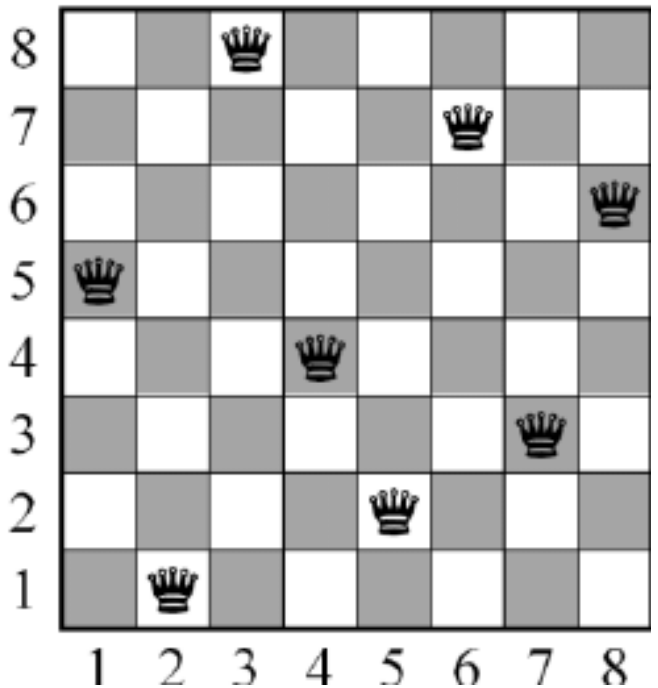
Search Problem – 8 queens

Objective:

Place eight queens on a chessboard such that no queen attacks any other.

(No two queens on the same row, column, diagonal)

(We don't care about how or how long you find the solution)



Search Problem – 8 queens

Formulate this problem.

- **States**: Any arrangement of 0 to 8 queens on the board is a state.
- **Initial state**: No queens on the board.
- **Actions**: Add a queen to any empty square.
- **Transition model**: Returns the board with a queen added to the specified square.
- **Goal test**: 8 queens are on the board, none attacked.

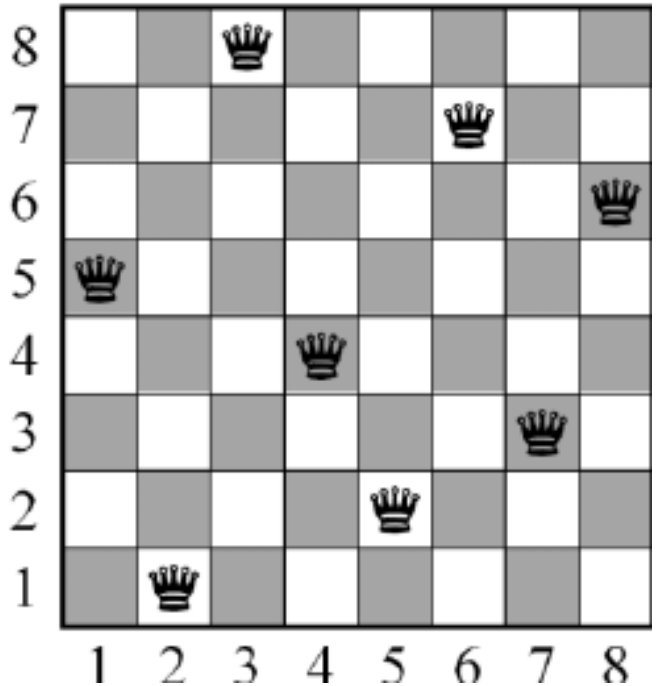
(We don't care about path cost here)

How many possible sequences?

$64! = 1.8 \times 10^{14}$

Search Problem – 8 queens

- **States**: All possible arrangements of n queens ($0 \leq n \leq 8$), one per column in the leftmost n columns, with no queen attacking another.
- **Actions**: Add a queen to any square in the leftmost empty column such that it is not attacked by any other queen.
- **Transition model**: Returns the board with a queen added to the specified square.
- **Goal test**: 8 queens are on the board, none attacked.



How large is the state space?

2057 (Why?)

Search Problem – 8 queens

- Incremental formulation
  - Start with an empty state
  - Each action adds a queen

- Complete-state formulation
  - Start with all 8 queens on the board
  - Moves queens around

In either case, path cost doesn't matter because only final state counts.

Search Problem Formulation - Exercise 1

- Two friends live in different cities on a map
- On every turn, we can simultaneously move each friend to a neighboring city
- Time(city $i \rightarrow$ neighbor j)=distance $d(i,j)$
- On each turn the friend that arrives first must wait until the other one arrives (and calls the first on his/her cell phone) before the next turn can begin.

- We want the two friends to meet as quickly as possible.

❑ **Write a formulation for this search problem**

Search Problem Formulation – Exercise 2

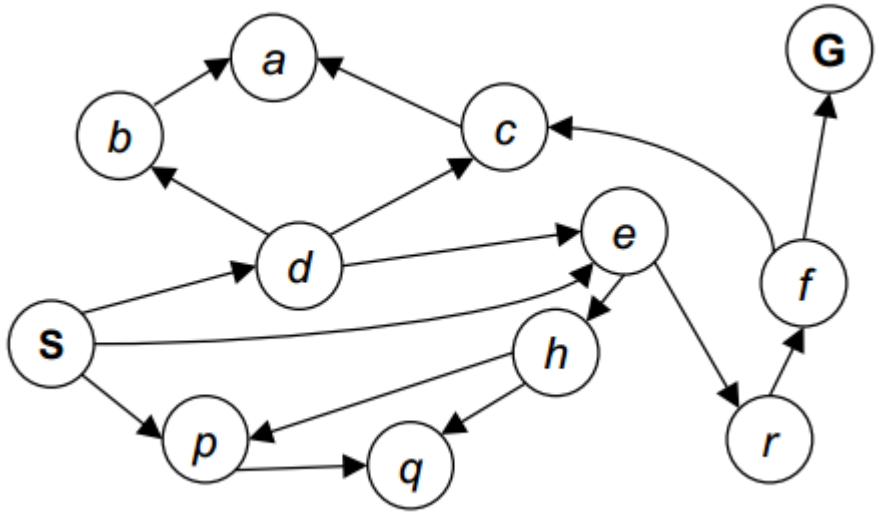
- 3 missionaries and 3 cannibals are on one side of a river
- A boat can hold one or two people.
- **NOT** allowed (on either side): # of cannibals > # of missionaries
- Find a way to get everyone to the other side

Write a formulation for this search problem

State space graph

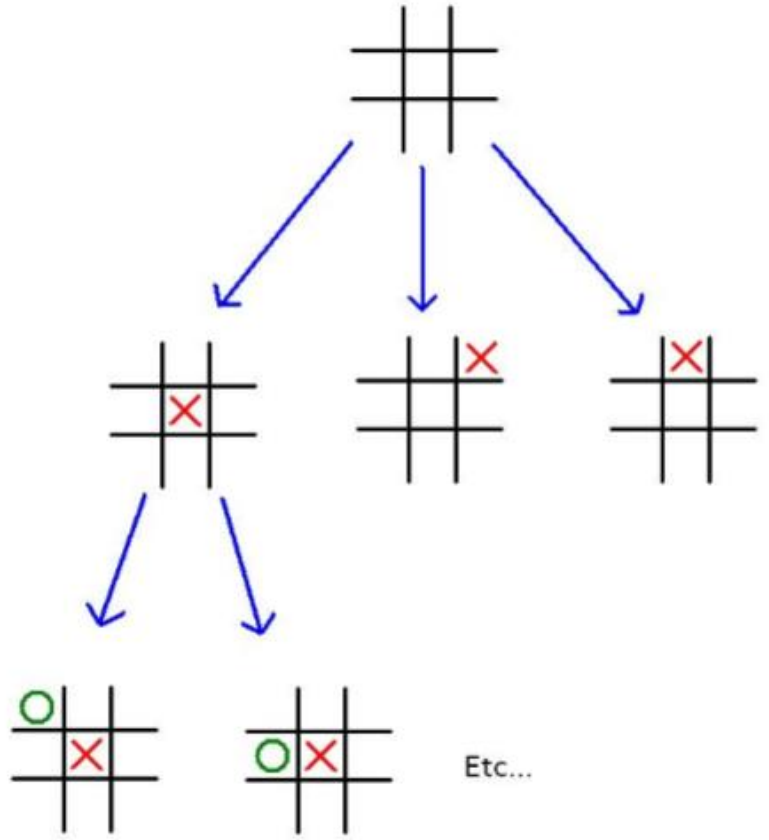
- Nodes are (abstracted) world configurations
- Arcs represent successors (action results)
- Goal test: one or a set of goal nodes

- Each state occurs only once!



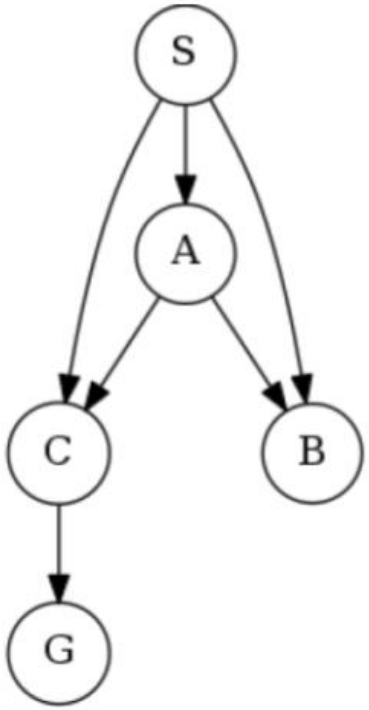
Search Tree

- A "what if" tree of plans and their outcomes
- Root: initial state
- Children: correspond to successors



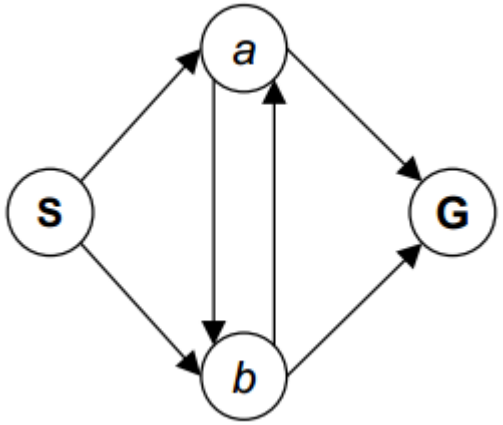
Quiz

- How many nodes are there in this search tree?



State Space Graph vs Search Tree

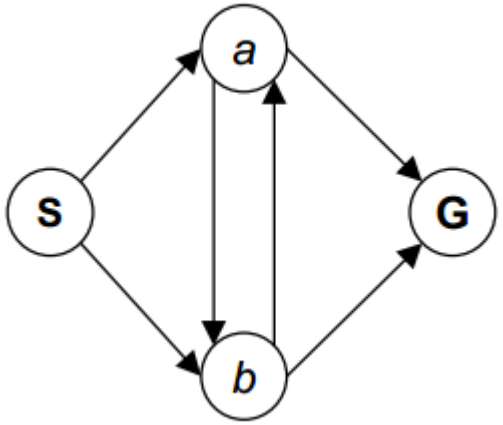
4-state graph



How big is the search tree?

State Space Graph vs Search Tree

4-state graph



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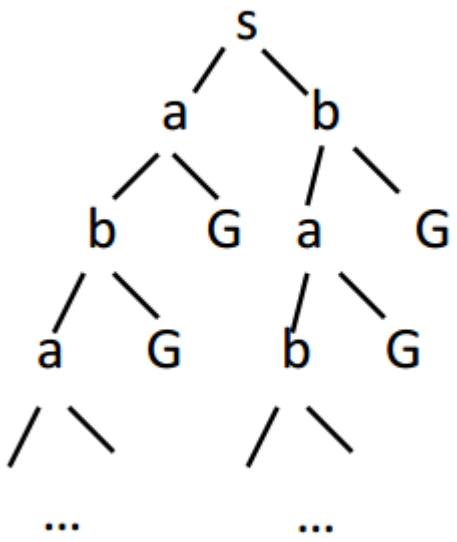

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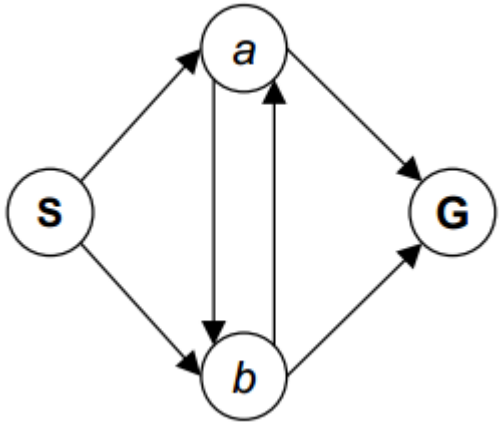
State Space Graph vs Search Tree

4-state graph



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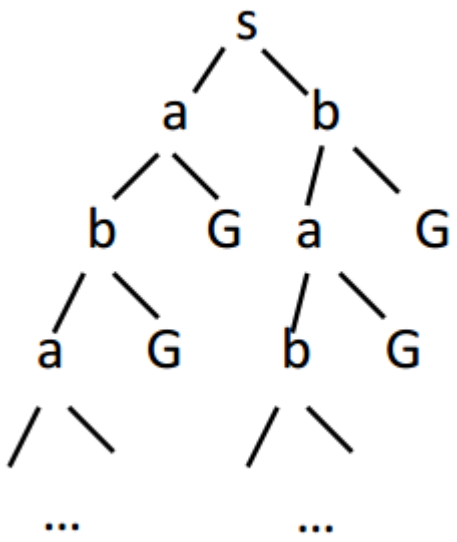

∞

- Expand out potential tree nodes
- Maintain a fringe of partial plans under consideration
- Try to expand as few tree nodes as possible