State Space Search

Overview

- Problem-solving as search
- How to formulate an AI problem as search.
- Uninformed search methods

What is search?

Environmental factors needed

- **Static** — The world does not change on its own, and our actions don't change it.
- **Discrete** — A finite number of individual states exist rather than a continuous space of options.
- **Observable** — States can be determined by observations.
- **Deterministic** — Action have certain outcomes.

Terminology

- A **state** is a set of properties that define the current conditions of the world our agent is in.
  - The entire set of possible states is called the **state space**.
- The **initial state** is the state the agent begins in.
- A **goal state** is a state where the agent may end the search.
- An agent may take different **actions** that will lead the agent to new states.

Formulating problems as search

- *Canonical problem*: route-finding
- Sliding block puzzle
- 8 queens puzzle
- Roomba cleaning
- Automatic CS 172 proof completion
- Solitaire
- What else?

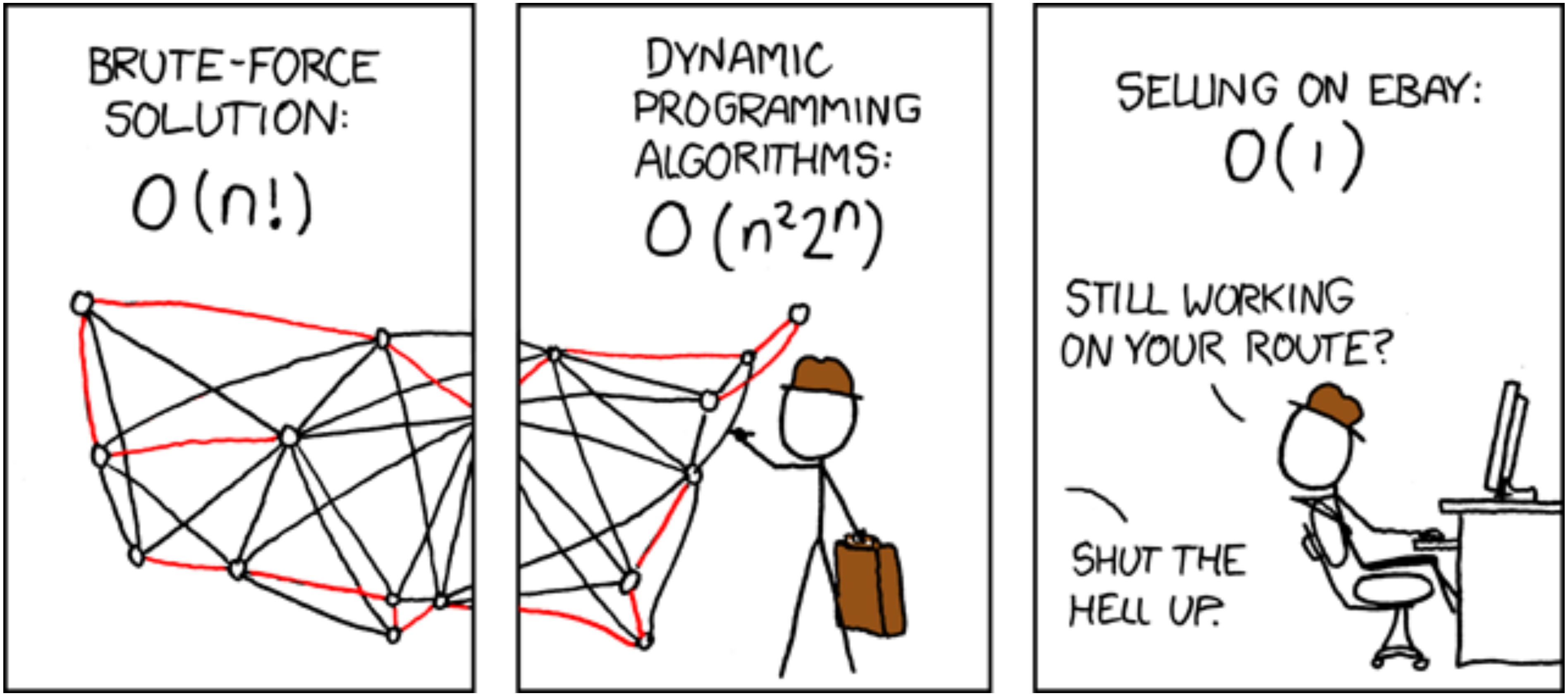
Formulating problems as search

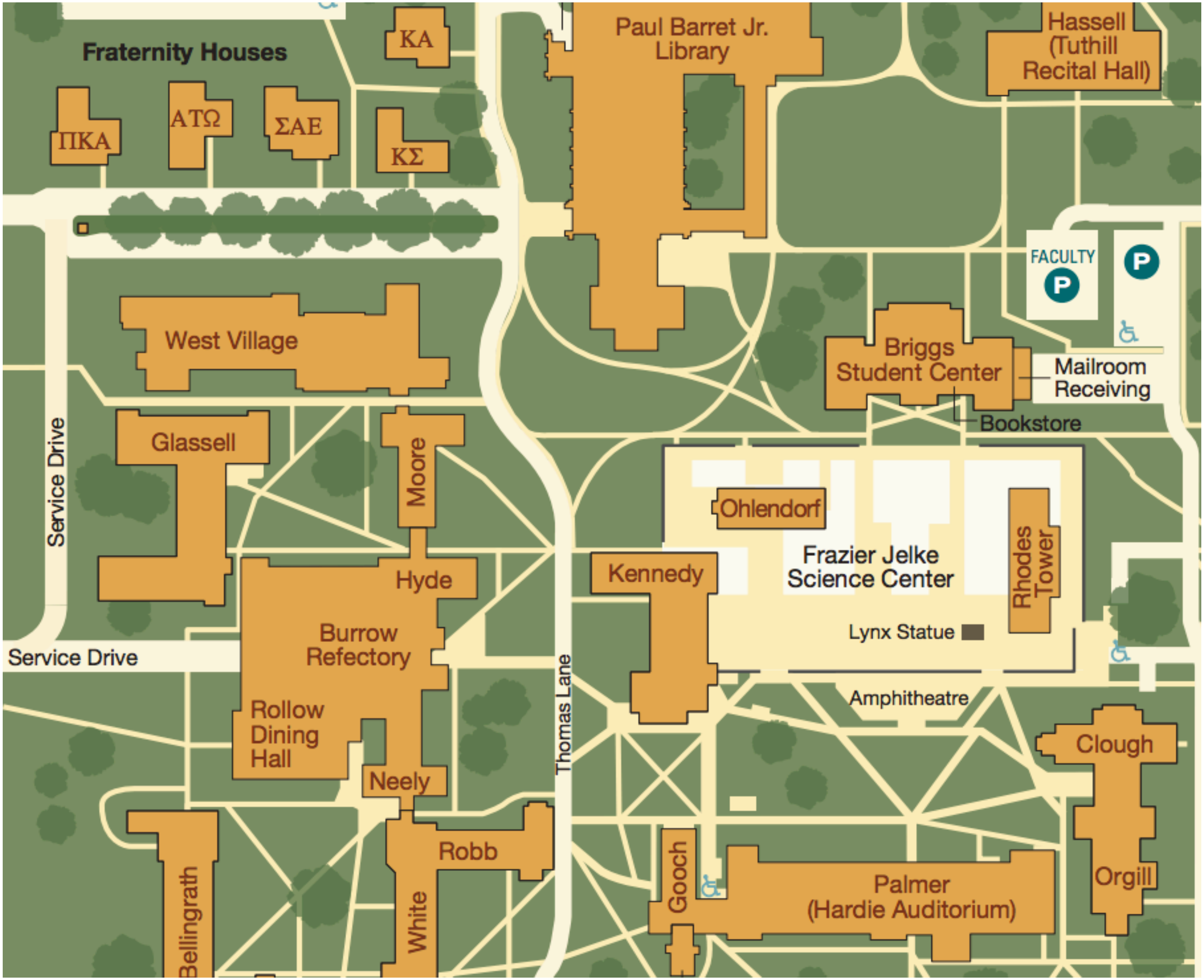
- Define:
  - What do my states look like?
  - What is my initial state?
  - What are my goal state(s)?
  - What is my cost function?
    - How do I know how "good" a state or action is?

Formulating problems as search

- Solution:
  - A ***path*** between the initial state and a goal state.
  - ***Quality*** is measured by path cost.
  - ***Optimal solutions*** have the lowest cost of any possible path.

- State space search gives us graph searching algorithms.
- Are we searching a ***tree*** or a (true) ***graph***?




Fraternity Houses
ΚΑ
ΑΤΩ
ΣΑΕ
ΠΚΑ
ΚΣ
Paul Barret Jr. Library
Hassell (Tuthill Recital Hall)
FACULTY
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West Village
Briggs Student Center
Mailroom Receiving
Bookstore
Glassell
Moore
Service Drive
Ohlendorf
Frazier Jelke Science Center
Rhodes Tower
Hyde
Kennedy
Burrow Refectory
Lynx Statue
Service Drive
Thomas Lane
Amphitheatre
Rollow Dining Hall
Clough
Neely
Robb
Gooch
Palmer (Hardie Auditorium)
Orgill
Bellingrath
White

Often-confusing point

- There are two simultaneous graph-ish structures used in search:
  - (1) Tree or graph of underlying state space.
  - (2) Tree maintaining the record of the current search in progress (the ***search tree***).

Infrastructure needed

- A node n of the search tree stores:
  - a state (of the state space)
  - a parent pointer to a node (usually)
  - the action that got you from the parent to this node (sometimes)
  - the path cost g(n): cost of the path *so far* from the initial state to n.
- Frontier is often stored as a stack, queue, or priority queue.
- Explored set is often stored using a data structure that enables quick look-up for membership tests.

Uninformed search methods

- These methods have no information about which nodes are on promising paths to a solution.
- Also called: *blind search*
- Question — What would have to be true for our agent to need uninformed search?
  - No knowledge of goal location; or
  - No knowledge of current location or direction (e.g., no GPS, inertial navigation, or compass)

How do you evaluate a search strategy?

- **Completeness** — Does it always find a solution if one exists?
- **Optimality** — Does it find the best solution?
- **Time complexity**
- **Space complexity**

Search strategies

- Breadth-first search
  - Variant — Uniform-cost search
- Depth-first search
- Depth-limited search
- Iterative deepening depth-first search
  - Variant — iterative lengthening search

Breadth-first search

- Choose shallowest node for expansion.
- Data structure for frontier?
  - Queue (regular)
- Suppose we come upon the same state twice. Do we re-add to the frontier?
  - No.
- Complete? Optimal? Time? Space?