Searching

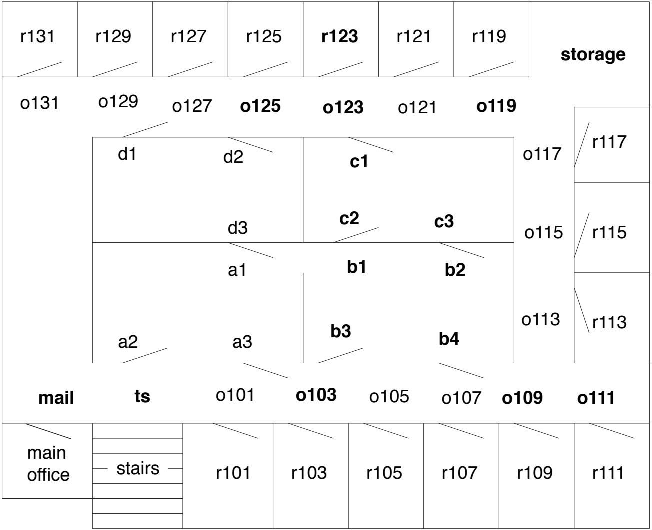
- Often we are not given an algorithm to solve a problem, but only a specification of what is a solution — we have to search for a solution.
- A typical problem is when the agent is in one state, it has a set of deterministic actions it can carry out, and wants to get to a goal state.
- Many AI problems can be abstracted into the problem of finding a path in a directed graph.
- Often there is more than one way to represent a problem as a graph.

Directed Graphs

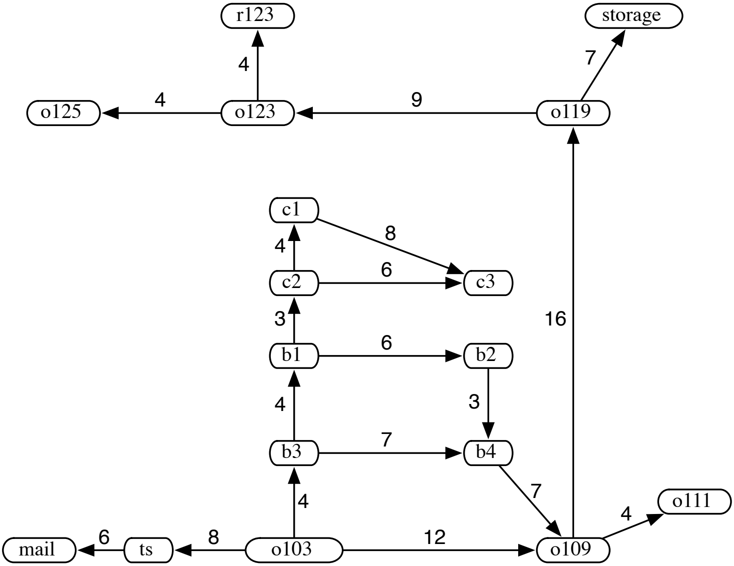
- A **graph** consists of a set N of **nodes** and a set A of ordered pairs of nodes, called **arcs**.
- Node n_2 is a **neighbor** of n_1 if there is an arc from n_1 to n_2. That is, if $\langle n_1, n_2 \rangle \in A$.
- A **path** is a sequence of nodes $\langle n_0, n_1, \ldots, n_k \rangle$ such that $\langle n_{i-1}, n_i \rangle \in A$.
- Given a set of **start nodes** and **goal nodes,** a **solution** is a path from a start node to a goal node.
- Often there is a **cost** associated with arcs and the cost of a path is the sum of the costs of the arcs in the path.

Example Problem for Delivery Robot

The robot wants to get from outside room 103 to the inside of room 123.

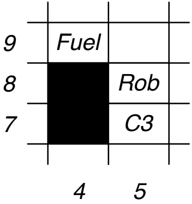


Graph for the Delivery Robot



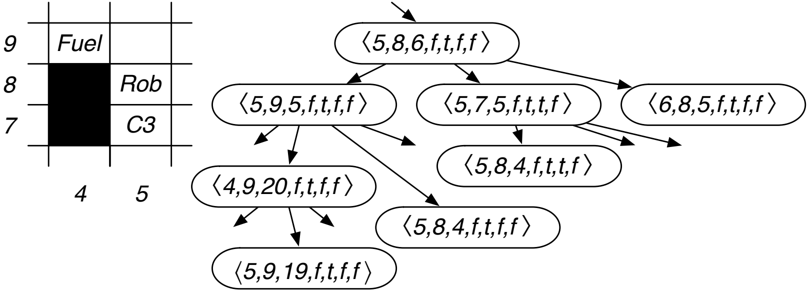
Partial Search Space for a Video Game

Grid game: collect coins C_1, C_2, C_3, C_4, don't run out of fuel, and end up at location $(1,1)$:



Partial Search Space for a Video Game

Grid game: collect coins C_1, C_2, C_3, C_4, don't run out of fuel, and end up at location $(1, 1)$:



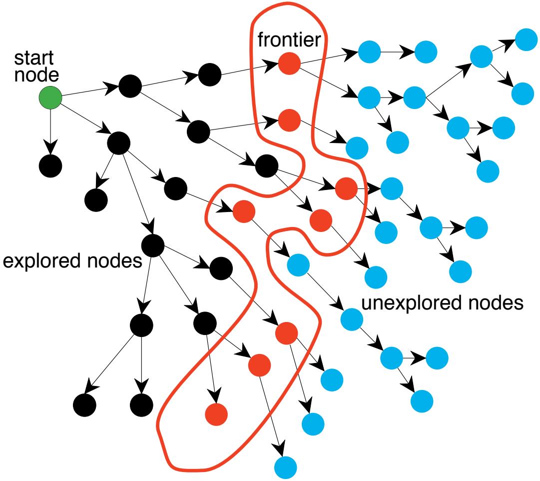
State: ⟨*X-pos,Y-pos,Fuel,C1,C2,C3,C4*⟩

Goal: ⟨*1,1,?,t,t,t,t*⟩

Graph Searching

- Generic search algorithm: given a graph, start nodes, and goal nodes, incrementally explore paths from the start nodes.
- Maintain a frontier of paths from the start node that have been explored.
- As search proceeds, the frontier expands into the unexplored nodes until a goal node is encountered.
- The way in which the frontier is expanded defines the search strategy.

Problem Solving by Graph Searching



Graph Search Algorithm

Input: a graph,
a set of start nodes,
Boolean procedure $goal(n)$ that tests if n is a goal node.

$frontier := \{\langle s \rangle : s \text{ is a start node}\}$;
while *frontier* is not empty:
  select and **remove** path $\langle n_0, \ldots, n_k \rangle$ from *frontier*;
  if $goal(n_k)$
    return $\langle n_0, \ldots, n_k \rangle$;
  for every neighbor n of n_k
    add $\langle n_0, \ldots, n_k, n \rangle$ to *frontier*;
end while

- We assume that after the search algorithm returns an answer, it can be asked for more answers and the procedure continues.
- Which value is selected from the frontier at each stage defines the search strategy.
- The *neighbors* defines the graph.
- *is_goal* defines what is a solution.