Search: Intro

Computer Science cpsc322, Lecture 4

(Textbook Chpt 3.0-3.3)

January, 11, 2010

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11-12 Wed

Modules we'll cover in this course: R&Rsys

First part of the course

Problem		Environment: Deterministic	Environment: Stochastic
Static	Constraint Satisfaction	*Vars + Constraints*: Arc Consistency, Search	
Static	Query	*Logics*: Search	*Belief Nets*: Var. Elimination
Sequential	Planning	*STRIPS*: Search	*Decision Nets*: Var. Elimination; *Markov Processes*: Value Iteration

Representation

Reasoning Technique

Lecture Overview

- **Simple Agent and Examples**
- Search Space Graph
- Search Procedure

Simple Planning Agent

Deterministic, goal-driven agent

- Agent is in a **start state**
- Agent is given a **goal** (subset of possible states)
- Environment changes only when the agent acts
- Agent perfectly knows:
  - **what actions can be applied** in any given state
  - **the state it is going to end up** in when an action is applied in a given state

- The sequence of actions and their appropriate ordering is the **solution**

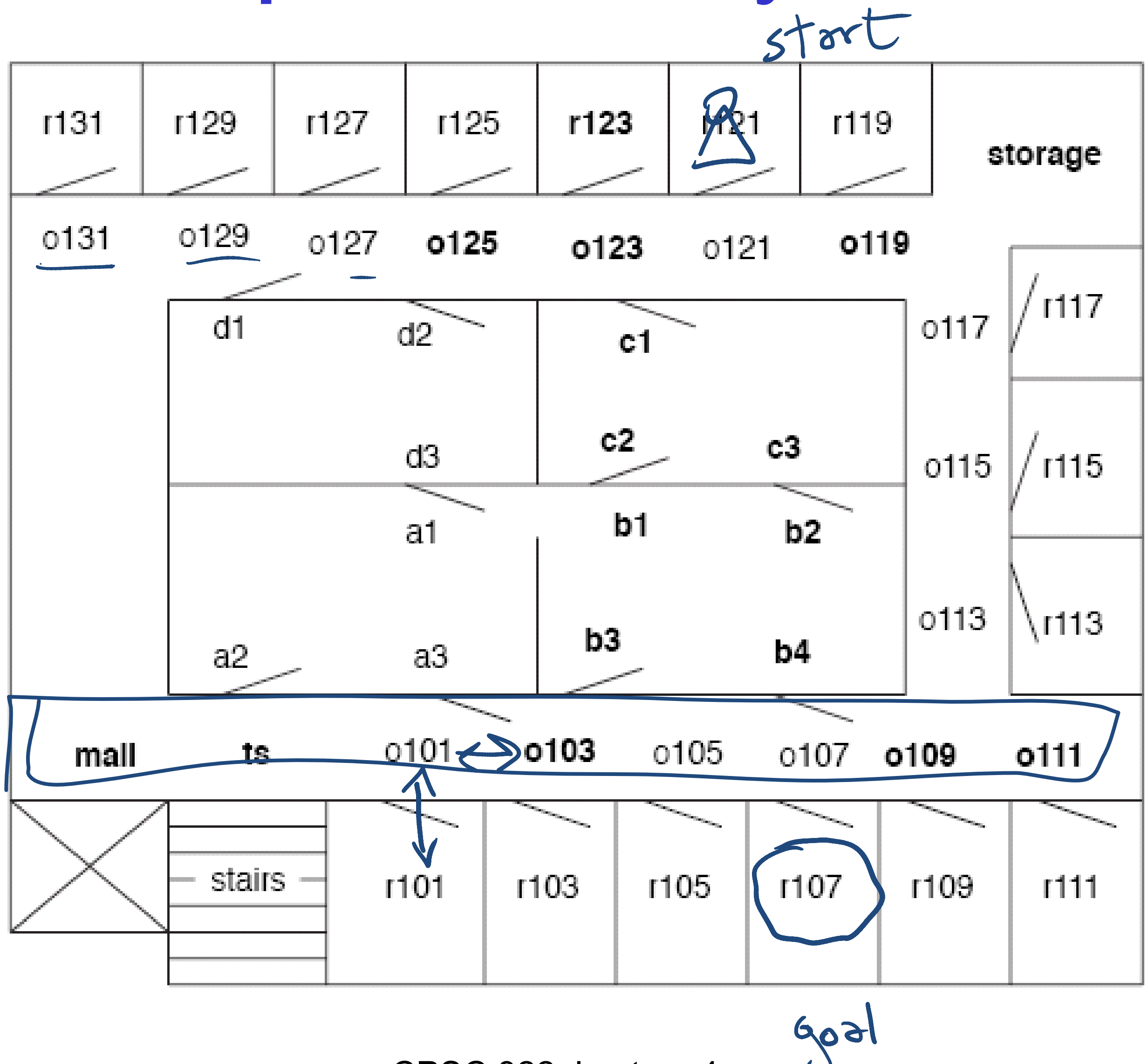
Three examples

1. A delivery robot planning the route it will take in a bldg. to get from one room to another

2. Solving an 8-puzzle

3. Vacuum cleaner world

Example1: Delivery Robot

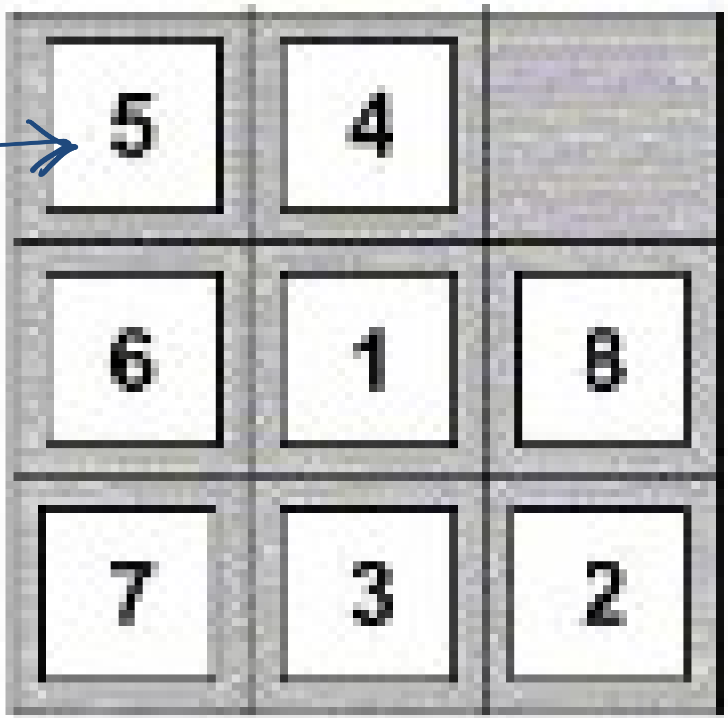


Example 2: 8-Puzzle?

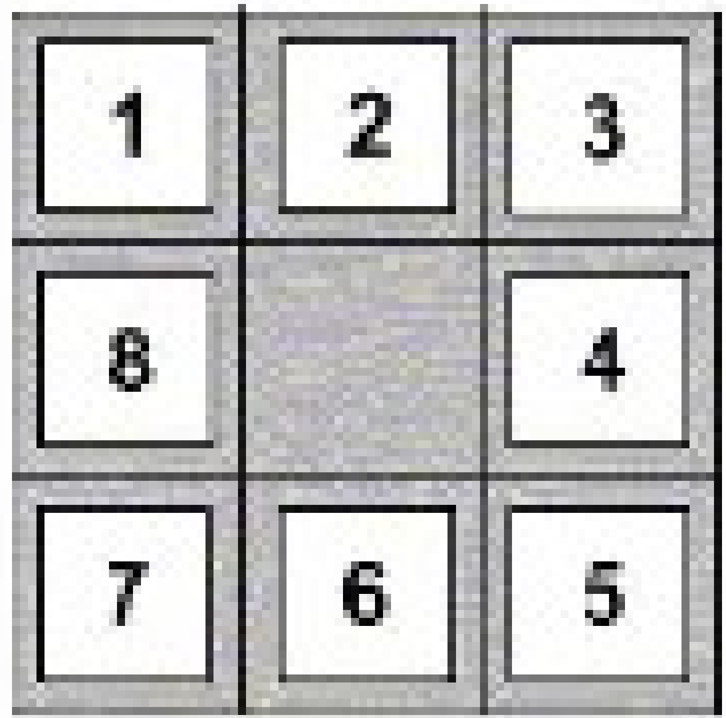
of states

$9!$

$\sim 360 \times 10^3$



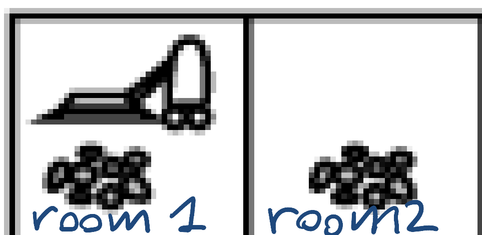
Possible start state



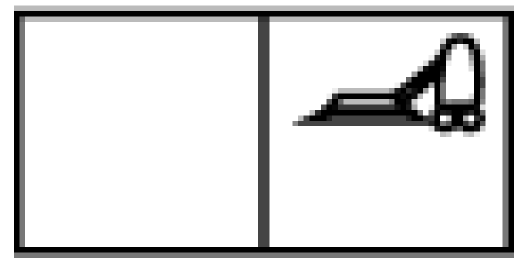
Goal state

Example: vacuum world

loc 2 values {r_1, r_2}
r1-clean T/F 2
r2-clean T/F 2



Possible start state K



Goal state

# of states
$2 \cdot 2^2$

given K cells GENERALIZES TO
$K \, 2^K$

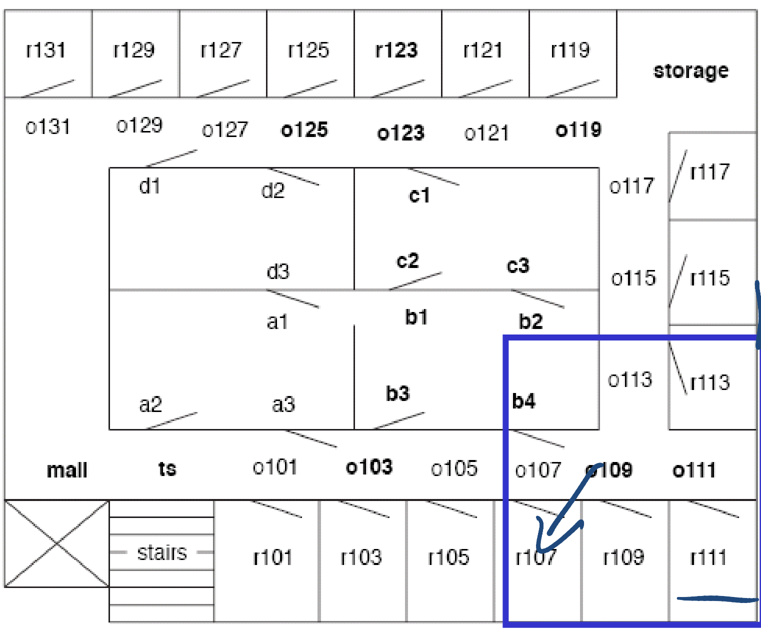
can be subset of states

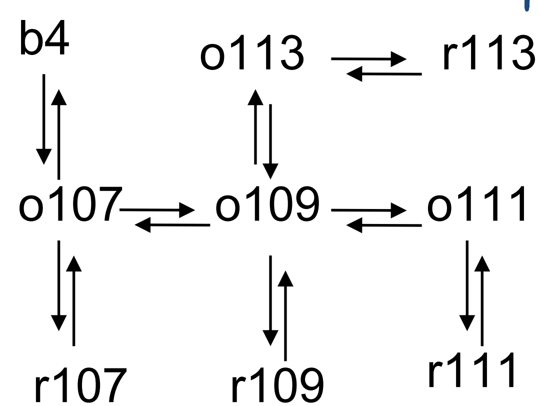
Lecture Overview

- Simple Agent and Examples
- Search Space Graph
- Search

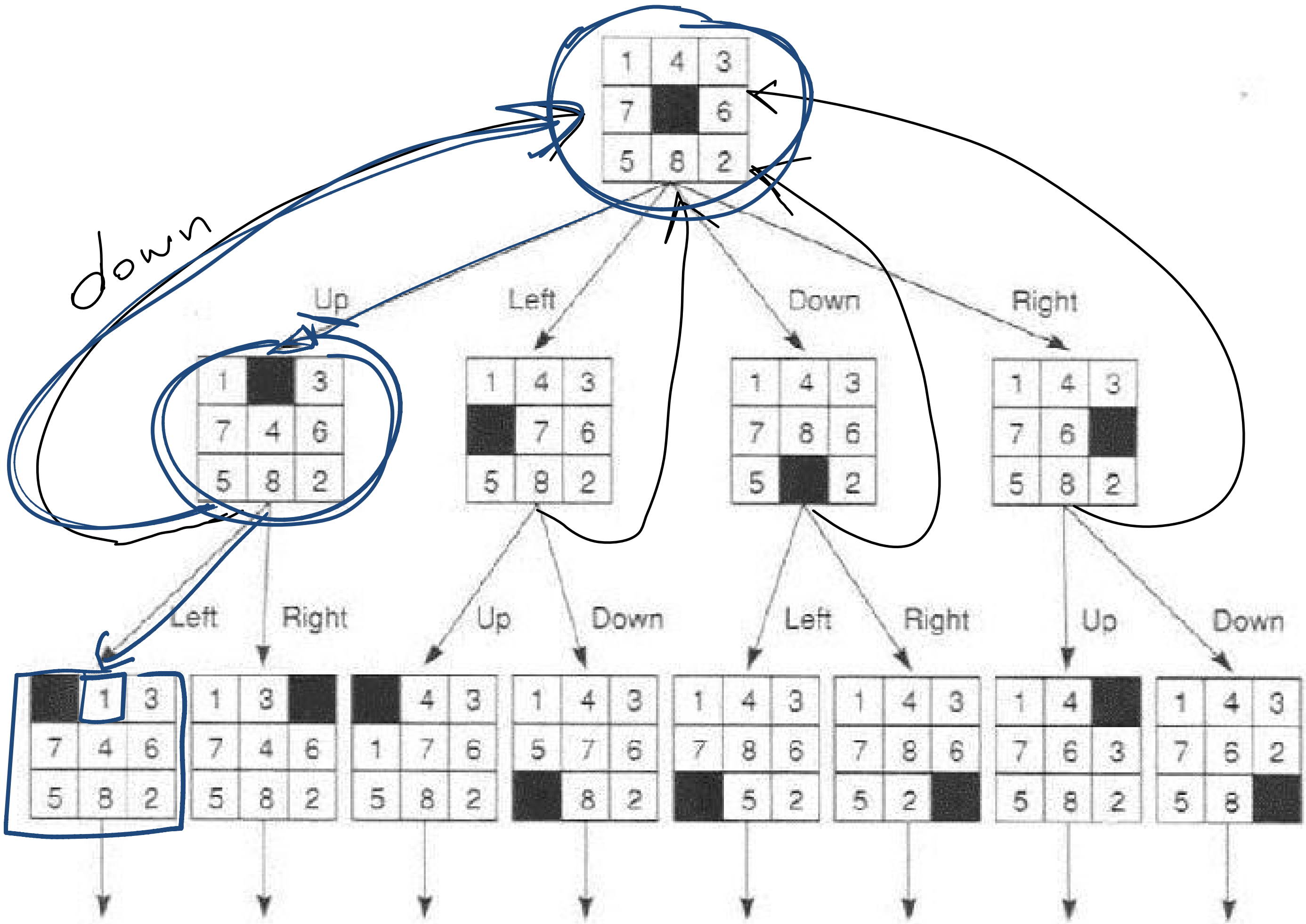
How can we find a solution?

- How can we find a sequence of actions and their appropriate ordering that lead to the goal?
- Define underlying **search space graph** where **nodes are states** and **edges are actions**.

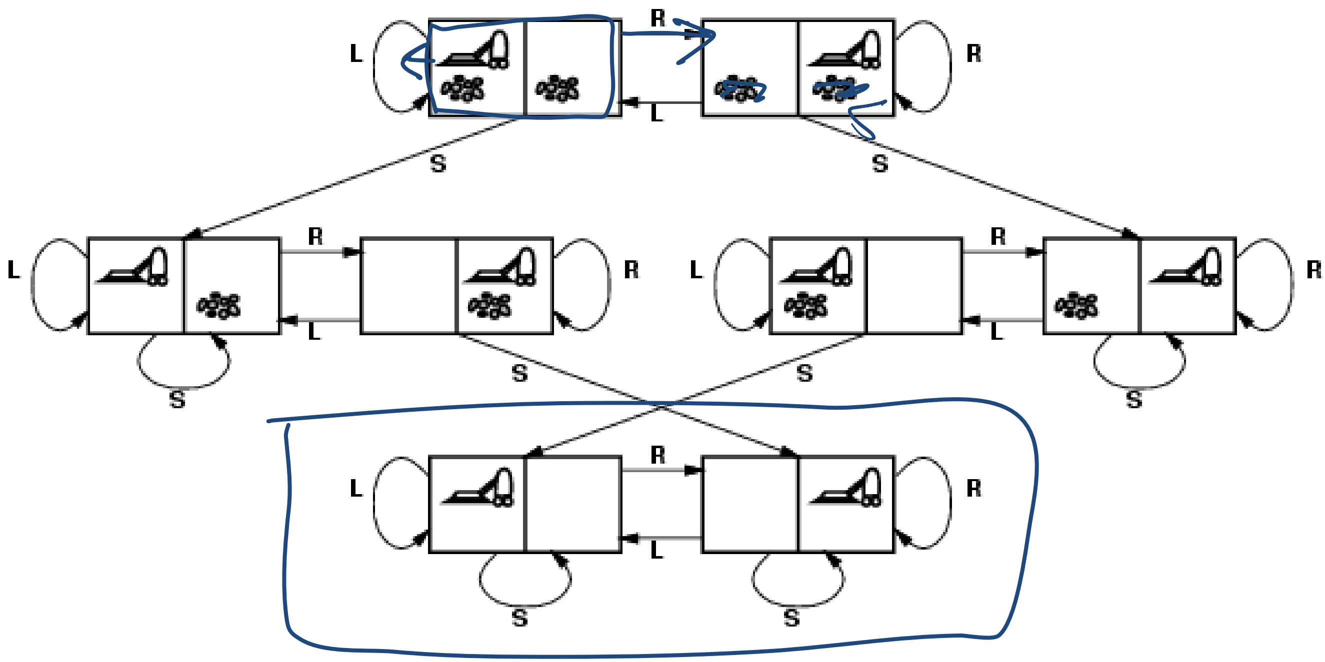




Search space for 8puzzle



Vacuum world: Search space graph



states? Where it is dirty and robot location

actions? *Left*, *Right*, *Suck*

Possible goal test? no dirt at all locations

Lecture Overview

- Simple Agent and Examples
- State Space Graph
- **Search Procedure**

Search: Abstract Definition

How to search

- Start at the start state
- Consider the effect of taking different actions starting from states that have been encountered in the search so far
- Stop when a goal state is encountered

To make this more formal, we'll need review the **formal definition of a graph**...

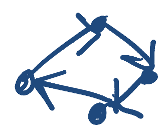
Search Graph

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 $n_0, n_1, n_2, \ldots, n_k$ such that $\langle n_{i-1}, n_i \rangle \in A$.

A *cycle* is a non-empty path such that the start node is the same as the end node



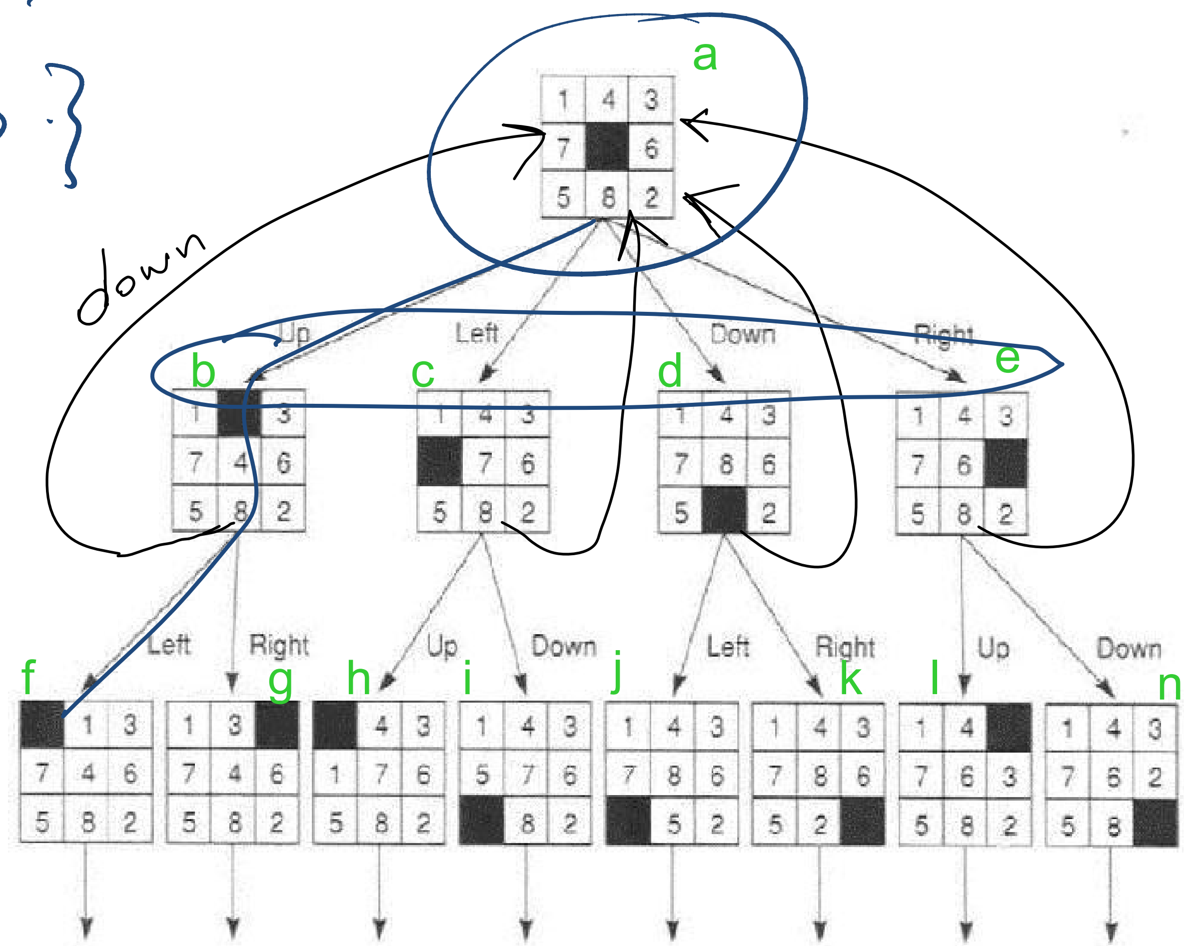
A *directed acyclic graph* (DAG) is a graph with no cycles

Given a start node and goal nodes, a *solution* is a path from a start node to a goal node.

Examples for graph formal def.

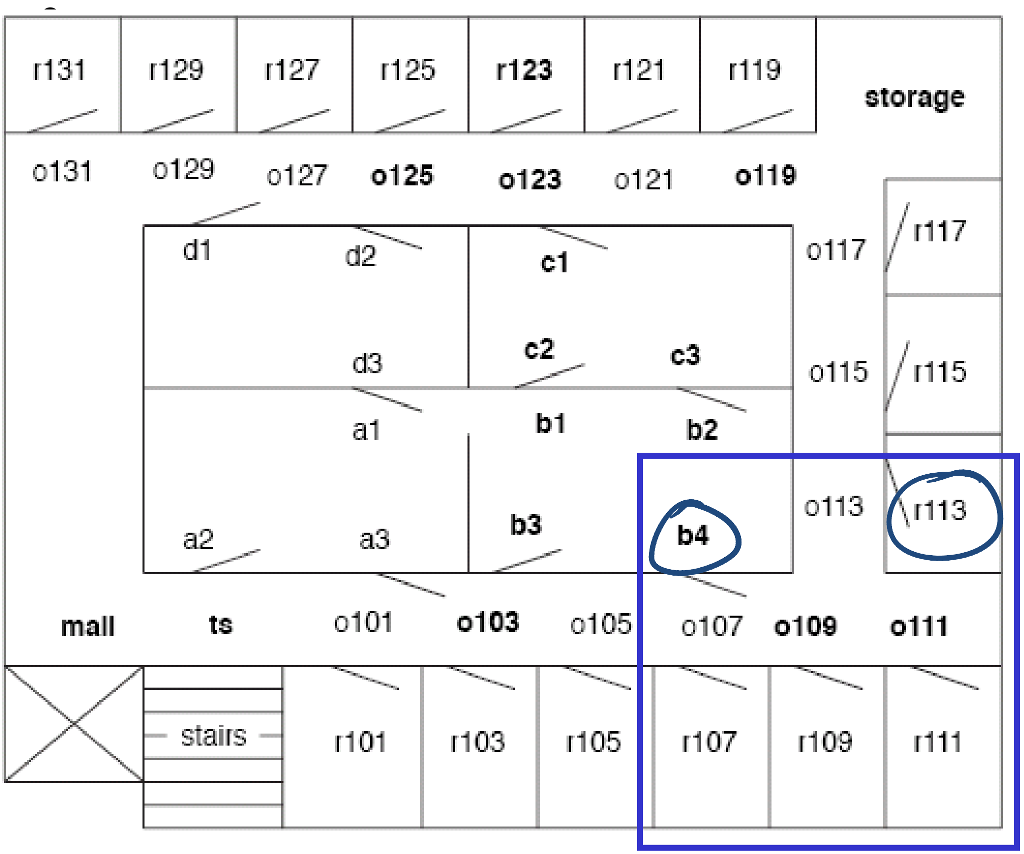
N {a b _ _ }

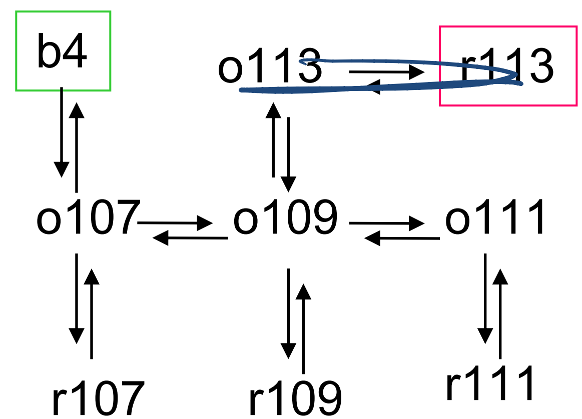
A {<a,b> <a,c> }



Examples of solution

- Start state b4, goal r113
- Solution <b4, o107, o109, o113, r113>





Graph Searching

Generic search algorithm: given a graph, start node, and goal node(s), incrementally explore paths from the start node(s).

Maintain a **frontier of paths** from the start node that have been explored.

As search proceeds, the frontier expands into the unexplored nodes until (hopefully!) a goal node is encountered.

The way in which the frontier is expanded defines the search strategy.

Generic Search Algorithm

Input: a graph, a start node, Boolean procedure *goal(n)* that tests if *n* is a goal node

frontier:= [<*s*>: *s* is a start node];

While *frontier* is not empty:

  select and **remove** path <$n_o, \ldots, n_k$> from *frontier;*

  If *goal*(n_k)

    return <$n_o, \ldots, n_k$>;

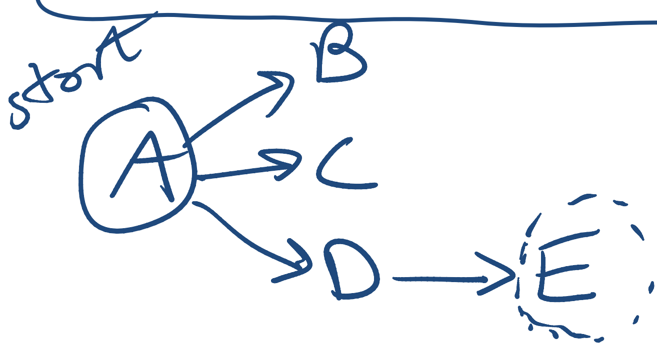
  For every neighbor *n* of n_k

    add <$n_o, \ldots, n_k$, *n*> to *frontier;*

end

with cycles may get into infinite loop

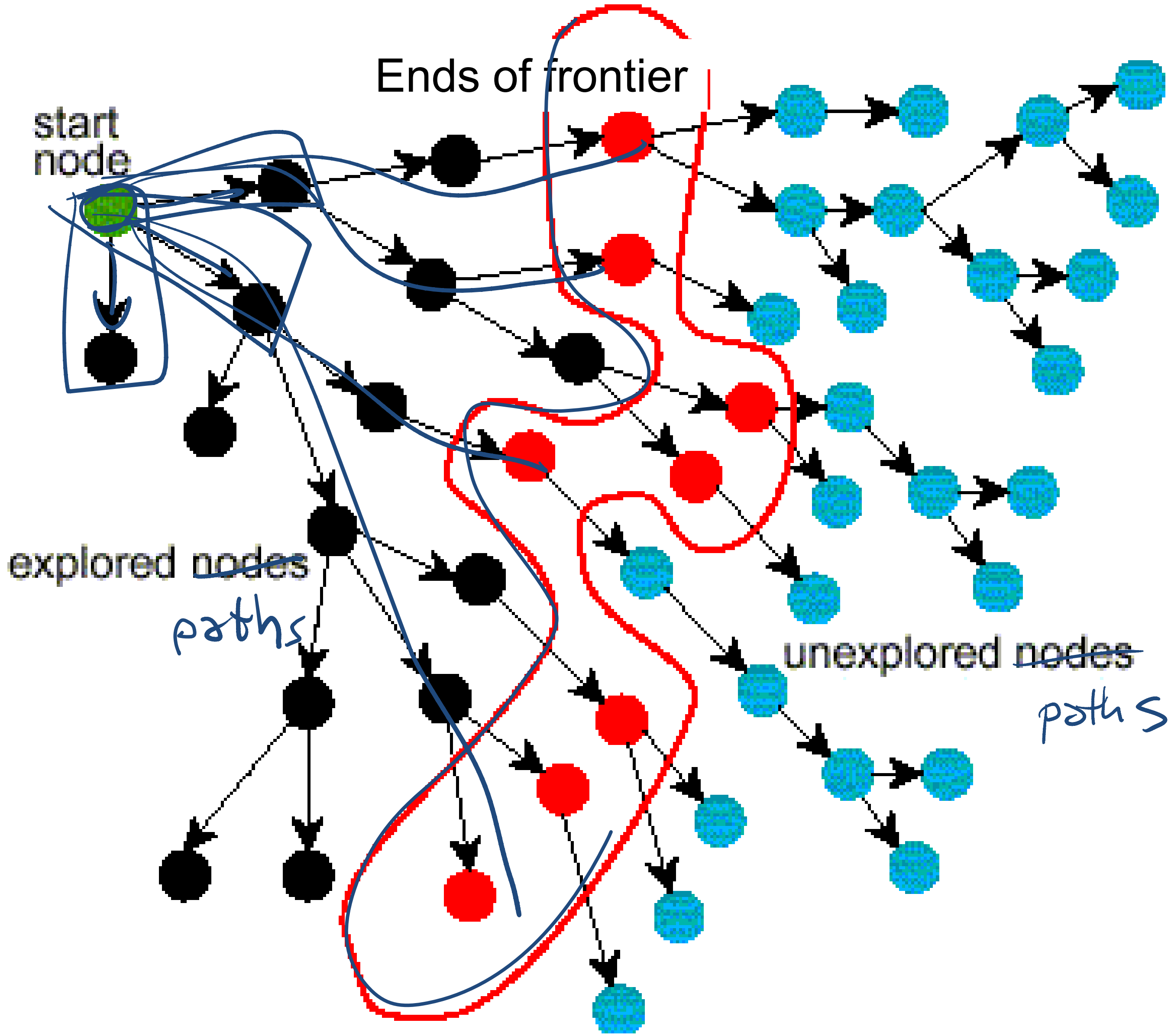
no solution found



goal(E) = T

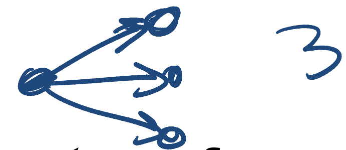
Frontier
<A>
<A B>
<A C>
<A D>
<A D E>

Problem Solving by Graph Searching



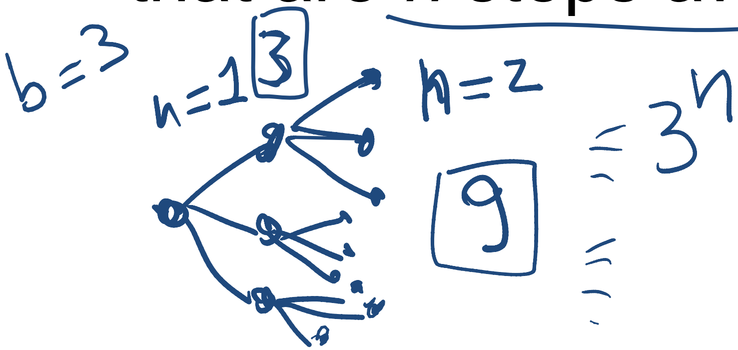
Branching Factor

The ***forward branching factor*** of a node is the number of arcs going out of the node



The ***backward branching factor*** of a node is the number of arcs going into the node

If the forward branching factor of any node is *b* and the graph is a tree, there are b^n nodes that are *n* steps away from a node



Lecture Summary

- Search is a key computational mechanism in many AI agents
- We will study the basic principles of search on the simple **deterministic planning agent model**

Generic search approach:

- define a search space graph,
- start from current state,
- incrementally explore paths from current state until goal state is reached.

The way in which the frontier is expanded defines the search strategy.

Learning Goals for today's class

- **Identify** real world examples that make use of deterministic, goal-driven planning agents
- **Assess** the size of the search space of a given search problem.
  How many possible states
- **Implement** the generic solution to a search problem.

see also Mars Explorer Lecture 2

Next class (Wed)

- Uninformed search strategies

(read textbook Sec. 3.4)

- First Practice Exercise will be posted today on WebCT