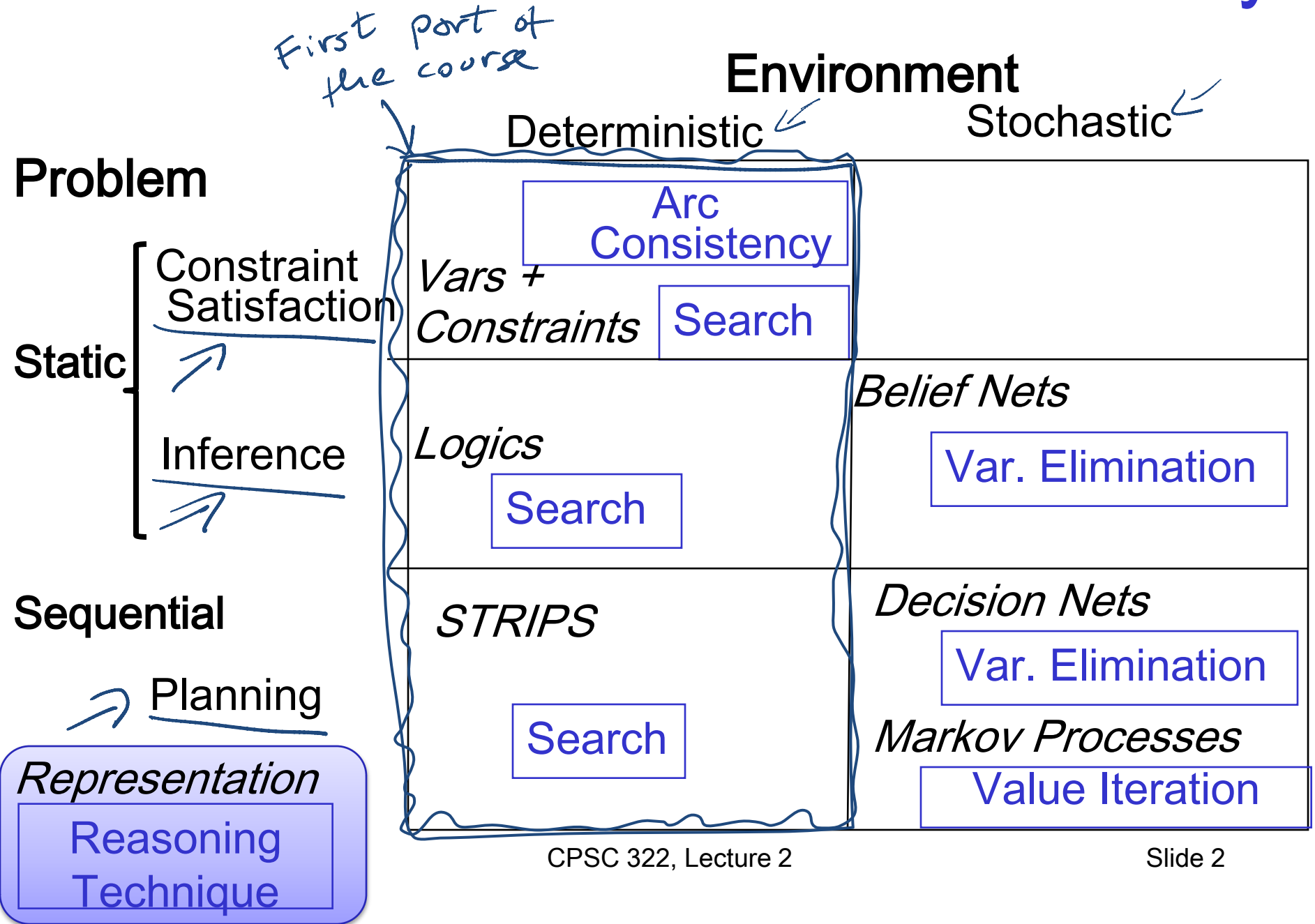
Search: Intro

Computer Science cpsc322, Lecture 4

(Textbook Chpt 3.0-3.3)

January, 12, 2009

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



Lecture Overview

- **Simple Agent and Examples**
- Search Spaces
- Search Procedure

Simple Planning Agent

Deterministic, goal-driven agent

- 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

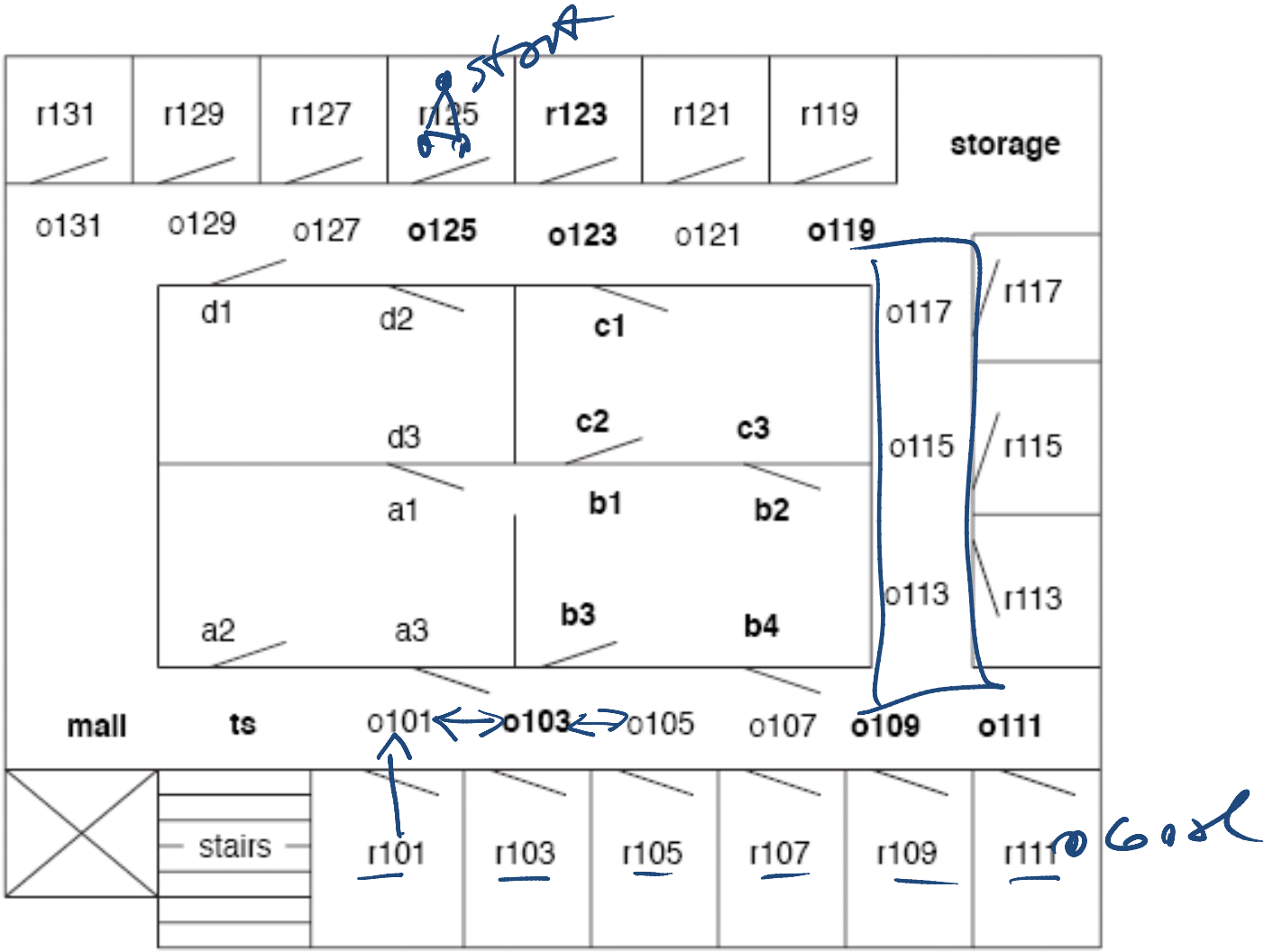
Three examples

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

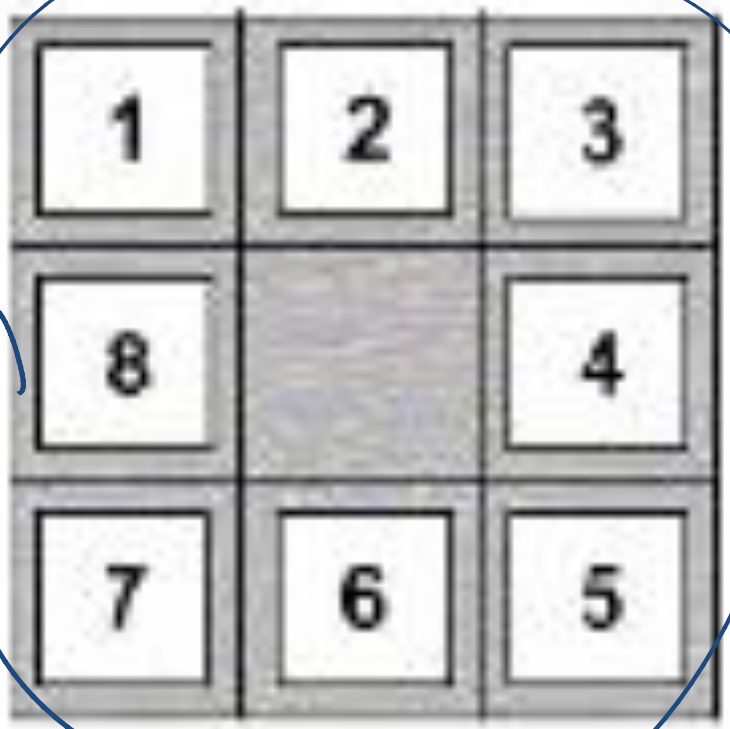
Example1: Delivery Robot



Example 2: 8-Puzzle?

of states = $9! \sim 360 * 10^3$

Possible start state



Goal state

Example: vacuum world

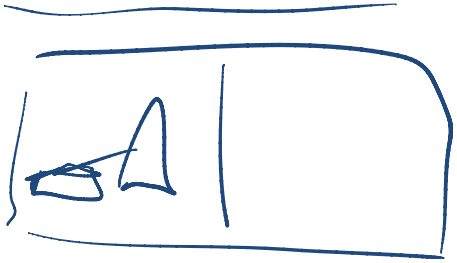
3 Features

the robot can be in two possible locations

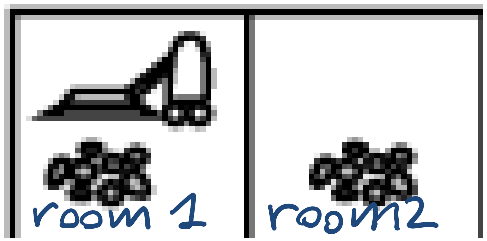
loc has two values $\{r_1, r_2\}$

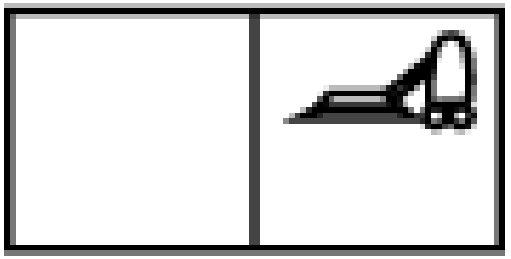
clean-r_1 " " {true, false}

clean-r_2 " " {true, false}



r_1 r_2





Possible start state

Goal state(s)

# of states

$2 * 2^2$

given K rooms

GENERALIZE

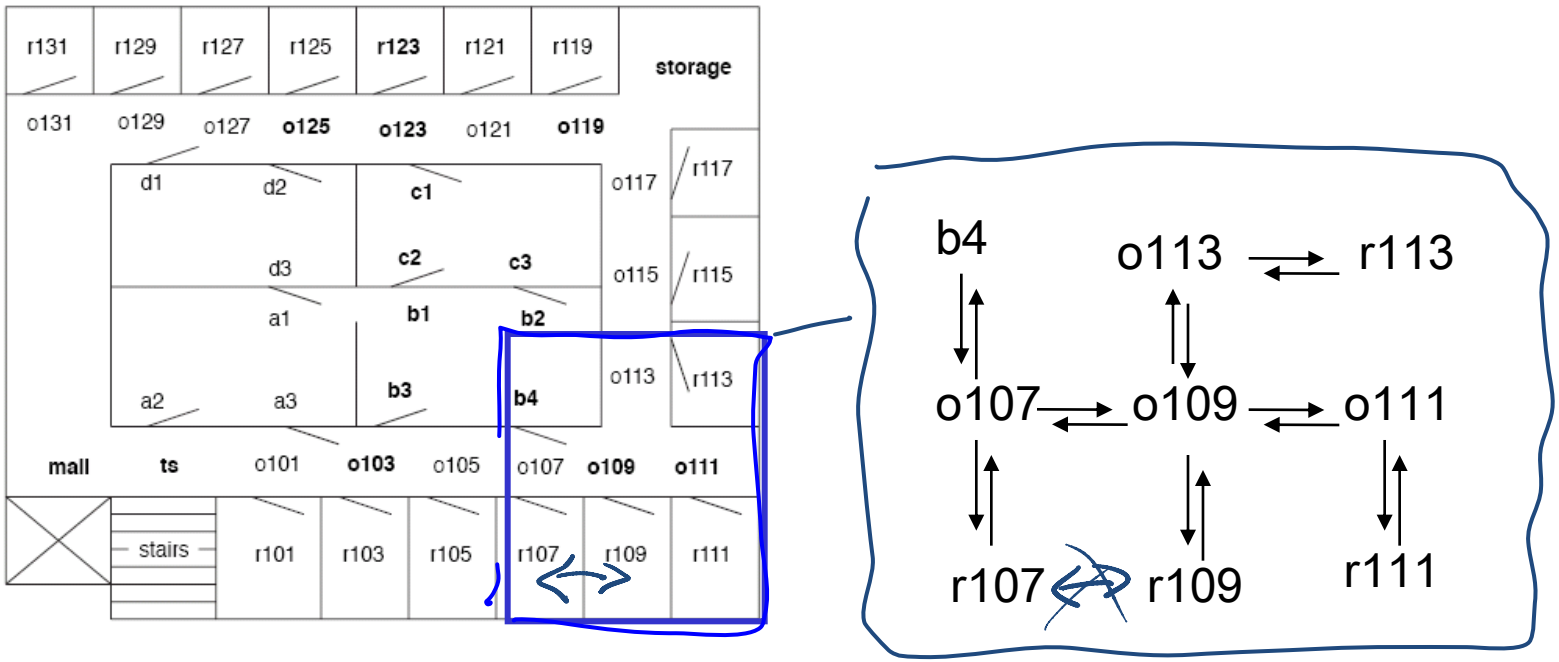
$K 2^K$ states

Lecture Overview

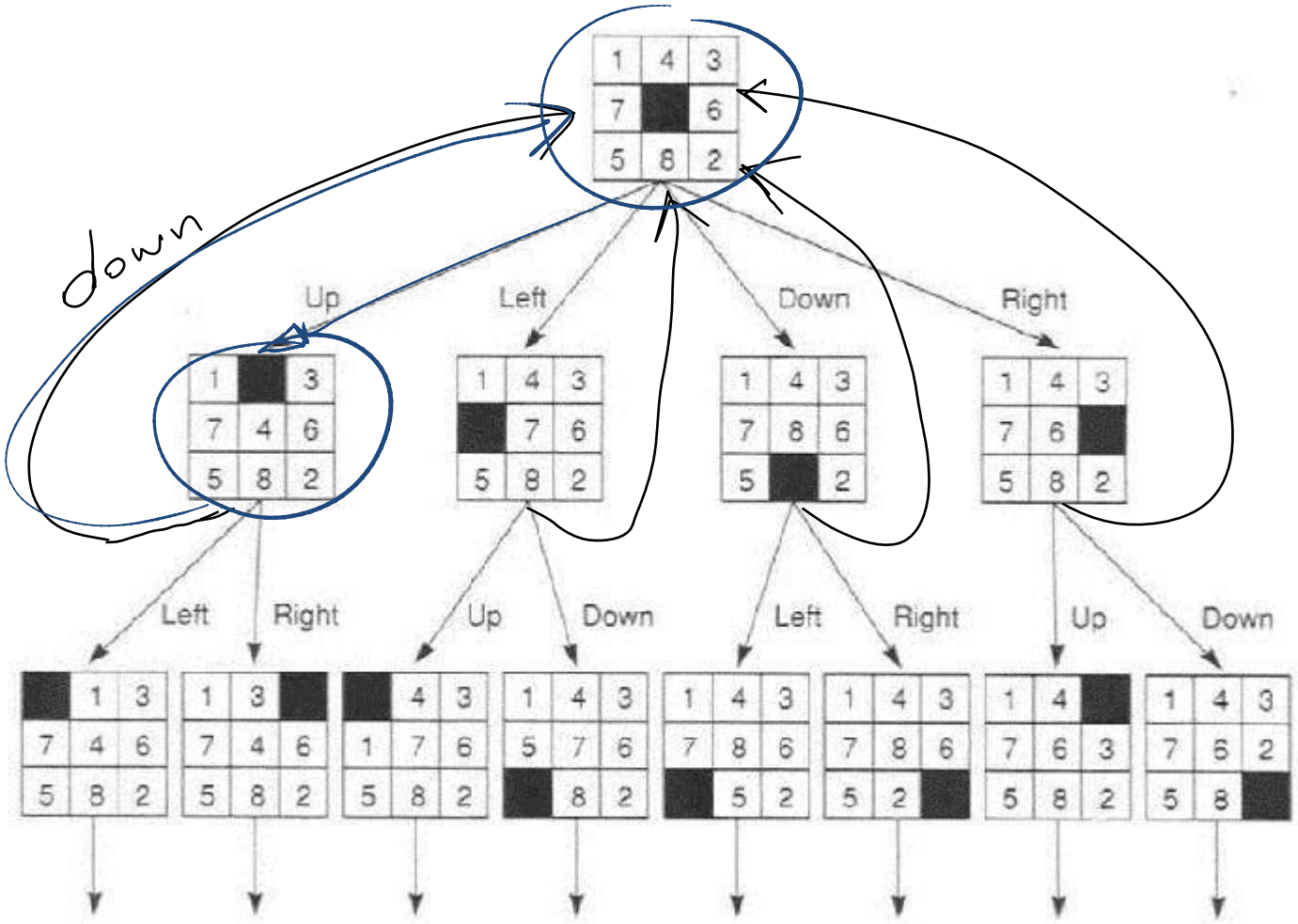
- Simple Agent and Examples
- Search Spaces ≈ Graph
- Search

How can we find a solution?

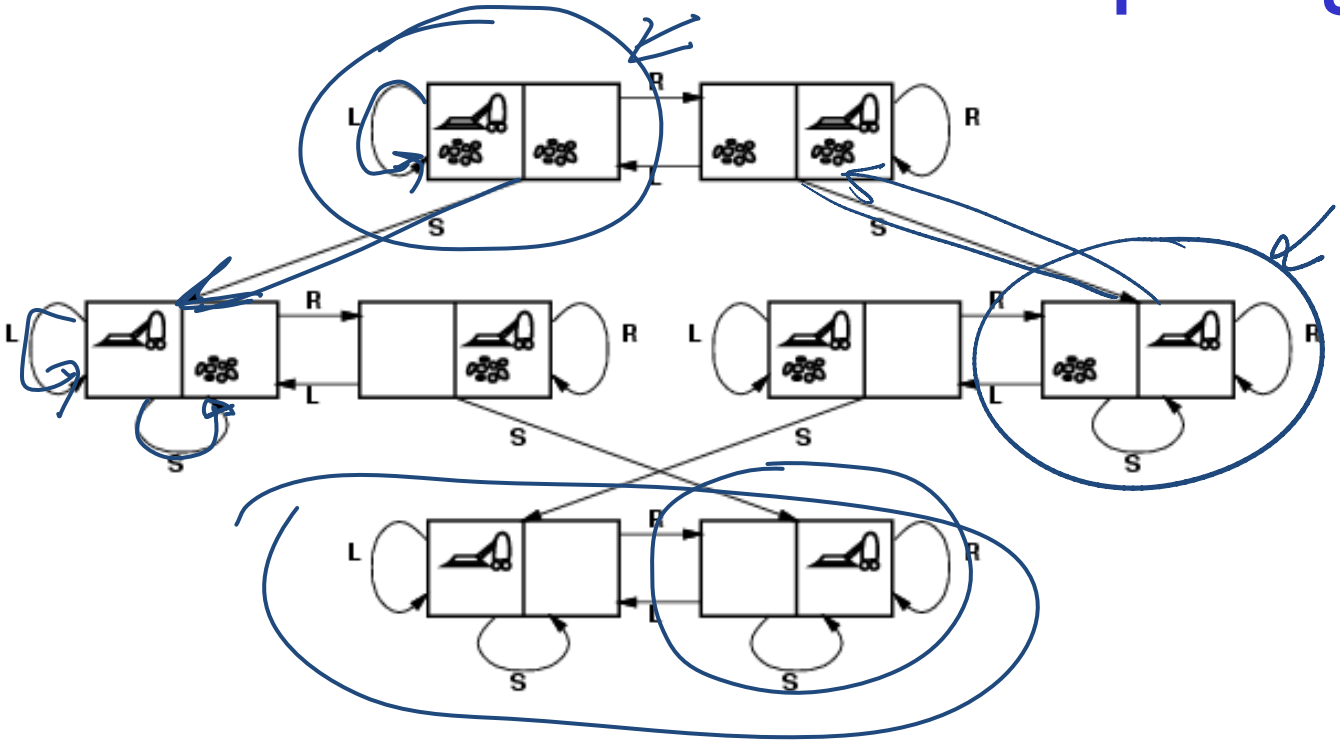
- How can we find a sequence of actions and their appropriate ordering that lead to the goal?
- Define underlying **search space**. A graph where **nodes are states** and **edges are actions**.



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 Spaces = 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 $\langle n_1, n_2 \rangle \in A$.

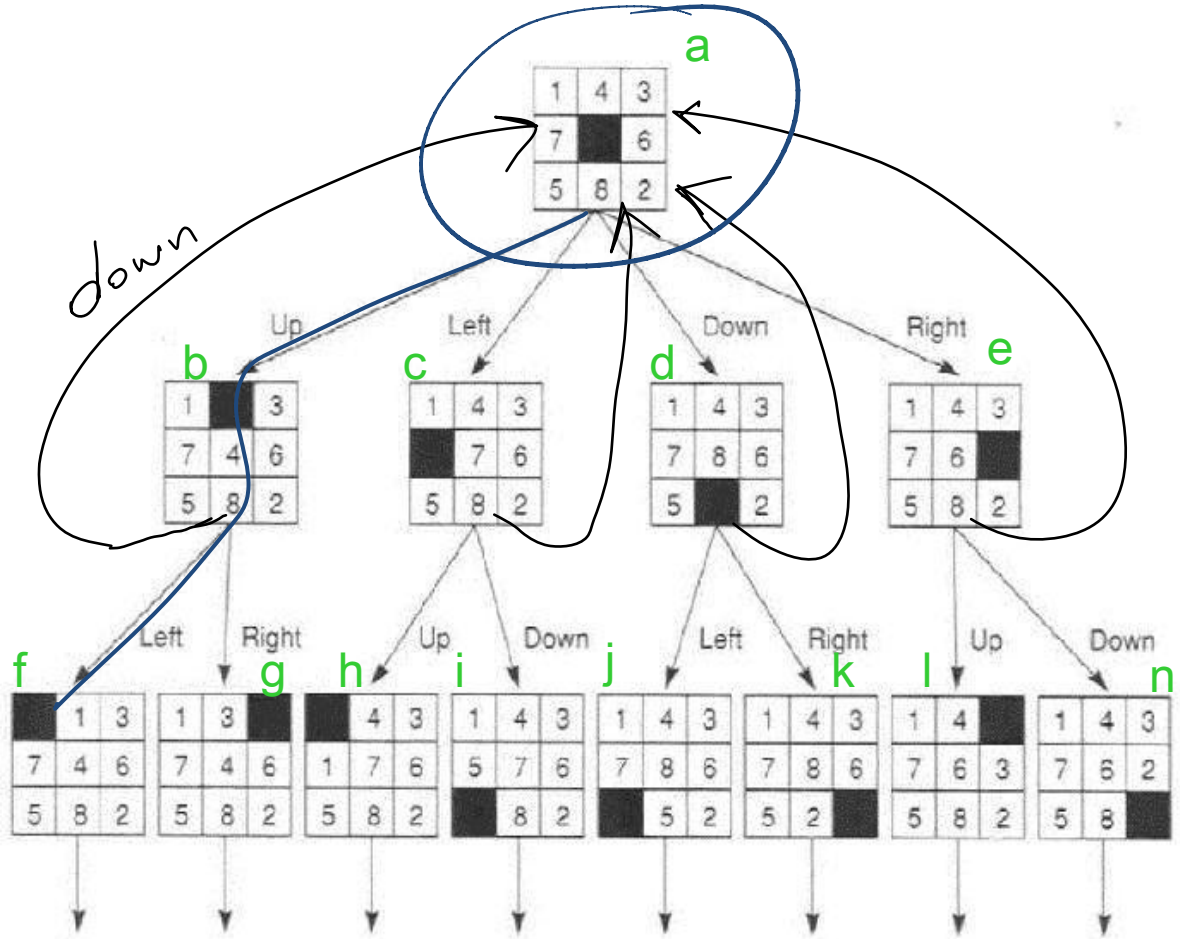
A ***path*** is a sequence of nodes $n_0, n_1, .., n_k$ such that $\langle n_{i-1}, n_i \rangle \in A$.

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

Examples for graph formal def.



Examples of solution

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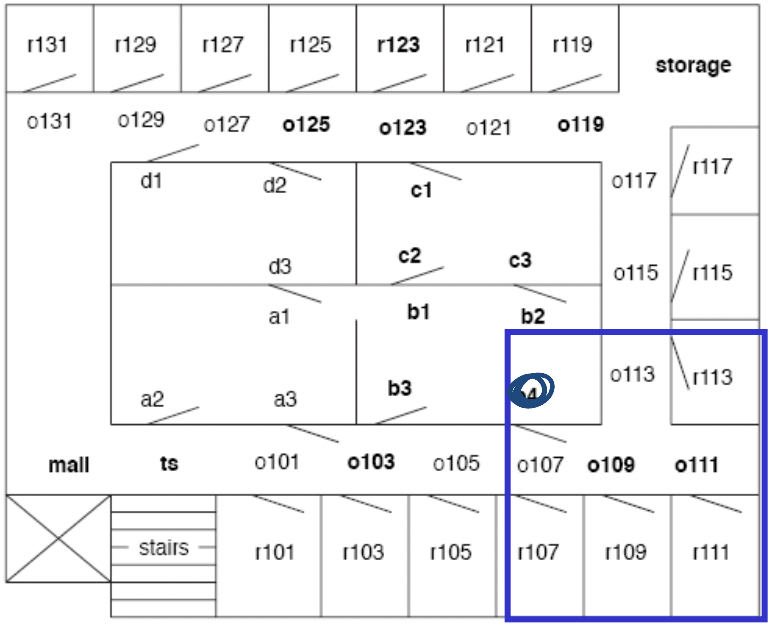
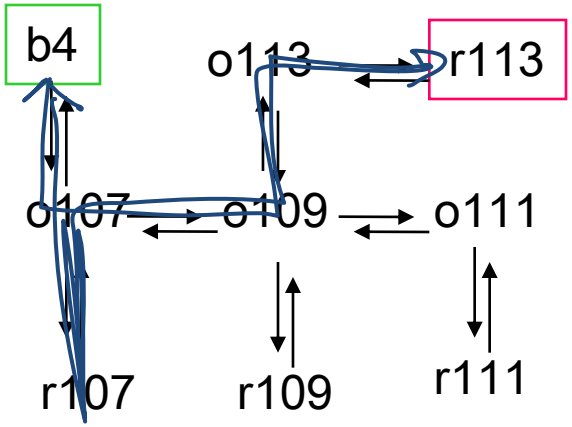




Graph Searching

Generic search algorithm: given a graph, start node(s), 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 set of start nodes, 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,….,n_k> from *frontier;*

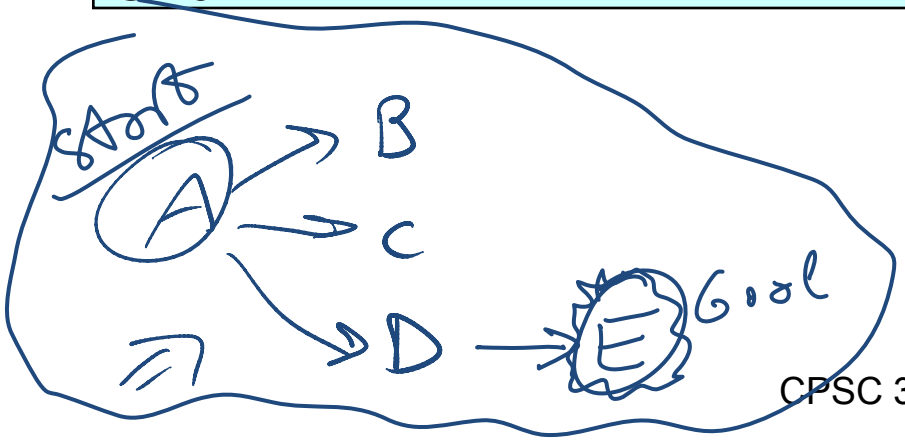
  If *goal*(n_k)

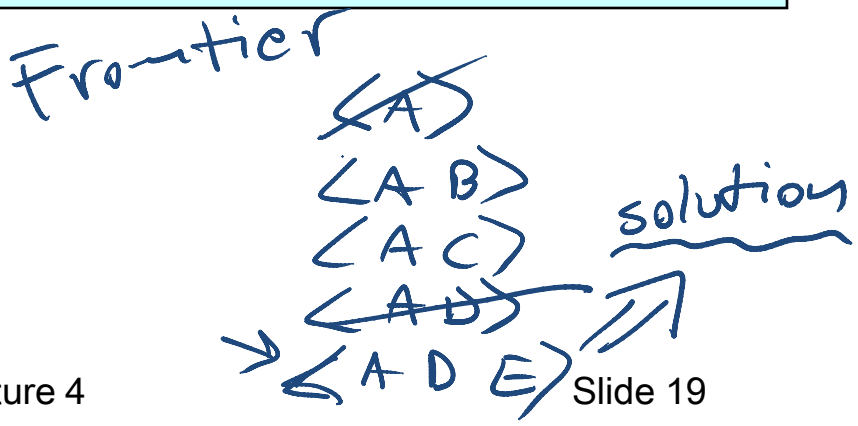
    return <n_o,….,n_k>;

  For every neighbor *n* of n_k

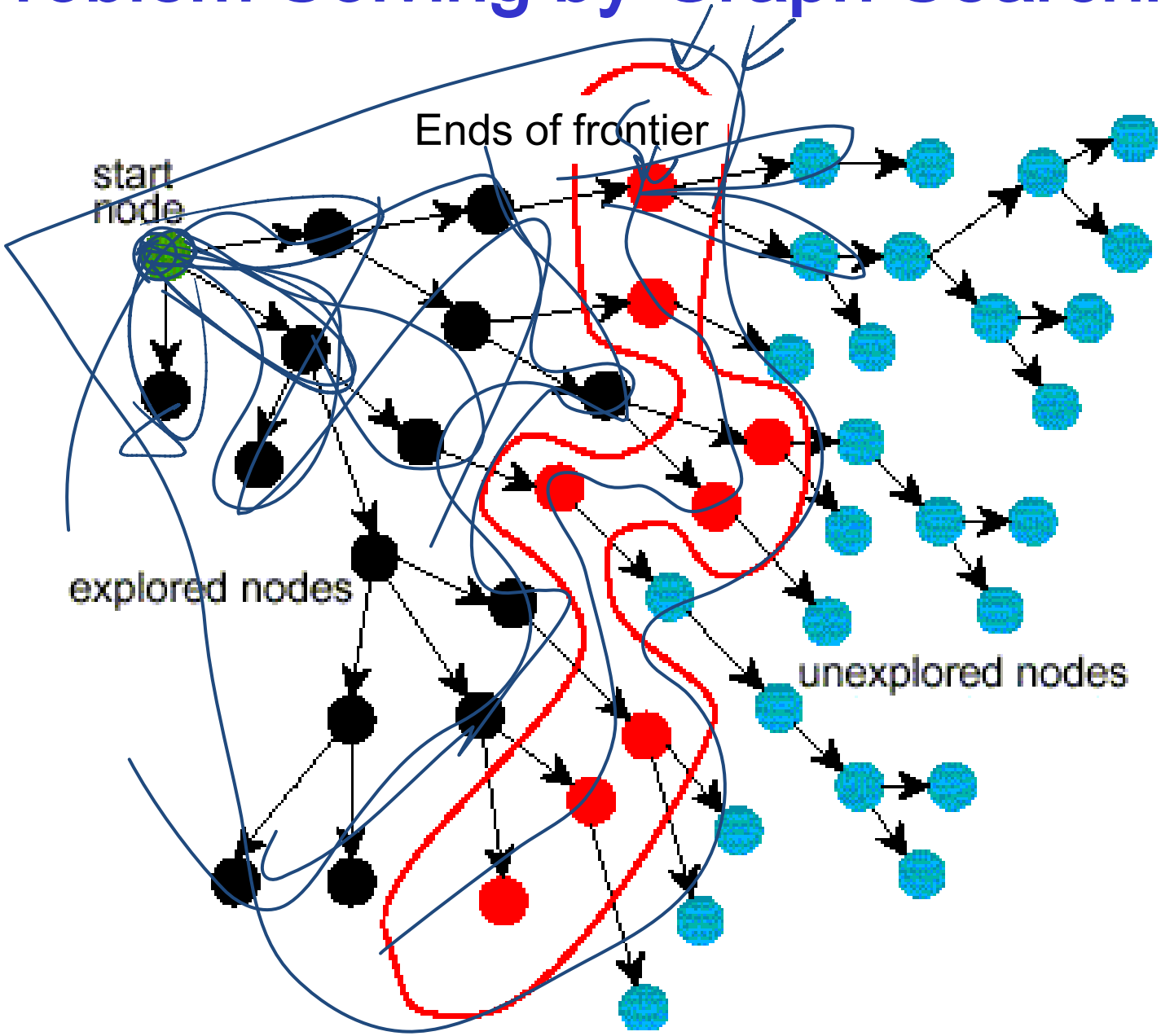
    add <n_o,….,n_k, *n*> to *frontier;*

end





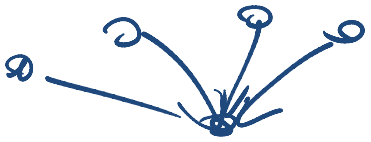
Problem Solving by Graph Searching



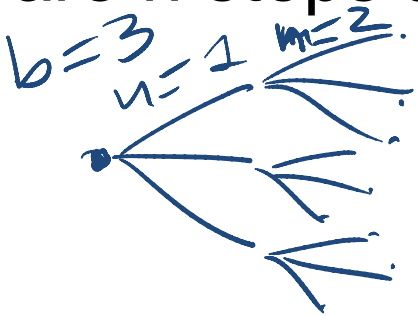
Branching Factor

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



3^2

30

5

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**

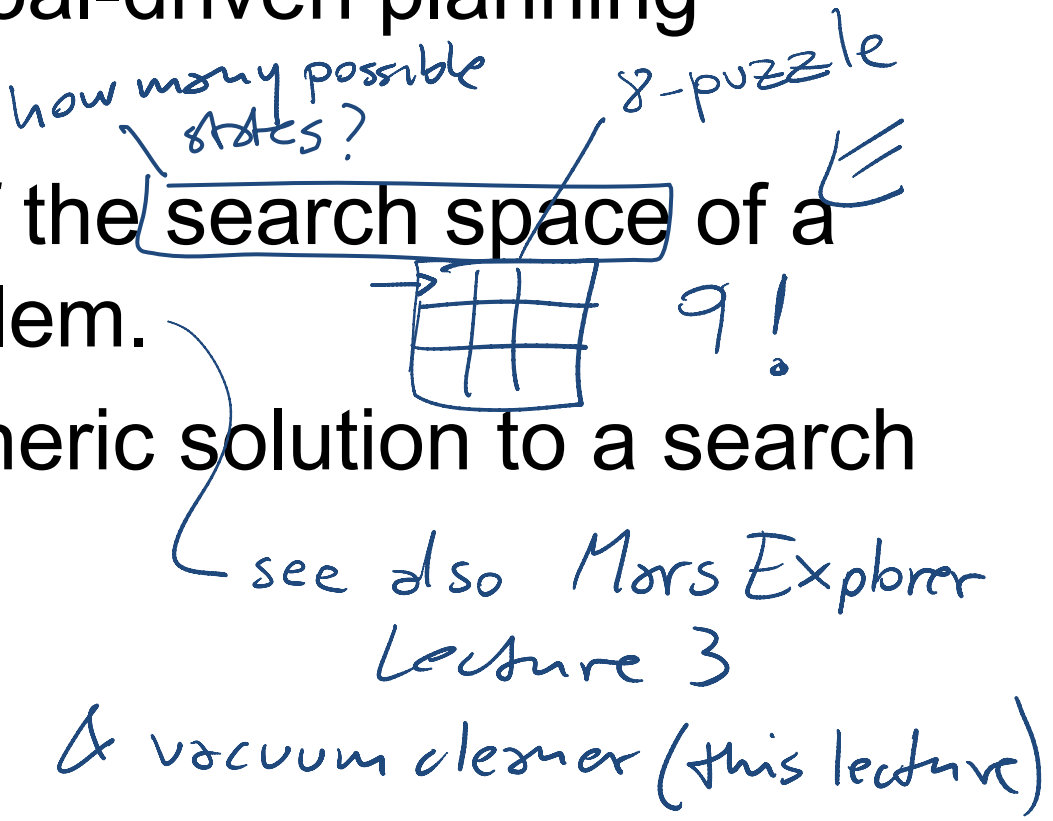
Generic search approach:

- 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.
- Implement the generic solution to a search problem.



Next class (Wed)

- Uninformed search strategies

(read textbook Sec. 3.4)

- First Practice Exercise will be posted today on WebCT