

## Problem solving

- What is problem solving?
- Weak and strong methods.
- Weak methods of problem solving.

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## There are problems all around us.

- Much of our life is spent solving problems.

Getting into the cookie jar without your mother noticing.



Stopping wars.



Doing a crossword puzzle.

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## What makes these problems?

- Four aspects to a problem
  - Goal
    - What is to be accomplished?
  - Givens
    - What is known from the start of the problem?
  - Means of transformation
    - How can the initial state be modified?
  - Obstacles
    - Something that stands between the initial state and the goal.
- What would happen if one of these aspects were missing?

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## Types of problems

- Well-defined problems

- All four aspects of the problem are specified.

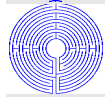
- Towers of Hanoi
- Mazes



- Ill-defined problems

- One or more of the aspects of the problem are not well specified.

- Stopping a war
- Getting cookies without your mother knowing.



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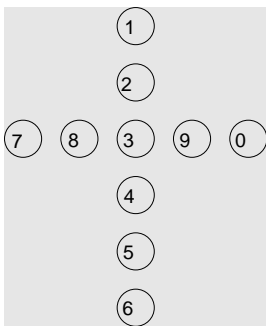
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Move one coin so that there are two straight lines of six coins which cross each other at the center point of each line.

What kind of problem is this?  
Ill-defined?  
Well-defined?

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## How do we solve problems?

- Sometimes a problem is novel
  - Then we use general problem solving strategies
  - These are called “weak” methods
- Sometimes a problem is more familiar
  - Then we can use our background knowledge
  - These are called “strong methods”
- We will focus on “weak” methods today
  - “Strong” methods will be discussed next class.

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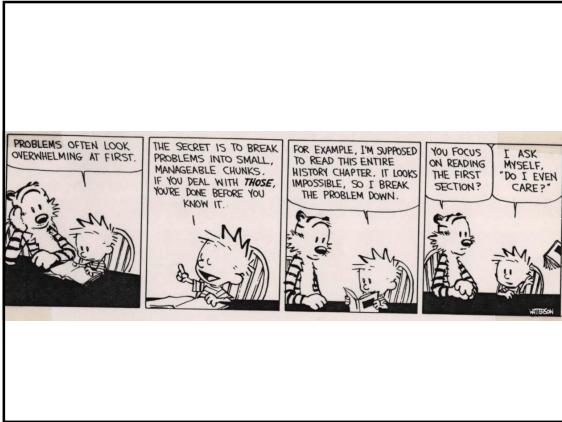
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### Problem solving as search

- Consider a well-defined problem
  - The givens are known
  - The means of transformation are known
  - The goal is known
- The obstacle is generally that there are so many possible solutions it is hard to find the right one.
  - We must search for the right solution.




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### The problem space

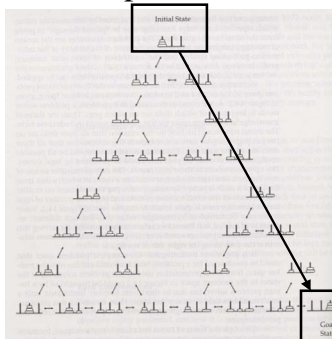
- 3 disc Towers of Hanoi problem.

Initial State

Goal State

Search for a path from the initial state to the end state.

For this problem, the whole space can be enumerated.




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## What if the search space is too large?

- It is not possible to enumerate the entire search space for all well-defined problems.
  - Chess: After a few moves, there are too many possible moves and counter moves to consider all of them.
- We must use constraints
  - Often called *heuristics*
  - A heuristic is a general guideline
    - It is likely to lead to a good solution
    - Not guaranteed to work

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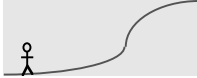
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## Hill climbing

- Find some measure of the distance between your present state and the end state.
  - Take a step in the direction that most reduces that distance.



- A potential local minimum problem.



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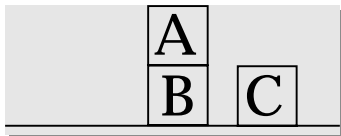
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## An example

- Stacking blocks



Create a stack with A on top, the B, then C.



Sometimes you have to move away from your solution to reach it.

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## Means-end analysis

- Try to reduce the largest difference between the initial state and the goal state first.
- How should you get from UT to the Empire State Building?
  - Fly from Austin to New York
    - That takes care of the biggest difference.
  - That creates new sub-problems
    - Getting from UT to the airport
    - Getting from a New York airport to the Empire State Building
  - Each of these new sub-problems needs to be solved.

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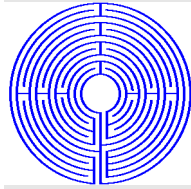
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## Working backward

- Sometimes it is hard to solve a problem by starting at the initial state
  - Many puzzles are intentionally designed to be hard to solve from the givens.
- It can be useful to start at the end state and work backward.



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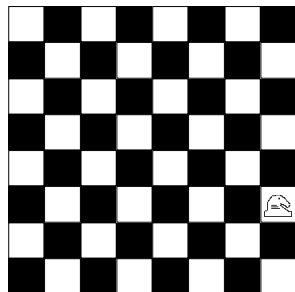
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## Problem Representation

- What is the largest number of knights you can put on a chessboard where no two knights can attack each other?



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## Summary

- Problems involve overcoming obstacles
- Weak methods of problem solving
  - Domain general heuristics for solving problems
  - Best for well-defined problems
    - No real mechanisms for dealing with ill-defined problems
    - Domain knowledge needed for this.

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