Section 2.4

Problem Solving and Heuristics

A CLASSIC PROBLEM

You have two water jugs: a 4-gallon jug and a 3-gallon jug. Neither jug has any measure markings on it. There is also a water pump that you can use to fill the jugs. Your problem, however, is that you need exactly 2 gallons of water in the larger jug so that you can make your secret recipe.

AN APPROACH TO PROBLEM SOLVING

- Define the problem precisely. This included precise specifications of what the initial situation will be as well as what constitutes an acceptable solution to the problem.
- Analyze the problem. Some feature or features can have a tremendous impact on the techniques we should use in solving the problem. Understand the "legal moves" you can make to try to find a solution.
- Choose the best technique and apply it.

LEGAL MOVES FOR THE WATER JUG PROBLEM

- We can fill either jug completely from the pump.
- We can pour all the water from one into the other jug.
- We can fill one jug from the other jug.
- We can dump all the water from either jug.

PROBLEM SOLVING APPROACH APPLIED TO GRAPH THEORY

- We want to move from one situation (vertex) to another by performing one of a set of **legal moves**.
- We want to move from our **present state** (the starting vertex) to some other state via a sequence of legal moves.
- The digraph (or graph) we create for the situation and the collection of legal moves that define its arcs constitute the **state space** (or **state graph**) of the problem.

BLIND SEARCH

Often applying the problem solving techniques in graph theory results in a **blind search**. A blind search is where we cannot see the entire graph only the local neighbors of the vertex we are currently examining.

OTHER APPROACHES

Sometimes we must sacrifice completeness to save time, money, etc. There are two common approaches.

- Sometimes an exact solution is not needed. In which case we search for the best approximate solution.
- Sometimes we make decisions during the search that mean we never examine all vertices. If we make “good” decisions, we avoid “wrong turns” and arrive at a solution more quickly.

HEURISTIC

A **heuristic** is a technique that improves the efficiency of a search, while possibly sacrificing claims of completeness. (The second idea on the previous slide.)

SEARCH HEURISTICS

- A **best-first search** goes to the “best” neighbor. (“Best” is defined at the beginning of our search.)
- A **hill climbing** technique goes to the neighbor that produces the greatest improvement relative to some heuristic test.

PROBLEMS THAT ARISE

- A **local maximum** is achieved if the present vertex is not a solution and all neighbors fail to improve our position.
- If all neighbors are essentially equivalent, a **plateau** has been reached.
- The state space could not be a connected graph, and we happen to be in a component that contains no solutions.

STRATEGIES FOR DEALING WITH PROBLEMS

- Backtrack to a previous vertex and start the search again.
- Make a “big jump” to a new vertex, possibly by making two or more moves without regard to the heuristic test.
- Apply two or more moves all the time, using several levels of vertices to try to determine the next state. This process is called **lookahead**.