Chapter 5

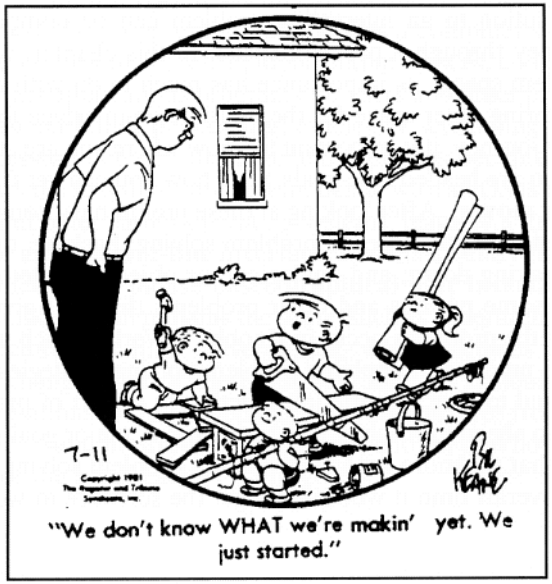
Problem Solving *before* Programming

5.1 Problem-Solving Strategies

Finding algorithmic solutions to programming problems is like solving mysteries in detective stories.

- **Analytical** problem-solving:
  - the “Hercule Poirot” approach
  - careful laying out of the evidence
  - logically putting together little clues
- **Analogical** approach:
  - the “Jane Marple” approach
  - finding solutions by analogy or comparison to already solved problems

- Trial and error, **hacking**:



This approach is, of course, less recommended — at least for beginners.

5.2 Algorithms as Paths Through "Problem Spaces"

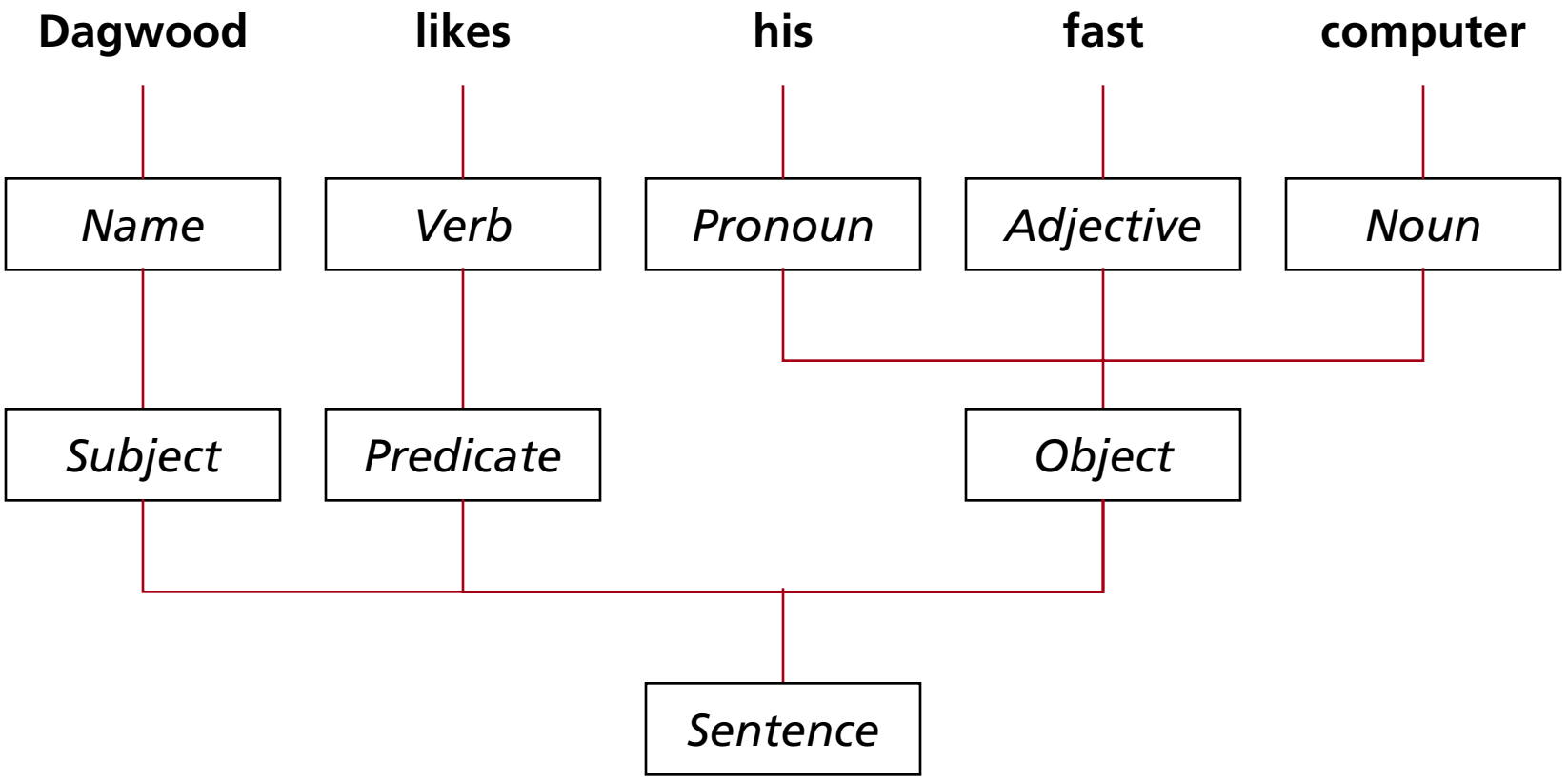
Algorithm: a precise specification of a behaviour intended to solve a well-defined problem

Coding: the translation of an algorithm into a particular programming language

Program: a step-by-step execution plan that a computer can perform as a sequence of simple steps or instructions

Sequences can have complex underlying structures.

Example: sentences



5.3 Givens, Goals, and Resources

- **Givens**: initial conditions of the problem
  (the way things are)
- **Goals**: desired state(s)
  (the way things should be)

Any problem can be formulated at least as givens and goals.

- **Resources**: the means or methods that can transform a problem state into another,
  in order to move the solver from givens to goals in a step-by-step manner

Differences in givens, goals, and resources make different problems (example: different levels of programming environments).

Examples:

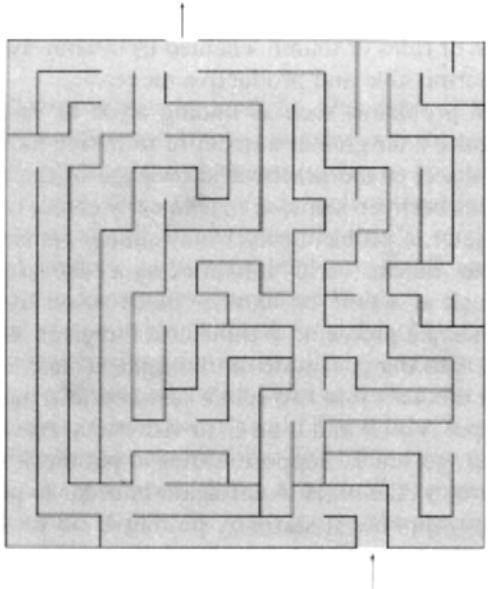
- **Game playing**
  - Given: initial game setup
  - Goal: win!
  - Resources: possible moves
- **Preparing a meal**
  - Givens: available ingredients and cookin facilities
  - Goal: end up with something to eat
  - Resources: recipe, the cook's experience, ...

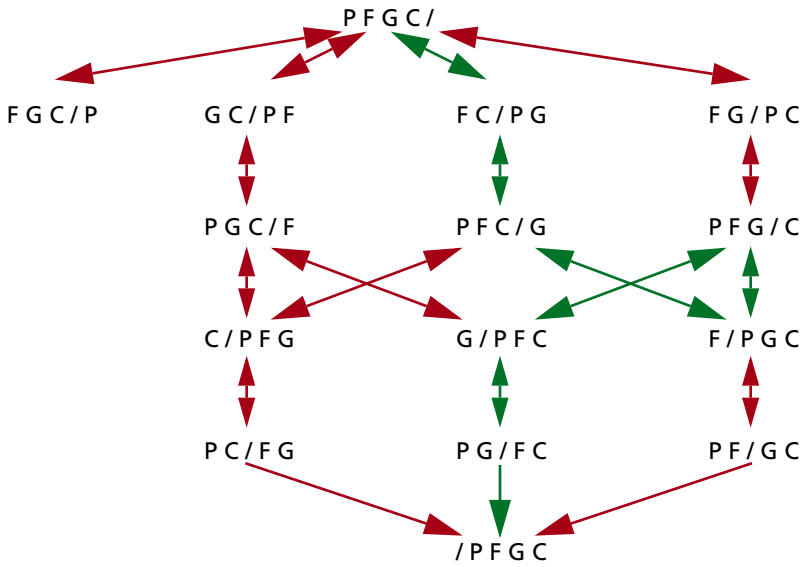
Note: Many of our daily problems are ill-defined: the givens, goals, resources, or combinations of the three, is **unclear**.

Example: client — application programmer — programming language — computer

5.4 Analysing and Exploring Problem Spaces

Problem space: a complete set of possible states, generated by exploring all the possible steps, or moves, which may or may not lead from a given state to a goal state.





What should we know for a preliminary analysis of a problem?

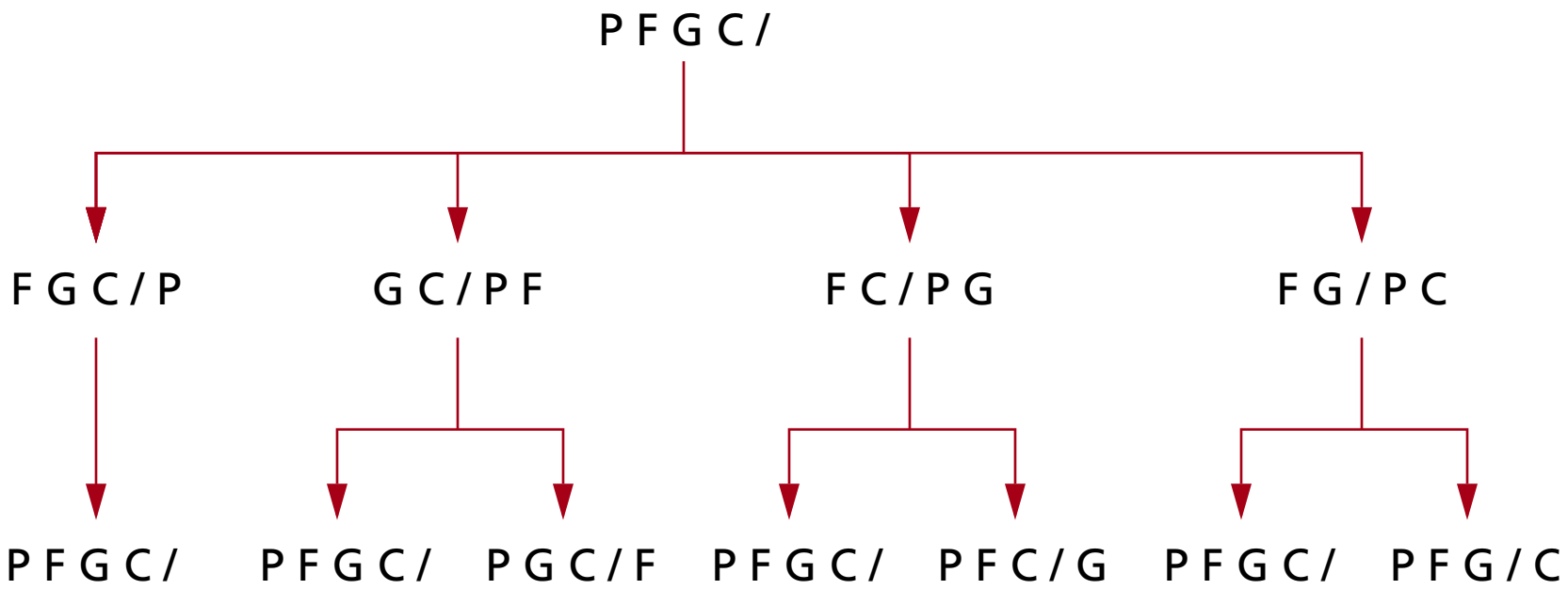
- What are the **givens**? Do we really have all of them?
  - Are the givens **specific** to a particular situation?
  - Can we **generalize**?
  - Is there a **notation** that represents the givens and other states succinctly?
- What is the **goal**?
  - Is there are single goal, or are there several?
  - If there is a single goal, can it be split into pieces?
  - If there are several goals or subgoals, are they independent or are they connected?
  - Are there obstacles to overcome to reach a goal? How can they be overcome?
  - Are there any constraints on developing a solution?

- What are the **resources** (moves, operators, procedures, rules, transformations)?
  - For each resource, are there constraints, or preconditions, to be addressed before applying it?
  - If so, are there other, possibly simpler, resources that meet the preconditions?
  - What are the variants? When you apply a resource, what changes?
  - What are the invariants? When you apply a resource, what stays the same?
  - Are there more powerful resources for this problem?
  - Would someone else know these resources?
  - ...

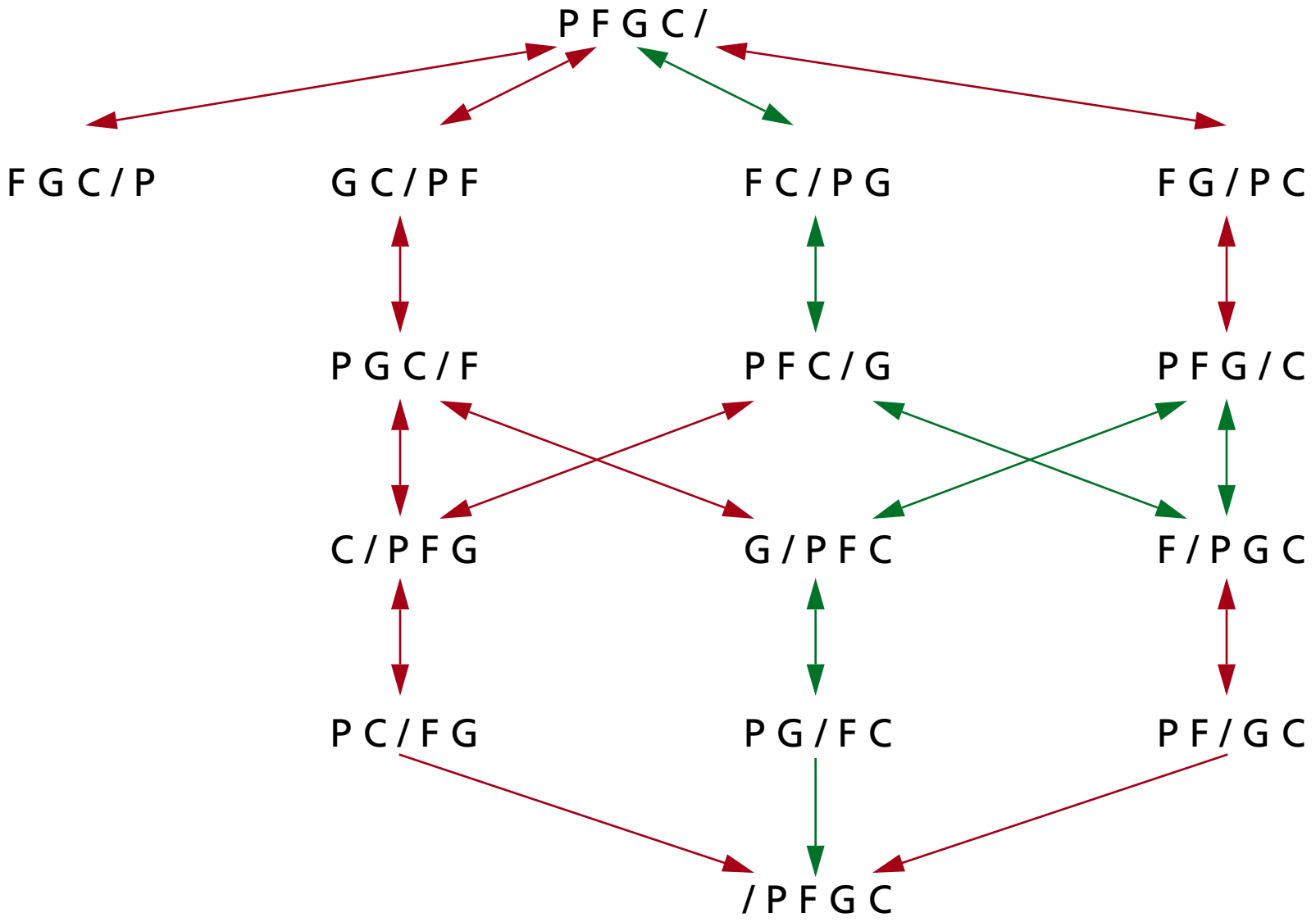
5.5 From Blind Search to Informed Search

Example: the FOX-CORN-GOOSE problem

Search tree (for two actions)



State space graph for the FOX-CORN-GOOSE problem



5.6 Analytical Reasoning

Example: Planning a menu for a meal

I. **Preceding Courses:** **(1)**

A. Soup course: (4)

1. Cream of lettice (8)
2. Light sherry (8)

B. Fish course: (4)

1. Filet of sole Veronique (5)

II. **Main Course:** **(1)**

A. **Main dish:** **(2)**

1. **Cornish game hen à l'orange** **(3)**
2. Red wine (12)

B. **Accompanying dishes:** **(2)**

1. **Creamed spinach** **(3)**
2. **Wild rice** **(3)**
3. **Beverage**: dry white wine **(3)** / (7)

III. **Following Courses:** **(1)**

A. Salad course: (5)
   1. Assorted green (9)
   2. Vinaigrette dressing (10)

B. Dessert: (5)
   1. Mandarin orange tart (10)
   2. Sweet, heavier white whine (11)

Laying out an algorithm or a problem solution is like planning a menu.

The different parts of the problem solution are developed in a **top-down** fashion.

An alternative approach would be to develop **bottom-up** (e.g., starting from the ingredients).

5.7 The Analogical Approach

Patient	Vomiting	Abdominal pain	Fever	Pulse	Drug successful
A	yes	yes	high	elevated	yes
B	yes	yes	no	normal	yes
C	yes	no	high	normal	no
D	no	yes	high	elevated	no
E	no	no	high	elevated	no
F	yes	yes	no	elevated	yes
New patient	yes	yes	low	normal	?

5.8 References

- G. Blank and R. Barnes, *The Universal Machine*, Boston, MA: WCB/ McGraw-Hill, 1998. Chapters 2.1 through 2.5.