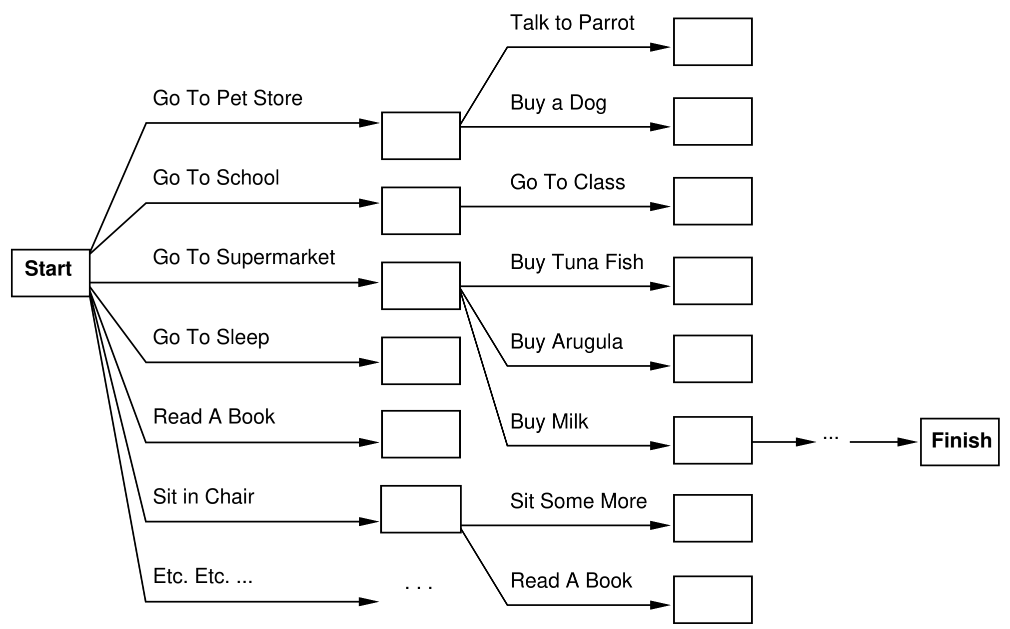

Figure 11.2 Solving a shopping problem with forward search through the space of situations in the world.

direct connections between states and actions. For example, if the agent knows that the goal is a conjunction that includes the conjunct *Have*(*Milk*), and that *Buy*(*x*) achieves *Have*(*x*), then the agent knows that it is worthwhile to consider a plan that includes *Buy*(*Milk*). It need not consider irrelevant actions such as *Buy*(*WhippingCream*) or *GoToSleep*.

The second key idea behind planning is that *the planner is free to add actions to the plan wherever they are needed, rather than in an incremental sequence starting at the initial state.* For example, the agent may decide that it is going to have to *Buy*(*Milk*), even before it has decided where to buy it, how to get there, or what to do afterwards. There is no necessary connection between the order of planning and the order of execution. By making "obvious" or "important" decisions first, the planner can reduce the branching factor for future choices and reduce the need to backtrack over arbitrary decisions. Notice that the representation of states as sets of logical sentences plays a crucial role in making this freedom possible. For example, when adding the action *Buy*(*Milk*) to the plan, the agent can represent the state in which the action is executed as, say, *At*(*Supermarket*). This actually represents an entire class of states—states with and without bananas, with and without a drill, and so on. Search algorithms that require complete state descriptions do not have this option.

The third and final key idea behind planning is that *most parts of the world are independent of most other parts.* This makes it feasible to take a conjunctive goal like "get a quart of milk *and* a bunch of bananas *and* a variable-speed cordless drill" and solve it with a divide-and-conquer strategy. A subplan involving going to the supermarket can be used to achieve the first two