rooms, and which locations they are At. We leave this, and the specification of the operators, as an exercise.

In conclusion, it is possible to represent simple domains with STRIPS operators, but it requires ingenuity in coming up with the right set of operators and predicates in order to stay within the syntactic restrictions that the language imposes.

11.9 SUMMARY

In this chapter, we have defined the planning problem and shown that situation calculus is expressive enough to deal with it. Unfortunately, situation calculus planning using a general-purpose theorem prover is very inefficient. Using a restricted language and special-purpose algorithms, planning systems can solve quite complex problems. Thus, planning comes down to an exercise in finding a language that is just expressive enough for the problems you want to solve, but still admits a reasonably efficient algorithm. The points to remember are as follows:

- Planning agents use lookahead to come up with actions that will contribute to goal achievement. They differ from problem-solving agents in their use of more flexible representations of states, actions, goals, and plans.
- The STRIPS language describes actions in terms of their preconditions and effects. It captures much of the expressive power of situation calculus, but not all domains and problems can be described in the STRIPS language.
- It is not feasible to search through the space of situations in complex domains. Instead we search through the space of plans, starting with a minimal plan and extending it until we find a solution. For problems in which most subplans do not interfere with each other, this will be efficient.
- The principle of least commitment says that a planner (or any search algorithm) should avoid making decisions until there is a good reason to make a choice. Partial-ordering constraints and uninstantiated variables allow us to follow a least-commitment approach.
- The causal link is a useful data structure for recording the purposes for steps. Each causal link establishes a protection interval over which a condition should not be deleted by another step. Causal links allow early detection of unresolvable conflicts in a partial plan, thereby eliminating fruitless search.
- The POP algorithm is a sound and complete algorithm for planning using the STRIPS representation.
- The ability to handle partially instantiated operators in POP reduces the need to commit to concrete actions with fixed arguments, thereby improving efficiency.