plan in the light of unexpected changes in the environment, which might include recovering from execution errors or removing steps that have been made redundant by serendipitous occurrences. Obviously, when it first gets a new goal the agent will have no actions ready to execute, so it will spend a while generating a partial plan. It is quite possible, however, for the agent to begin execution before the plan is complete, especially when it has independent subgoals to achieve. The situated agent continuously monitors the world, updating its world model from new percepts even if its deliberations are still continuing.

As in the discussion of the conditional planner, we will first go through an example and then give the planning algorithm. We will keep to the formulation of steps and plans used by the partial-order planner POP, rather than the more expressive languages used in Chapter 12. It is, of course, possible to incorporate more expressive languages, as well as conditional planning techniques, into a situated planner.

The example we will use is a version of the blocks world. The start state is shown in Figure 13.10(a), and the goal is $On(C,D) \wedge On(D,B)$. The action we will need is $Move(x,y)$, which moves block x onto block y, provided both are clear. Its action schema is

Op(ACTION:$Move(x,y)$,
PRECOND:$Clear(x) \wedge Clear(y) \wedge On(x,z)$,
EFFECT:$On(x,y) \wedge Clear(z) \wedge \neg On(x,z) \wedge \neg Clear(y)$)

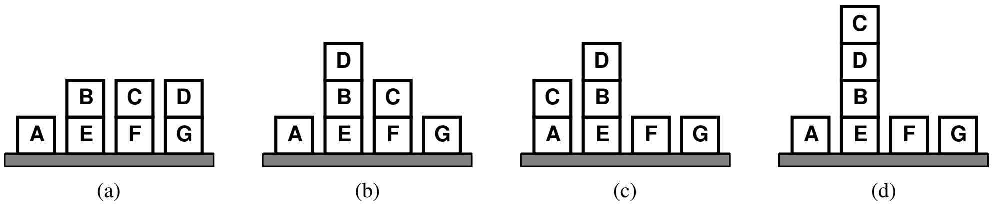

Figure 13.10 The sequence of states as the situated planning agent tries to reach the goal state $On(C,D) \wedge On(D,B)$ as shown in (d). The start state is (a). At (b), another agent has interfered, putting D on B. At (c), the agent has executed $Move(C,D)$ but has failed, dropping C on A instead. It retries $Move(C,D)$, reaching the goal state (d).

The agent first constructs the plan shown in Figure 13.11. Notice that although the preconditions of both actions are satisfied by the initial state, there is an ordering constraint putting $Move(D,B)$ before $Move(C,D)$. This is needed to protect the condition $Clear(D)$ until $Move(D,B)$ is completed.

At this point, the plan is ready to be executed, but nature intervenes. An external agent moves D onto B (perhaps the agent's teacher getting impatient), and the world is now in the state shown in Figure 13.10(b). Now $Clear(B)$ and $On(D,G)$ are no longer true in the initial state, which is updated from the new percept. The causal links that were supplying the preconditions $Clear(B)$ and $On(D,G)$ for the $Move(D,B)$ action become invalid, and must be removed from the plan. The new plan is shown in Figure 13.12. Notice that two of the preconditions for $Move(D,B)$