achieves the *At*(*Home*) precondition.) On the other hand, if the agent goes to the supermarket first, then it cannot go from home to the hardware store.

At this point, we have reached a dead end in the search for a solution, and must back up and try another choice. The interesting part is seeing how *a planner could notice that this partial plan is a dead end without wasting a lot of time on it.* The key is that the the causal links in a partial plan are **protected links**. A causal link is protected by ensuring that **threats**—that is, steps that might delete (or **clobber**) the protected condition—are ordered to come before or after the protected link. Figure 11.10(a) shows a threat: The causal link $S_1 \xrightarrow{c} S_2$ is threatened by the new step S_3 because one effect of S_3 is to delete c. The way to resolve the threat is to add ordering constraints to make sure that S_3 does not intervene between S_1 and S_2. If S_3 is placed before S_1 this is called **demotion** (see Figure 11.10(b)), and if it is placed after S_2, it is called **promotion** (see Figure 11.10(c)).

PROTECTED LINKS
THREATS
DEMOTION
PROMOTION

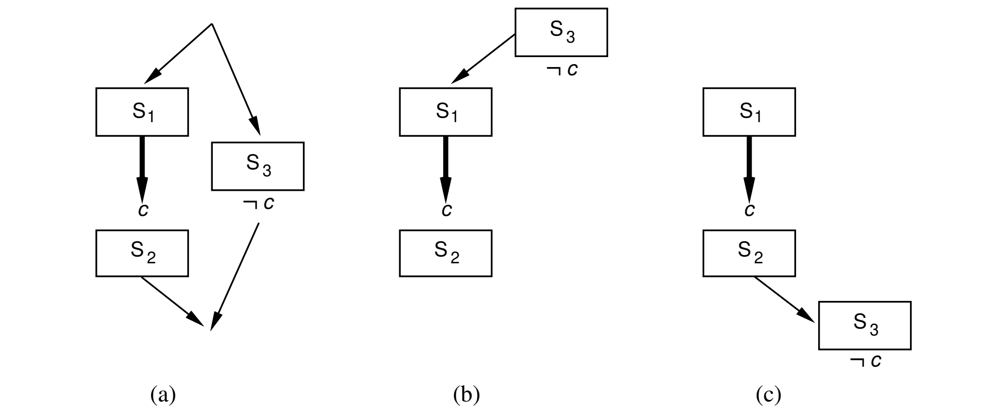

Figure 11.10 Protecting causal links. In (a), the step S_3 threatens a condition c that is established by S_1 and protected by the causal link from S_1 to S_2. In (b), S_3 has been demoted to come before S_1, and in (c) it has been promoted to come after S_2.

In Figure 11.9, there is no way to resolve the threat that each *Go* step poses to the other. Whichever *Go* step comes first will delete the *At*(*Home*) condition on the other step. Whenever the planner is unable to resolve a threat by promotion or demotion, it gives up on the partial plan and backs up to try a different choice at some earlier point in the planning process.

Suppose the next choice is to try a different way to achieve the *At*(x) precondition of the *Go*(*SM*) step, this time by adding a causal link from *Go*(*HWS*) to *Go*(*SM*). In other words, the plan is to go from home to the hardware store and then to the supermarket. This introduces another threat. Unless the plan is further refined, it will allow the agent to go from the hardware store to the supermarket without first buying the drill (which was why it went to the hardware store in the first place). However much this might resemble human behavior, we would prefer our planning agent to avoid such forgetfulness. Technically, the *Go*(*SM*) step threatens the *At*(*HWS*) precondition of the *Buy*(*Drill*) step, which is protected by a causal link. The threat is resolved by constraining *Go*(*SM*) to come after *Buy*(*Drill*). Figure 11.11 shows this.