Planning and Acting

Chapter 13

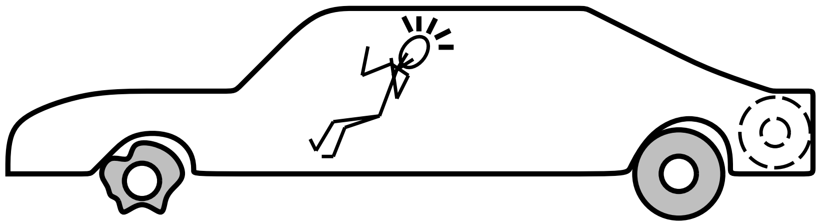
Outline

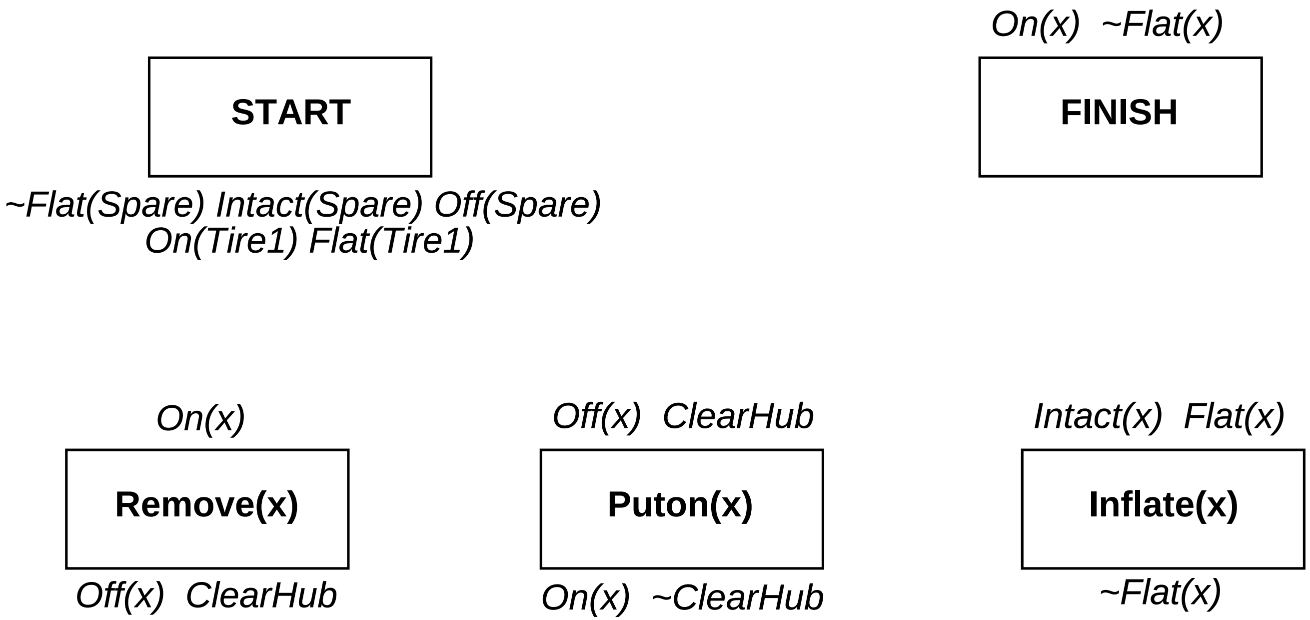
◊ The real world

◊ Conditional planning

◊ Monitoring and replanning

The real world





Things go wrong

Incomplete information

Unknown preconditions, e.g., $Intact(Spare)$?

Disjunctive effects, e.g., $Inflate(x)$ causes

$$Inflated(x) \lor SlowHiss(x) \lor Burst(x) \lor BrokenPump \lor \ldots$$

Incorrect information

Current state incorrect, e.g., spare NOT intact

Missing/incorrect postconditions in operators

Qualification problem:

can never finish listing all the required preconditions and possible conditional outcomes of actions

Solutions

Conformant or sensorless planning

Devise a plan that works regardless of state or outcome

Such plans may not exist

Conditional planning

Plan to obtain information (**observation actions**)

Subplan for each contingency, e.g.,

$[Check(Tire1), \mathbf{if}\ Intact(Tire1)\ \mathbf{then}\ Inflate(Tire1)\ \mathbf{else}\ CallAAA$

Expensive because it plans for many unlikely cases

Monitoring/Replanning

Assume normal states, outcomes

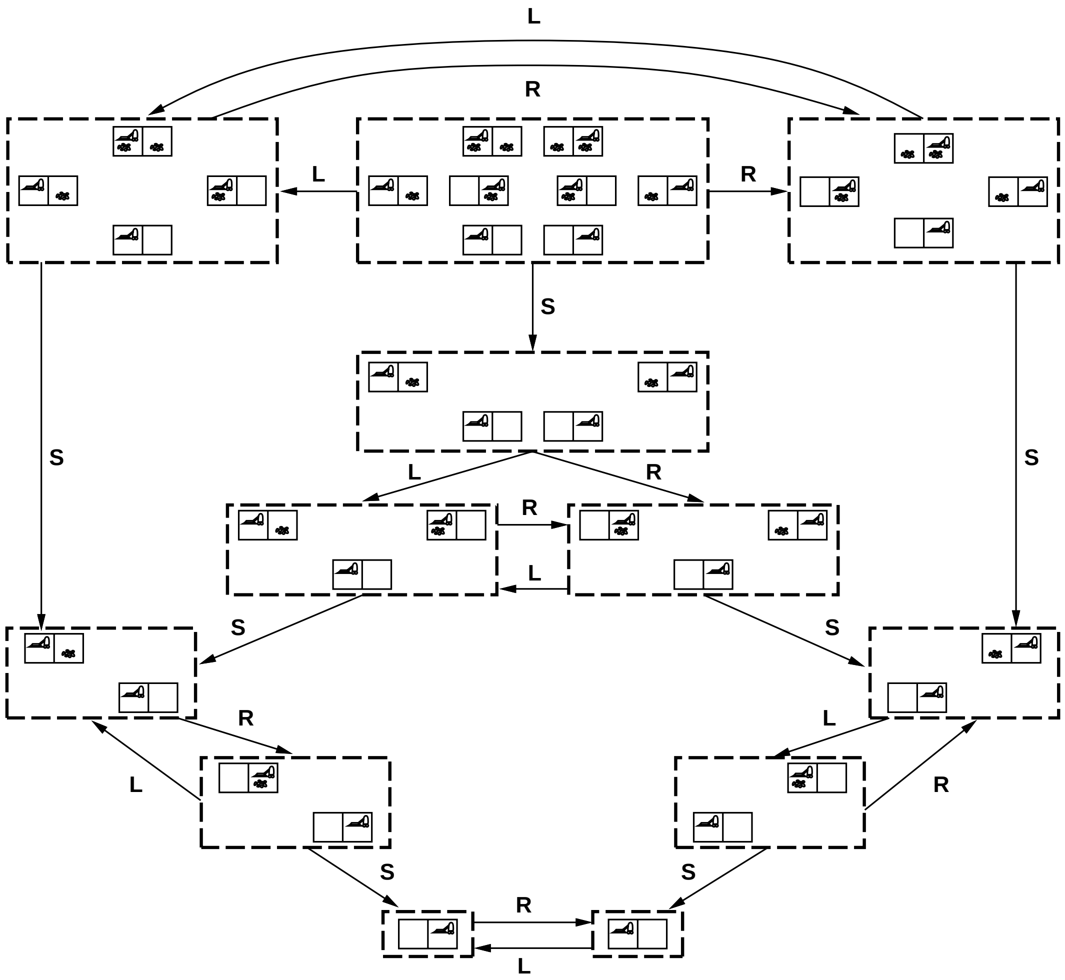
Check progress *during execution*, replan if necessary

Unanticipated outcomes may lead to failure (e.g., no AAA card)

(Really need a combination; plan for likely/serious eventualities, deal with others when they arise, as they must eventually)

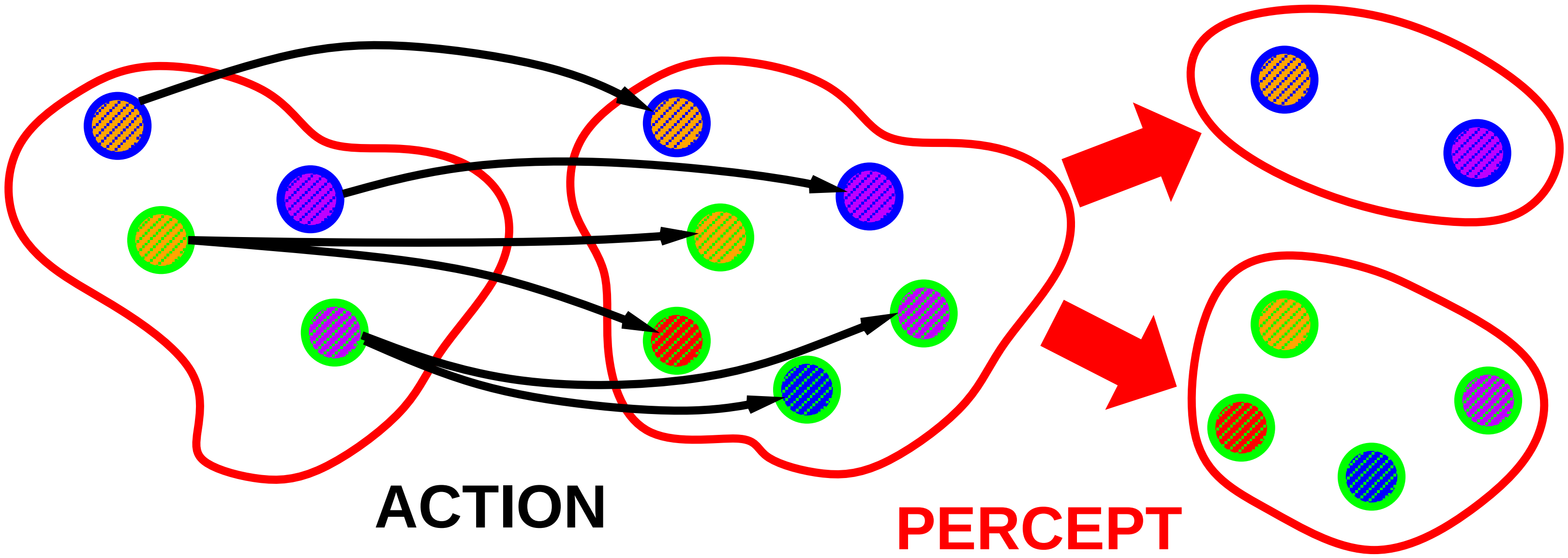
Conformant planning

Search in space of **belief states** (sets of possible actual states)



Conditional planning

If the world is nondeterministic or partially observable
then percepts usually *provide information*,
i.e., *split up* the belief state



Conditional planning contd.

Conditional plans check (any consequence of KB $+$) percept

$[\ldots, \textbf{if } C \textbf{ then } Plan_A \textbf{ else } Plan_B, \ldots]$

Execution: check C against current KB, execute "then" or "else"

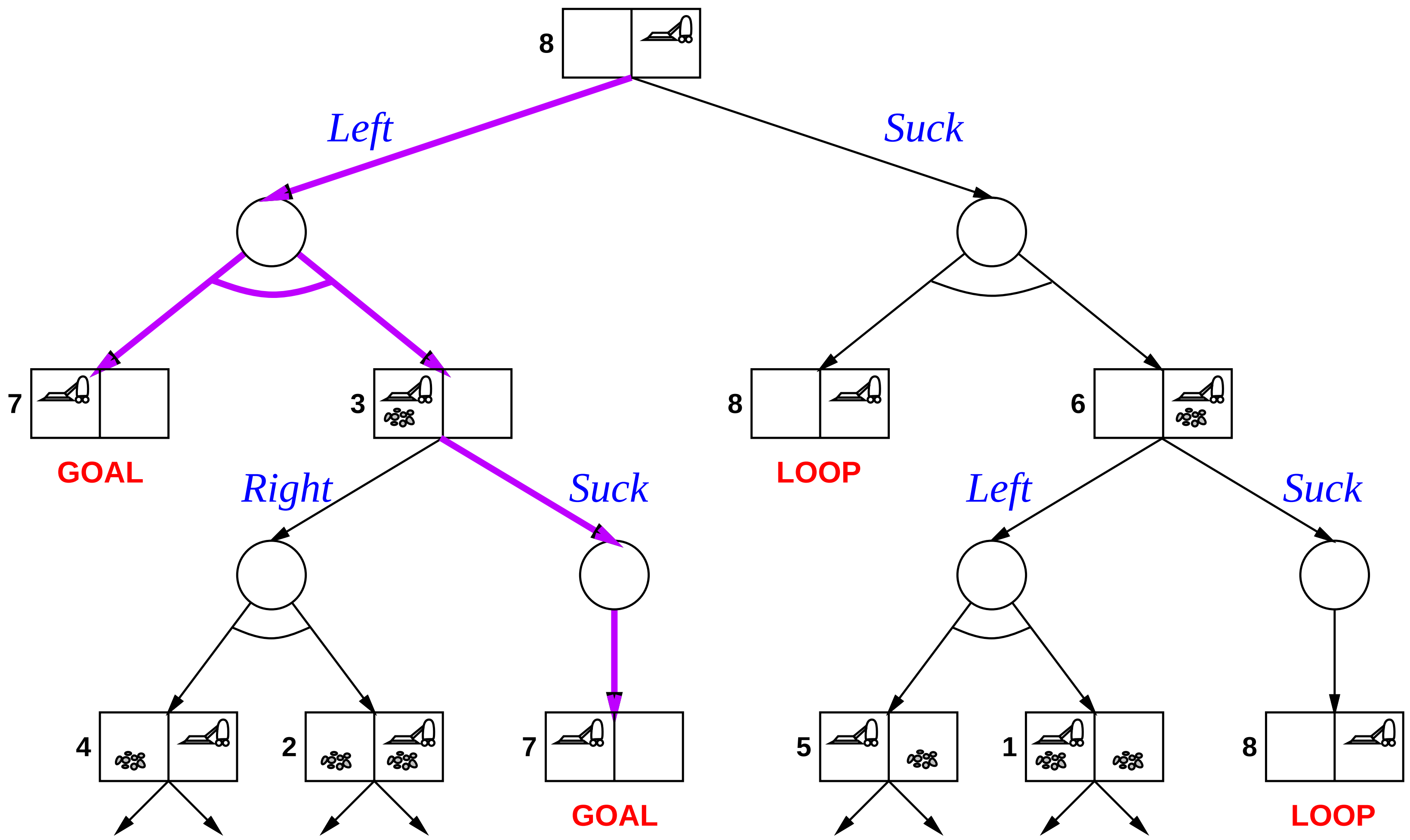
Need *some* plan for *every* possible percept

(Cf. game playing: *some* response for *every* opponent move)
(Cf. backward chaining: *some* rule such that *every* premise satisfied

AND–OR tree search (very similar to backward chaining algorithm)

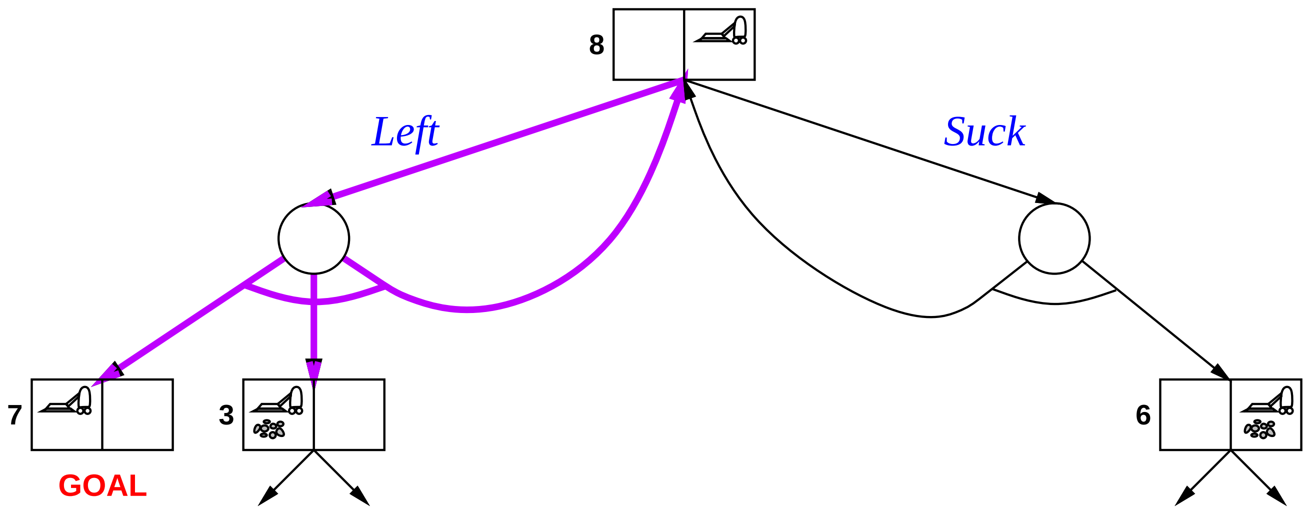
Example

Double Murphy: sucking or arriving may dirty a clean square



Example

Triple Murphy: also sometimes stays put instead of moving



$[L_1: \ Left, \textbf{if } AtR \textbf{ then } L_1 \textbf{ else } [\textbf{if } CleanL \textbf{ then } [\,] \textbf{ else } Suck]]$

or $[\textbf{while } AtR \textbf{ do } [Left], \textbf{if } CleanL \textbf{ then } [\,] \textbf{ else } Suck]$

"Infinite loop" but will eventually work unless action always fails

Execution Monitoring

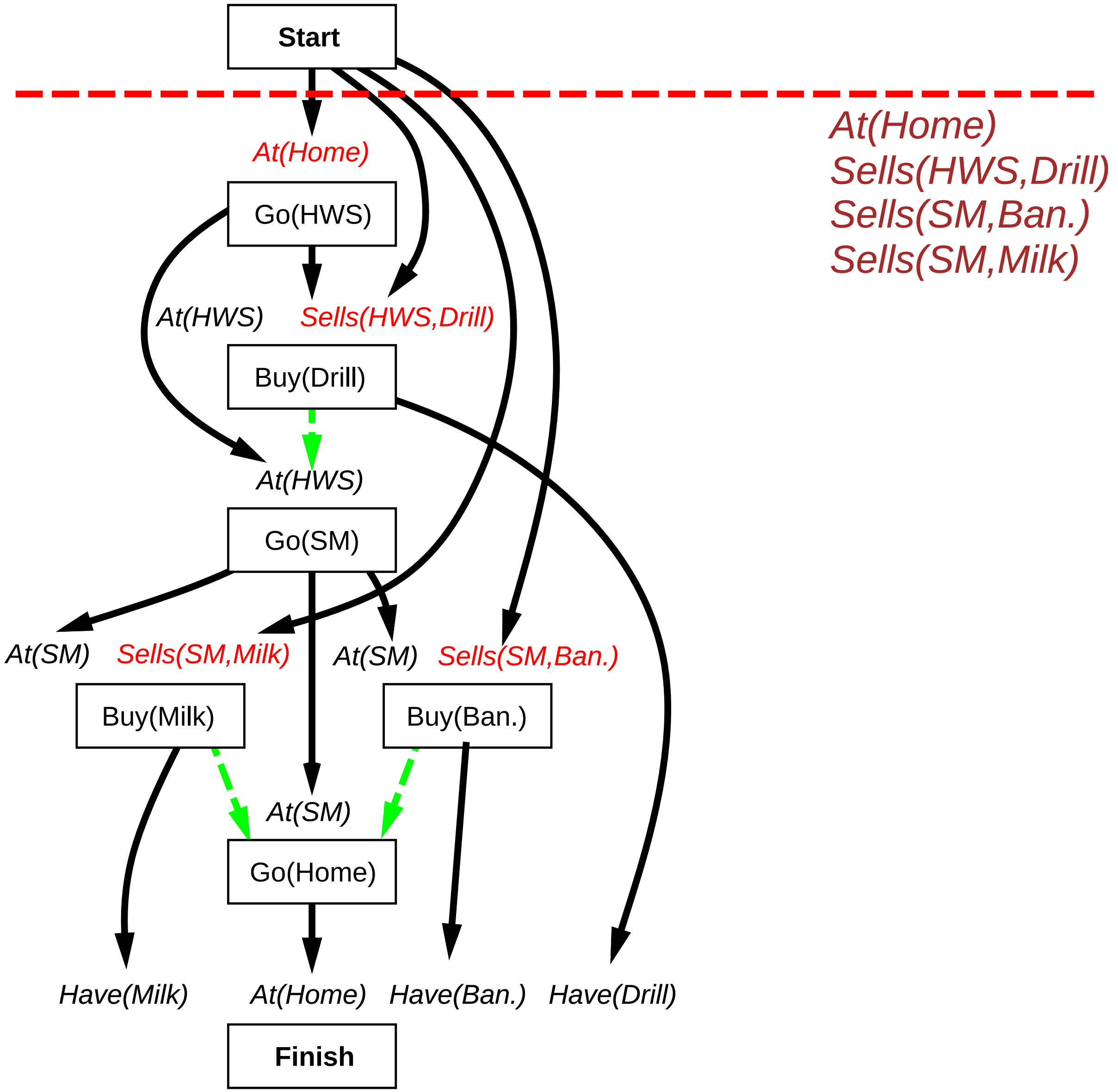
"Failure" = preconditions of *remaining plan* not met

Preconditions of remaining plan
= all preconditions of remaining steps not achieved by remaining steps
= all causal links *crossing* current time point

On failure, resume POP to achieve open conditions from current state

IPEM (Integrated Planning, Execution, and Monitoring):
keep updating $Start$ to match current state
links from actions replaced by links from $Start$ when done

Example


Start
At(Home)
Go(HWS)
At(HWS)
Sells(HWS,Drill)
Buy(Drill)
At(HWS)
Go(SM)
At(SM)
Sells(SM,Milk)
At(SM)
Sells(SM,Ban.)
Buy(Milk)
Buy(Ban.)
At(SM)
Go(Home)
Have(Milk)
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Have(Ban.)
Have(Drill)
Finish
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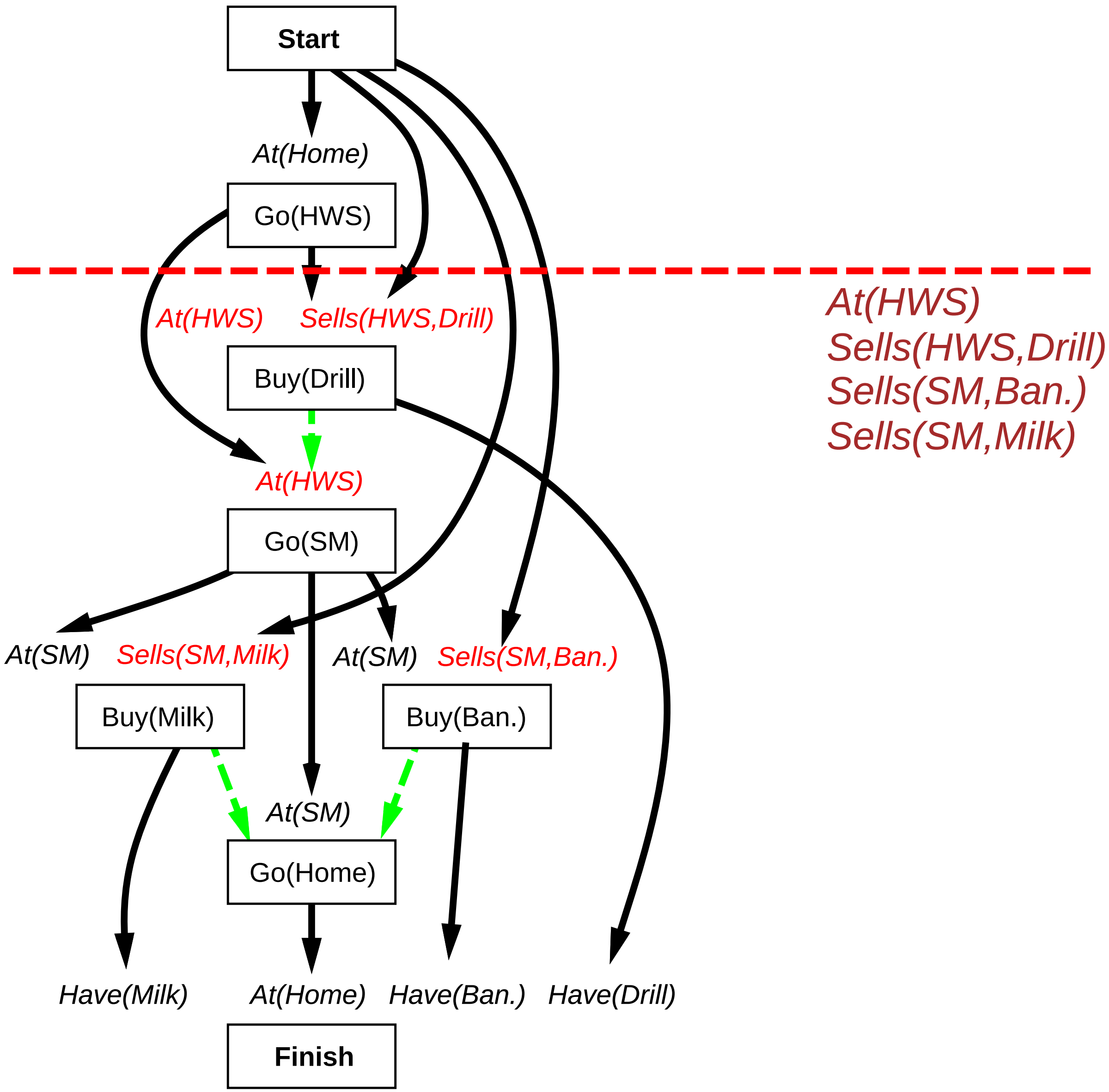
Example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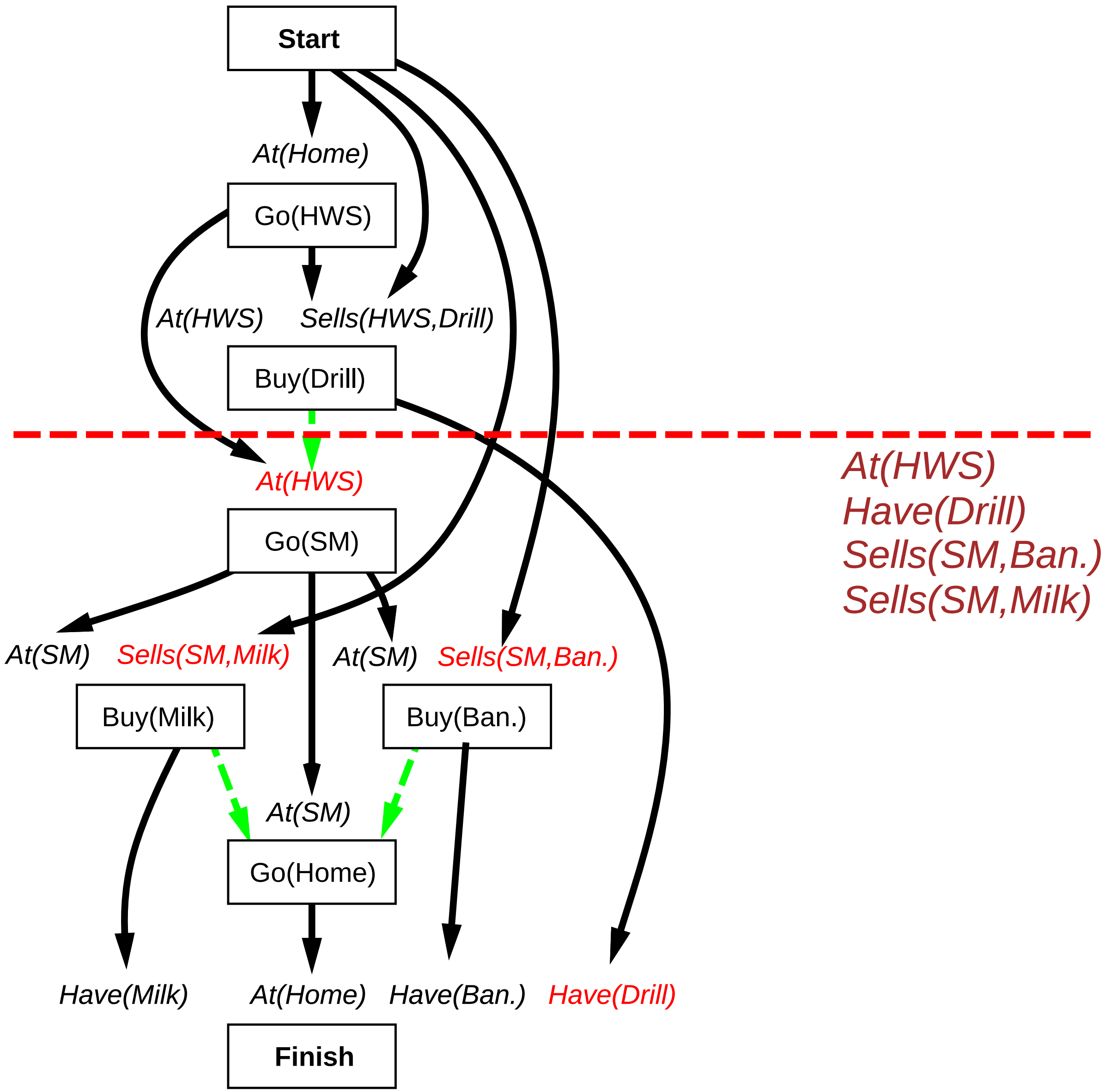

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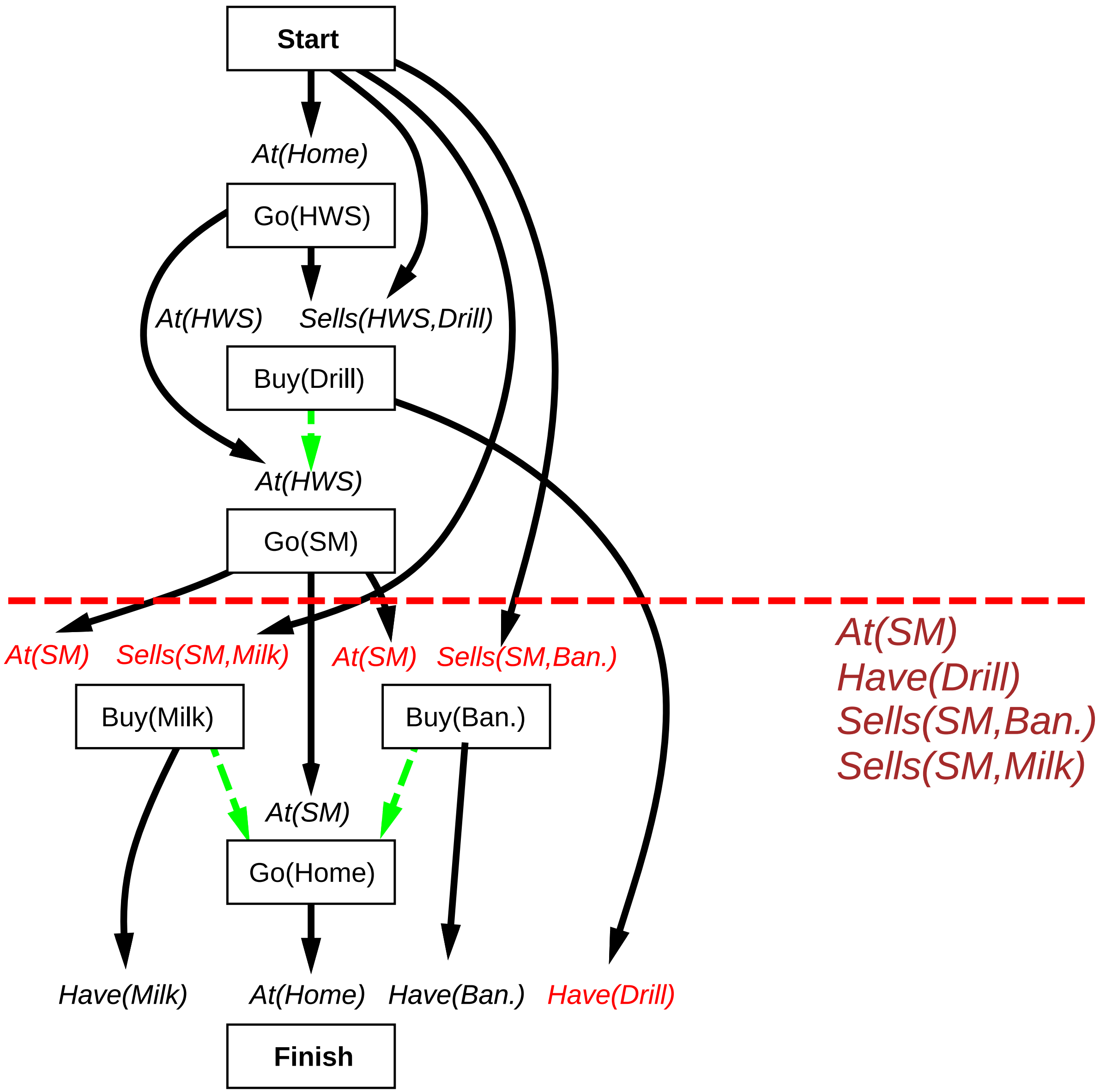
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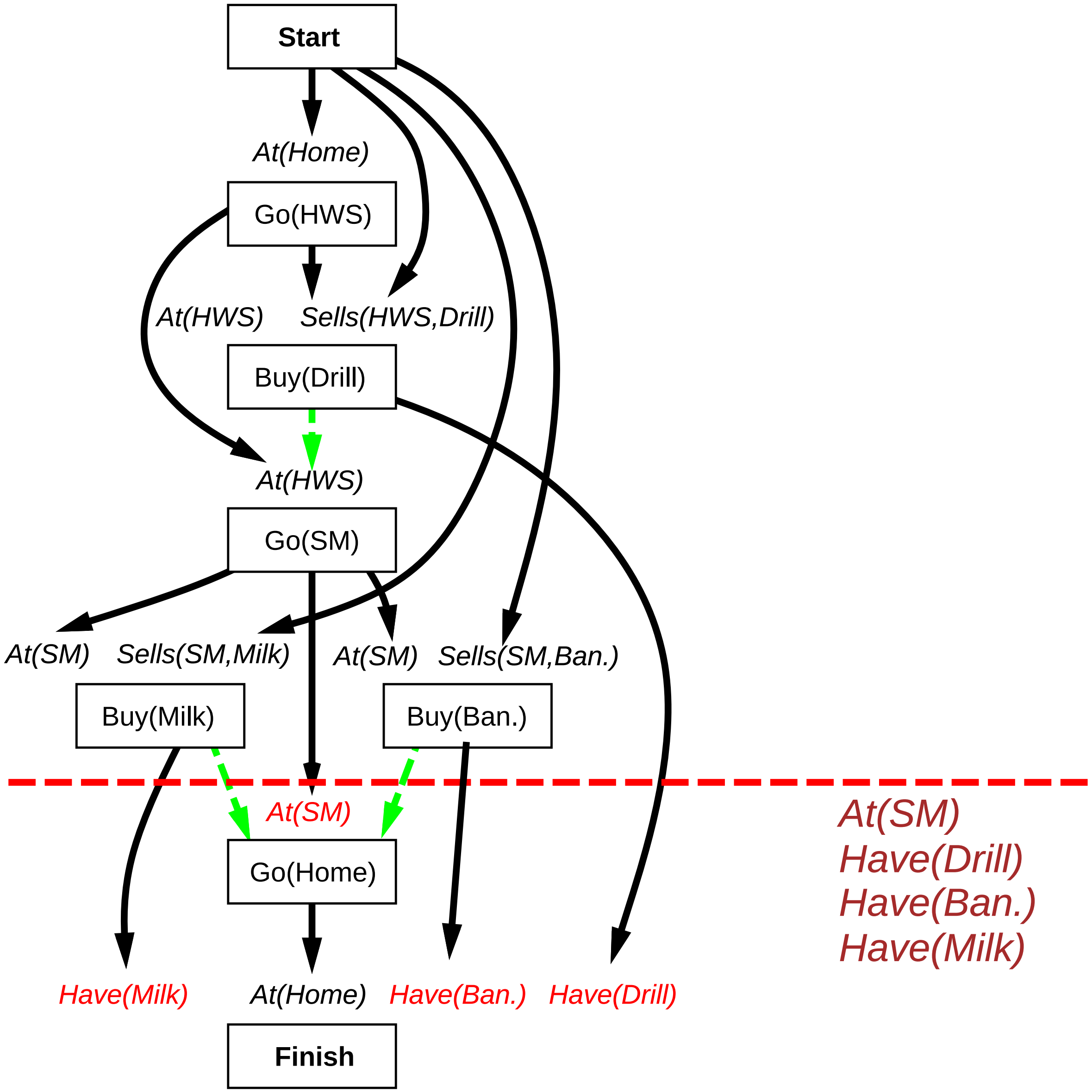
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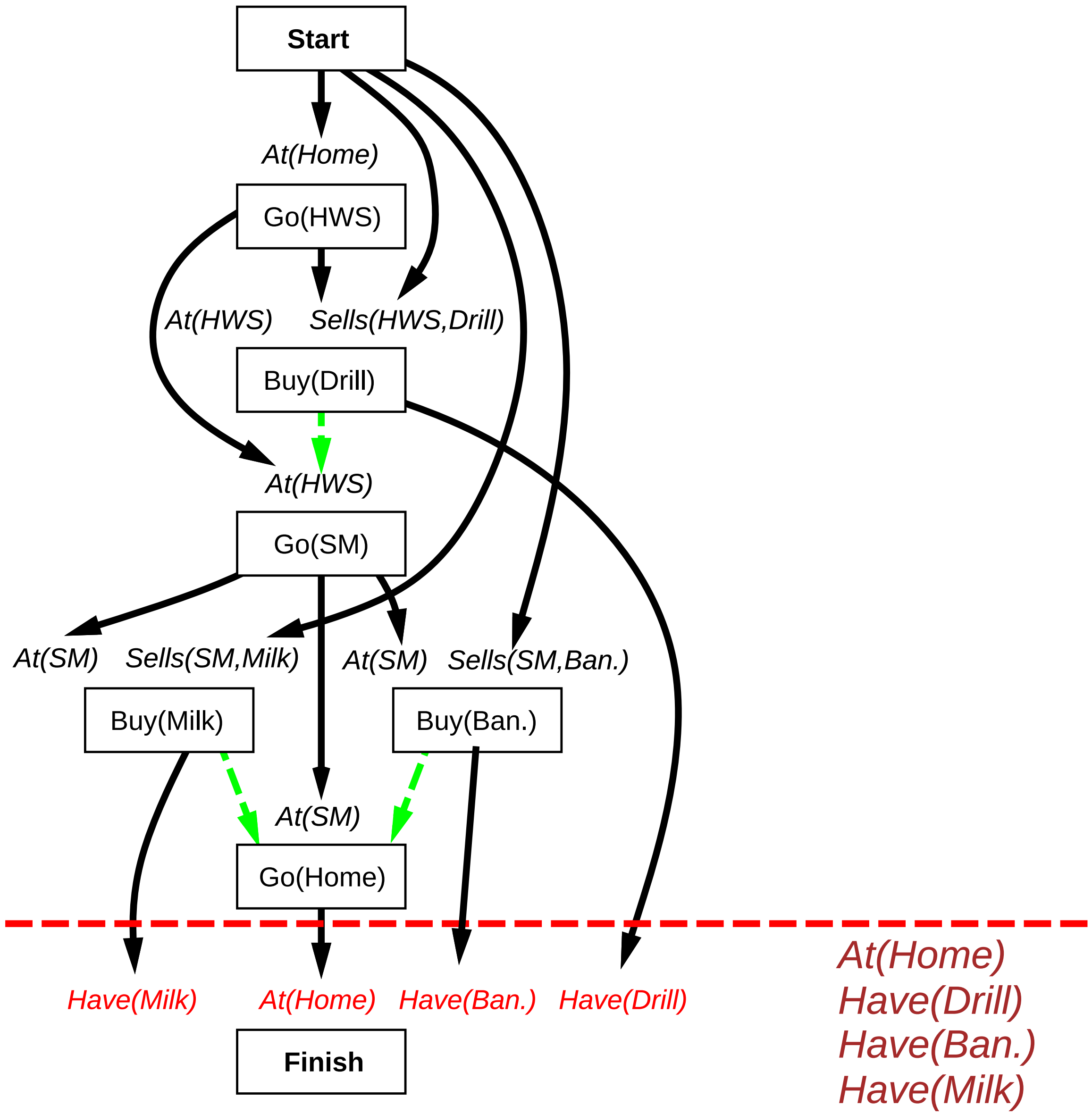
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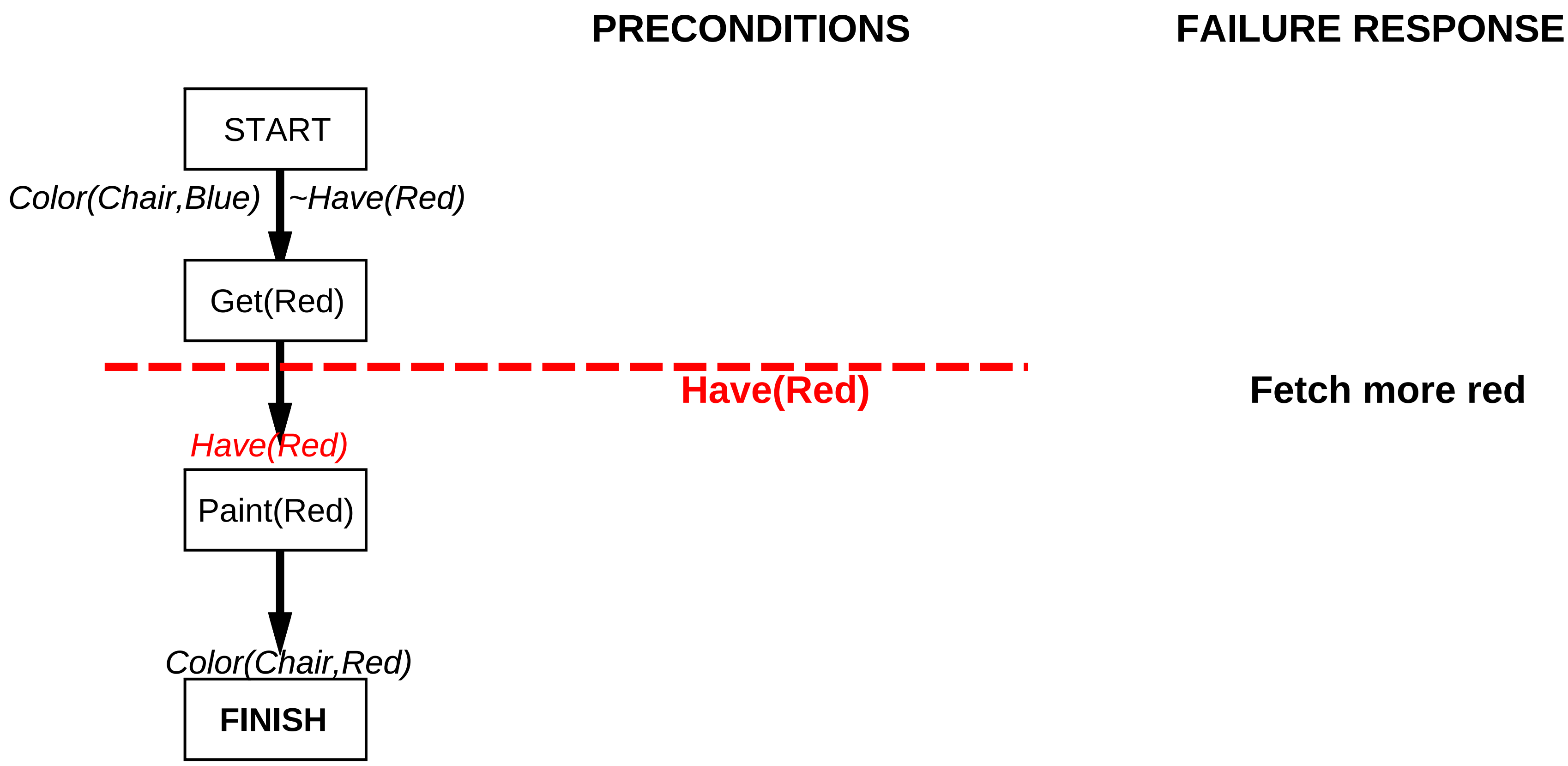
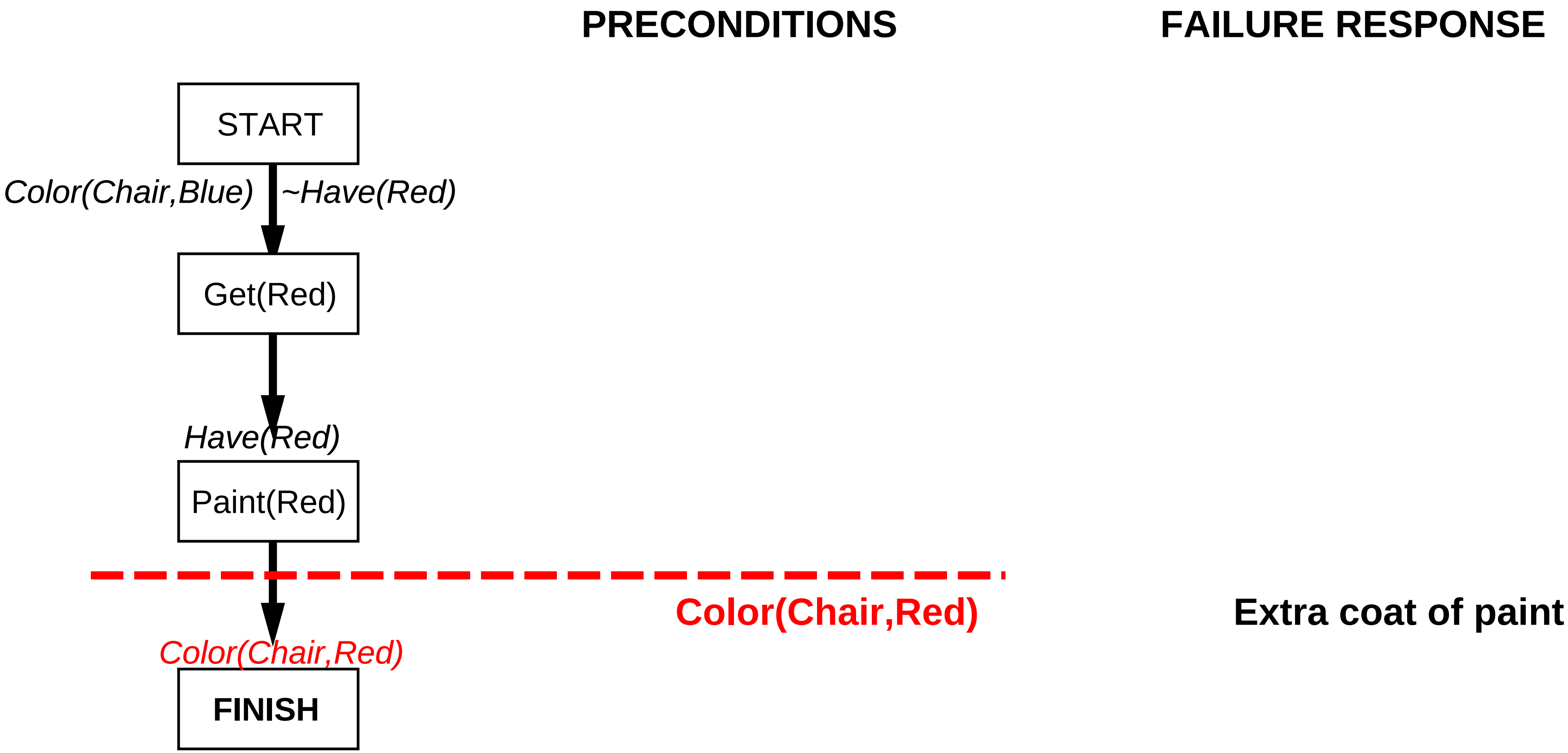
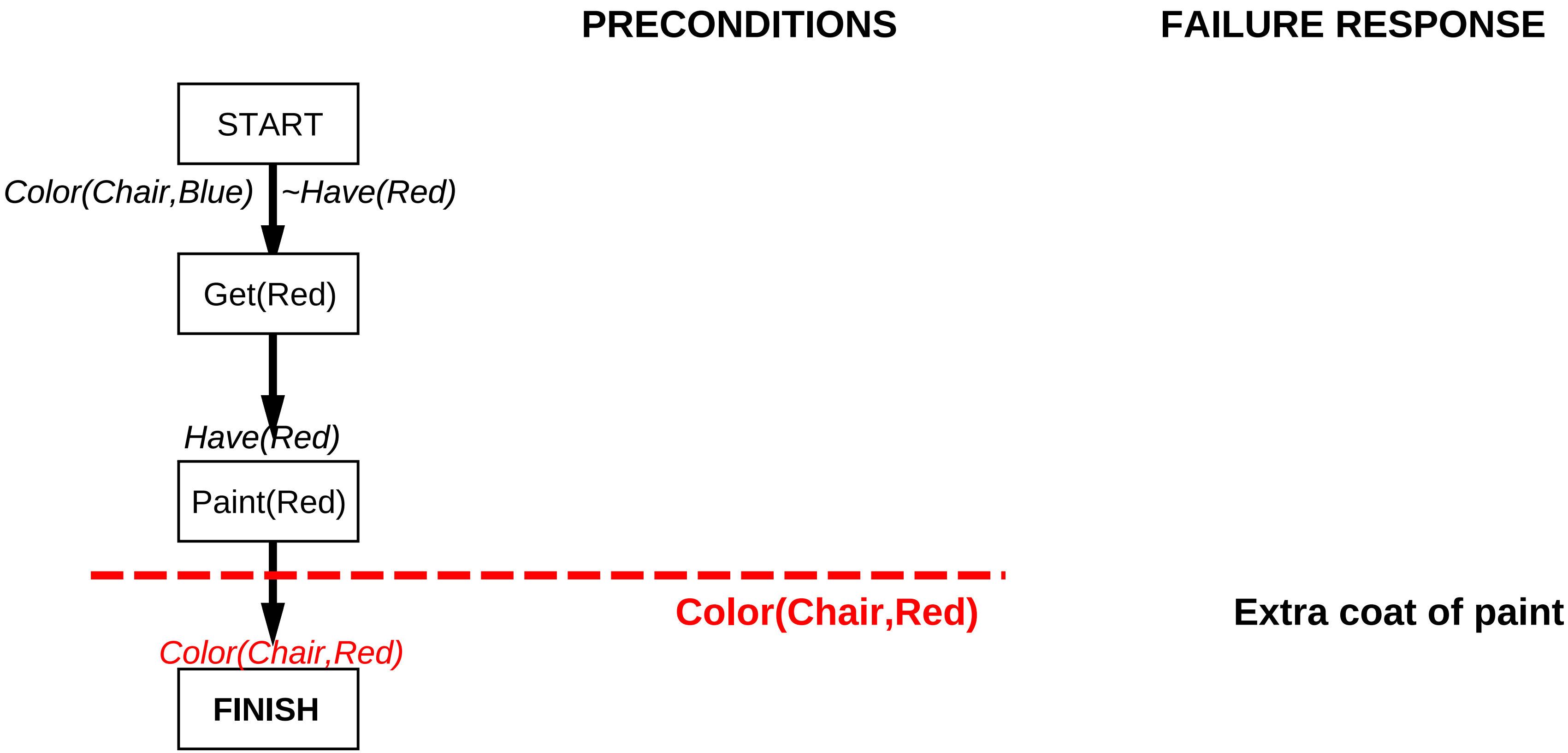
Emergent behavior



Emergent behavior



Emergent behavior



"Loop until success" behavior *emerges* from interaction between monitor/replan agent design and uncooperative environment