

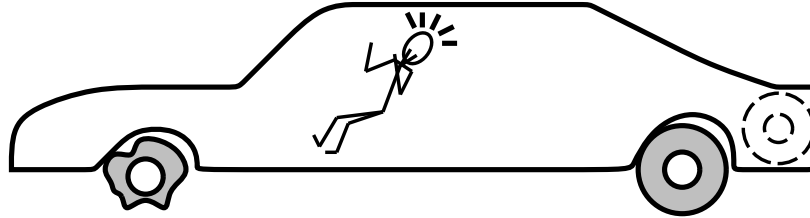
# Planning and Acting

## CHAPTER 13

# Outline

- ◇ The real world
- ◇ Conditional planning
- ◇ Monitoring and replanning

# The real world



**START**

*$\sim Flat(Spare)$   $Intact(Spare)$   $Off(Spare)$   
 $On(Tire1)$   $Flat(Tire1)$*

*$On(x)$   $\sim Flat(x)$*

**FINISH**

*$On(x)$*

**Remove(x)**

*$Off(x)$   $ClearHub$*

*$Off(x)$   $ClearHub$*

**Puton(x)**

*$On(x)$   $\sim ClearHub$*

*$Intact(x)$   $Flat(x)$*

**Inflate(x)**

*$\sim Flat(x)$*

## Things go wrong

### Incomplete information

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

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

$\textit{Inflated}(x) \vee \textit{SlowHiss}(x) \vee \textit{Burst}(x) \vee \textit{BrokenPump} \vee \dots$

### 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

## Conditional planning

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

- Subplan for each contingency, e.g.,

- $[Check(Tire1), \mathbf{If}(Intact(Tire1), [Inflate(Tire1)], [CallAAA])]$

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)

In general, some monitoring is unavoidable

## Conditional planning

$[\dots, \mathbf{If}(p, [then\ plan], [else\ plan]), \dots]$

Execution: check  $p$  against current KB, execute “then” or “else”

Conditional planning: just like POP except

- if an open condition can be established by observation action
- add the action to the plan
- complete plan for each possible observation outcome
- insert conditional step with these subplans

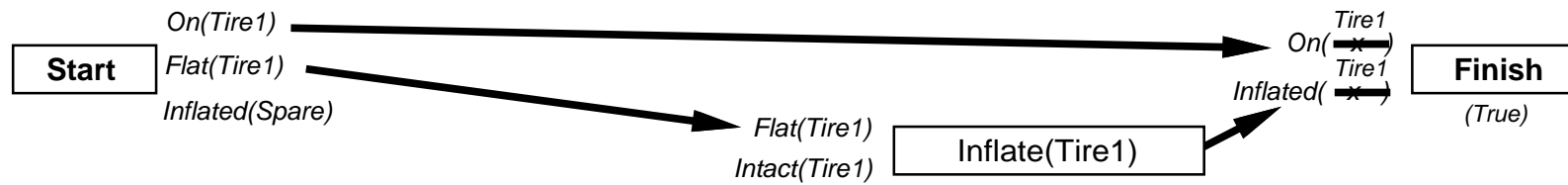
**CheckTire(x)**

*KnowsIf(Intact(x))*

# Conditional planning example

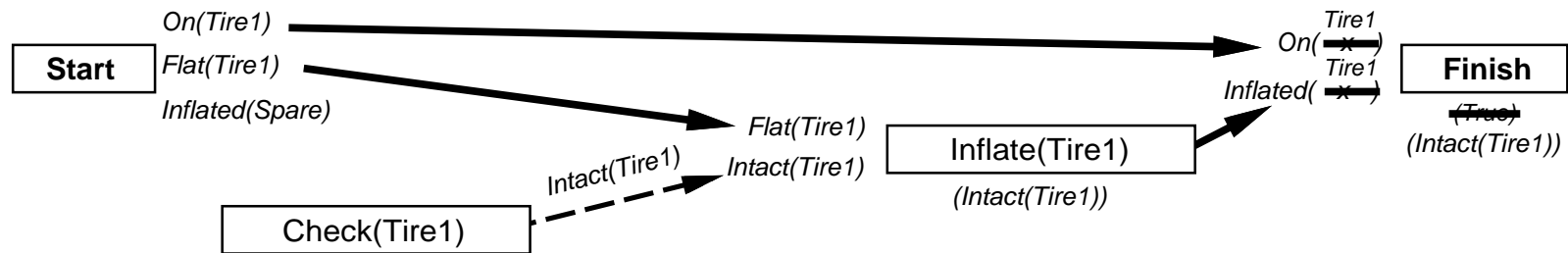


# Conditional planning example

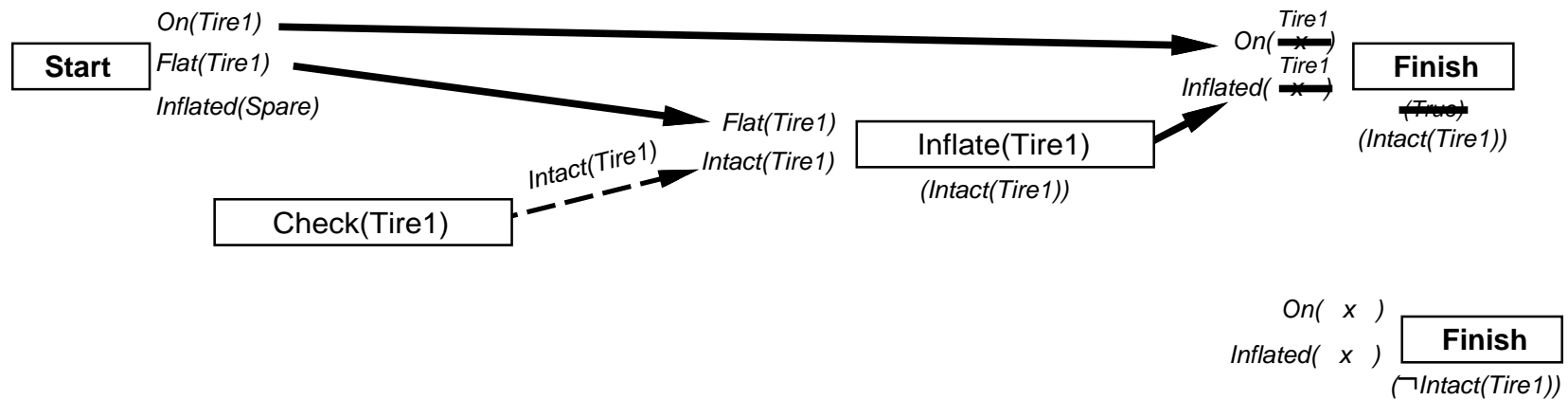




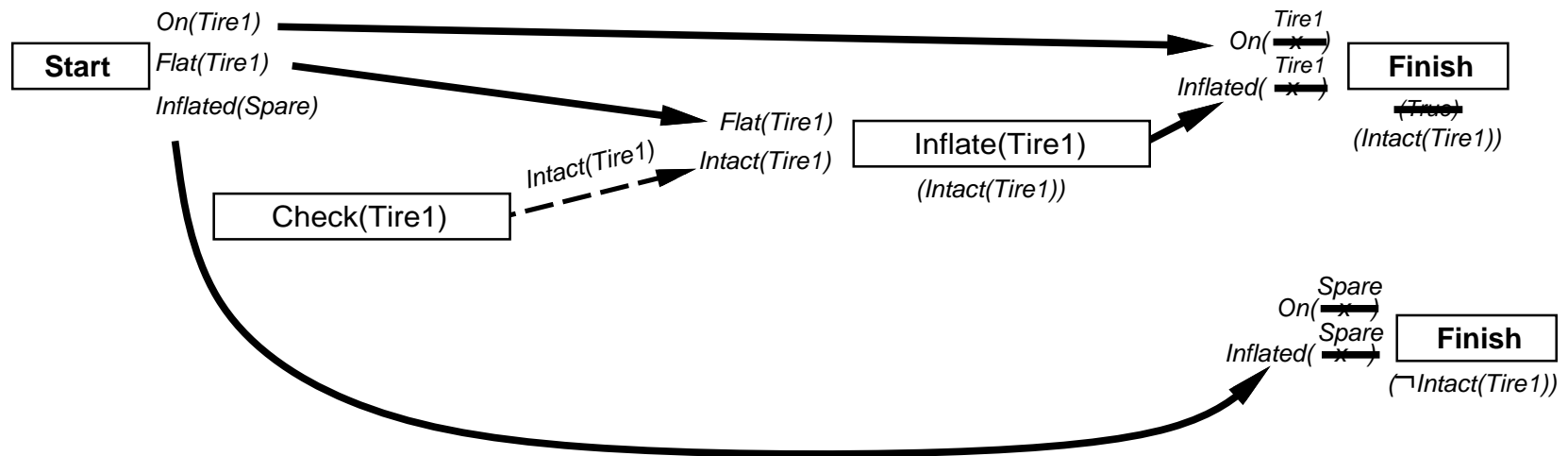
# Conditional planning example



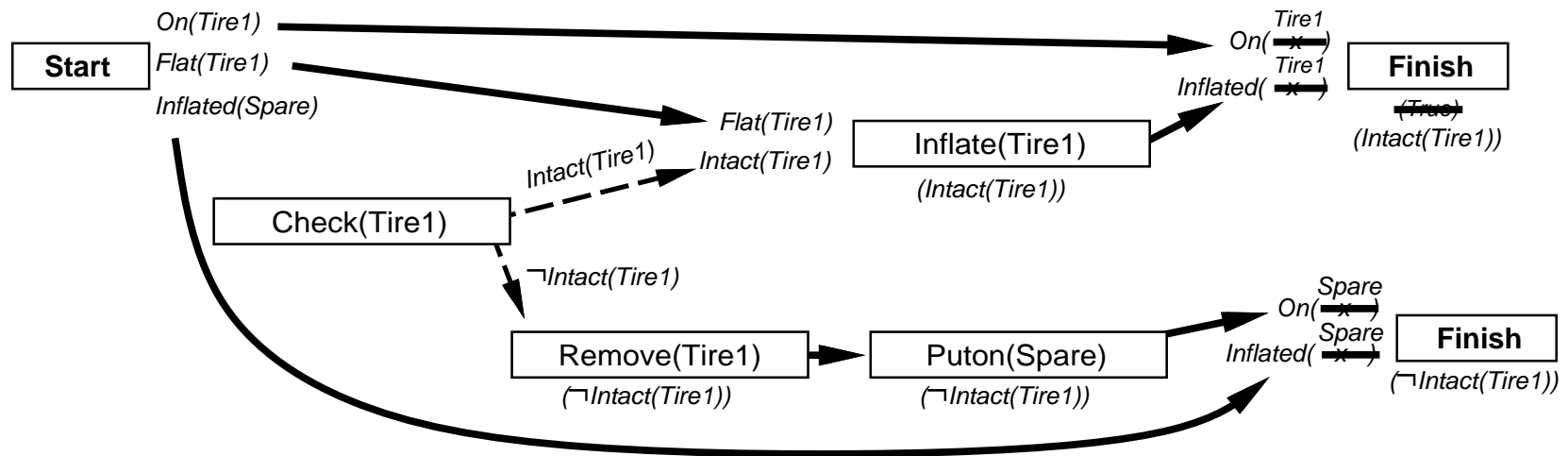
# Conditional planning example



# Conditional planning example



# Conditional planning example



# Monitoring

## Execution monitoring

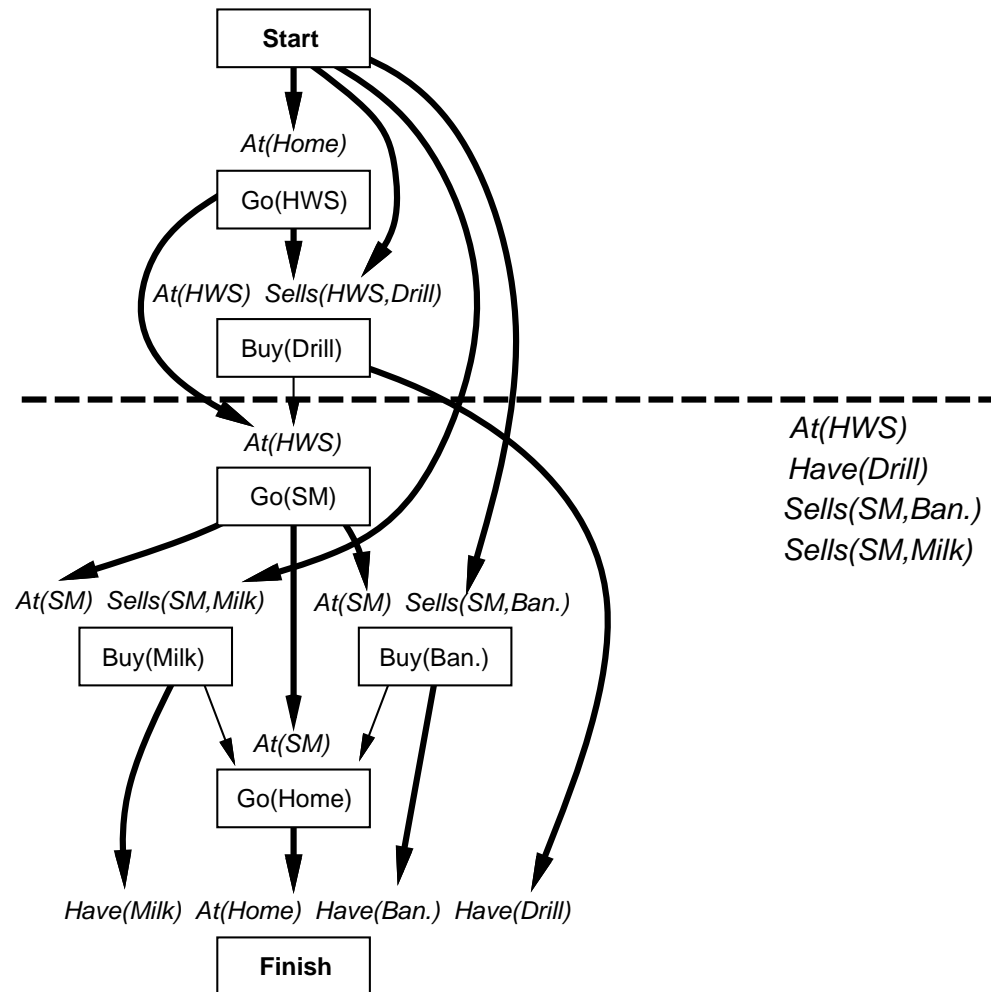
“failure” = preconditions of *remaining plan* not met  
preconditions = causal links at current time

## Action monitoring

“failure” = preconditions of *next action* not met  
(or action itself fails, e.g., robot bump sensor)

In both cases, need to *replan*

# Preconditions for remaining plan



# Replanning

Simplest: on failure, replan from scratch

Better: plan to get back on track by reconnecting to best continuation  
Generates “loop until done” behavior with no explicit loop

