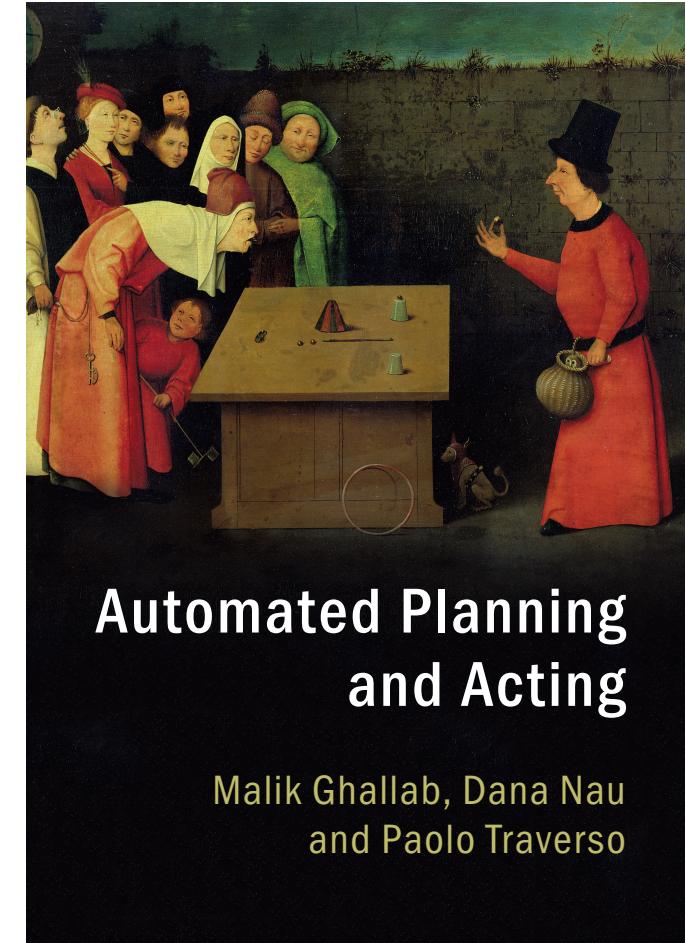


Chapter 1

Introduction

*Adapted from Dana S. Nau
University of Maryland*



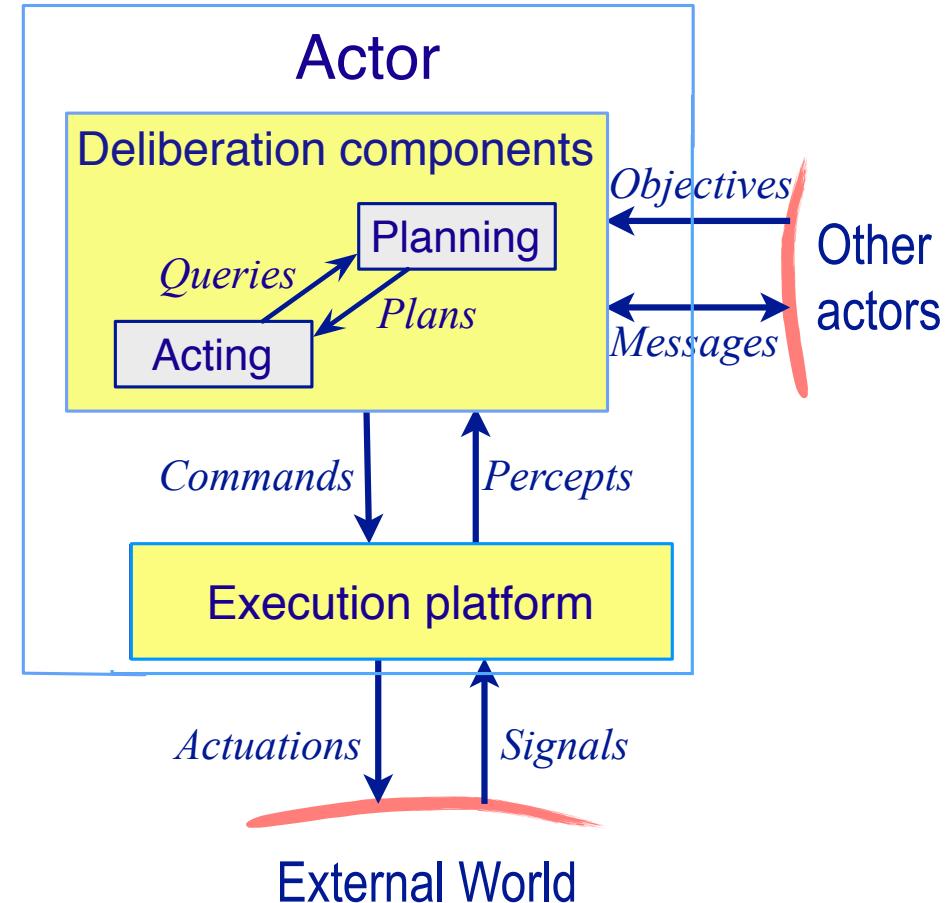
Automated Planning and Acting

Malik Ghallab, Dana Nau
and Paolo Traverso

<http://www.laas.fr/planning>

Motivation

- *Agent*: entity capable of interacting with external world
- *Action*: something an agent does
- *Actor*: agent that performs actions
- *Deliberation* for actions
 - ▶ Planning
Which actions to perform
 - ▶ Acting
How to perform them
- Deliberation implies *reasoning*!
 - ▶ Before and during acting



Questions

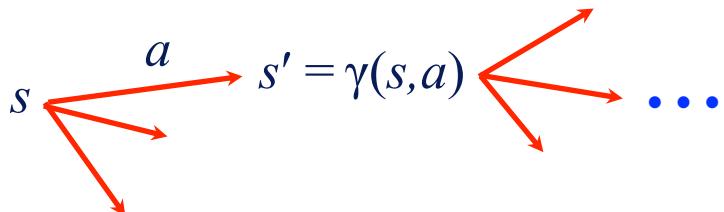
- If an agent performs an action, what will the result be?
- Which actions should an agent undertake, and how should the agent perform the chosen actions to produce a desired effect?
- Consider a bird in the following three scenes...
 - To visually track a target, the bird moves its eyes, head, and body.
 - To get some food that is out of reach, the bird takes a wire rod, finds a wedge to bend the wire into a hook, uses the hook to get the food.
 - To reach a worm floating in a pitcher, the bird picks up a stone and drops it into the pitcher, repeats with other stones until the water has risen to a reachable level, and then picks up the worm. □
- The first scene is more reactive than deliberate
- The second and third scenes illustrate our intuitive notion of acting deliberately!

Motivation in the context of AI

- To understand, through effective formal models, the cognitive capabilities that correspond to acting deliberately.
- To build actors that exhibit these capabilities.
- To develop technologies that address socially useful needs.

Planning

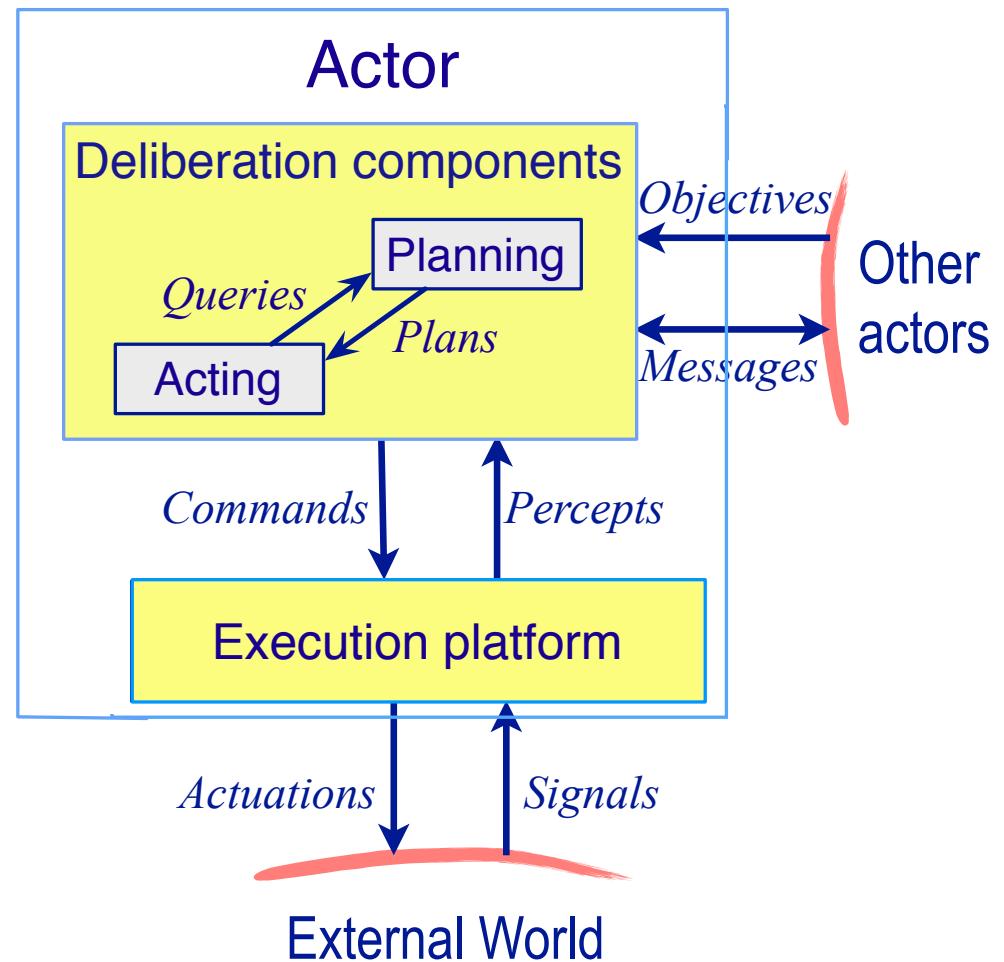
- Relies on *prediction + search*
- Uses *descriptive models* of the actions
 - ▶ Predict *what* the actions will do
 - ▶ Don't tell *how* to do them
- Search over *predicted states* and possible organizations of feasible actions
- Different types of actions ⇒
 - ▶ Different predictive models
 - ▶ Different planning problems and techniques
 - ▶ Motion and manipulation planning
 - ▶ Perception planning
 - ▶ Navigation planning
 - ▶ Communication planning
 - ▶ **Task planning**



Most AI planning

Acting

- Traditional “AI planning” view:
 - ▶ Carrying out an action is just execution
 - ▶ Can ignore how it’s done
- *Sometimes* that’s OK
 - ▶ If the environment has been engineered to make actions predictable
 - ▶ Example on next slide
- Usually acting is more complicated
 - ▶ Example later



Acting as Execution



Video: <https://www.cs.umd.edu/~nau/apa/kiva.mp4>

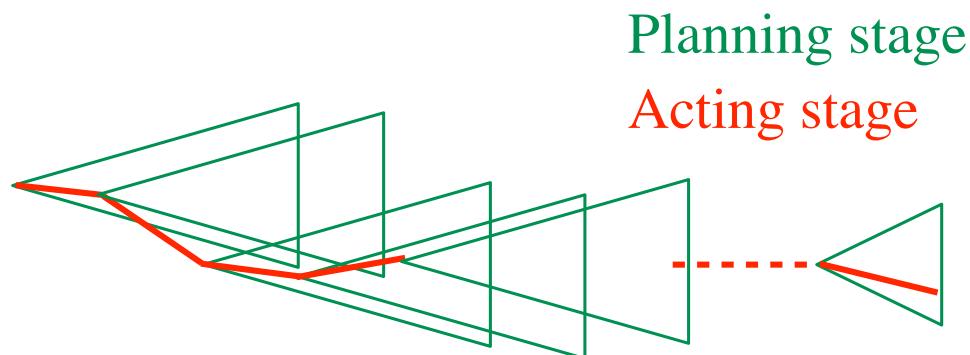
Deliberative Acting



Video: <https://www.cs.umd.edu/~nau/apa/crow.mov>

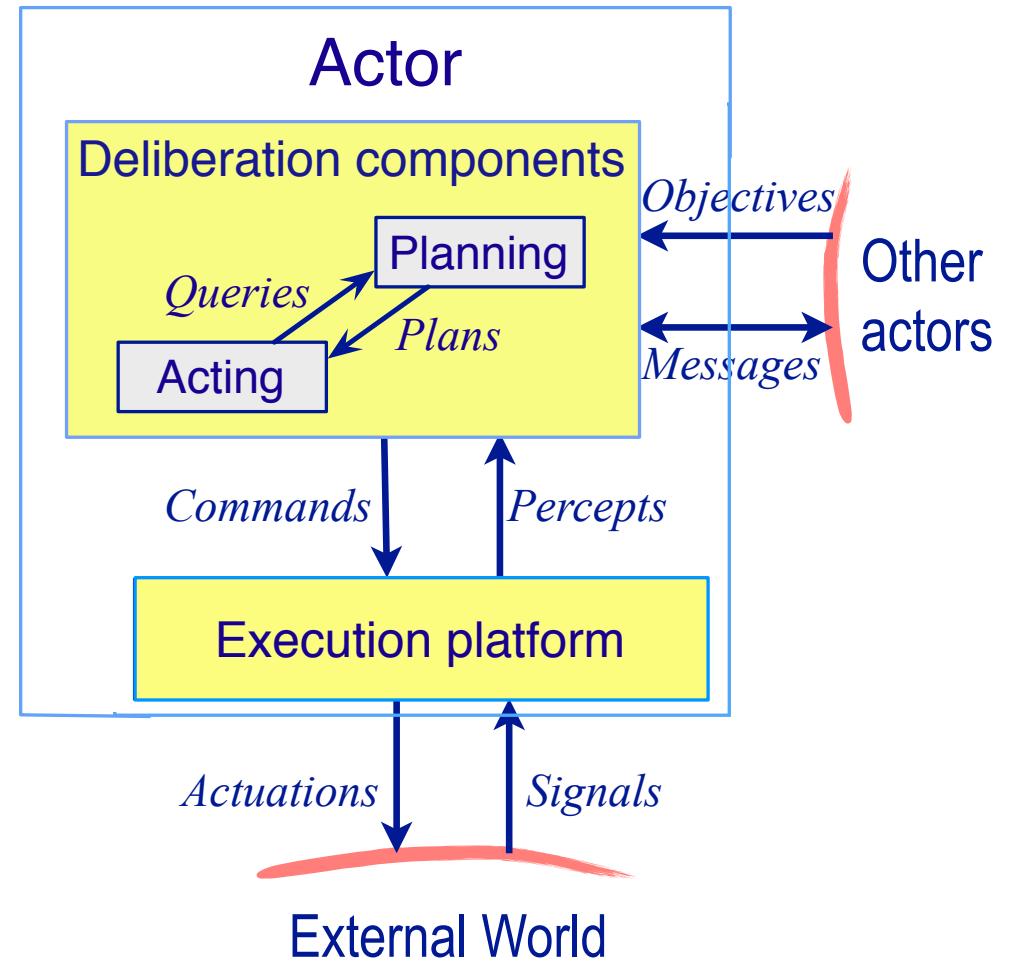
Deliberative Acting

- Actor is in a dynamic unpredictable environment
 - Adapt actions to current context
 - React to events
- Relies on
 - *Operational models* telling *how* to perform the actions
 - Observations of *current state*



Planning and Acting

- *Multiple levels of abstraction*
 - ▶ Actors are organized into physical subsystems
 - ▶ Deliberation reflects this
- *Heterogeneous reasoning*
 - ▶ Different techniques
 - at different levels
 - different subsystems at same level
- *Continual online planning*
 - ▶ Can't plan everything in advance
 - ▶ Plans are abstract and partial until more detail is needed

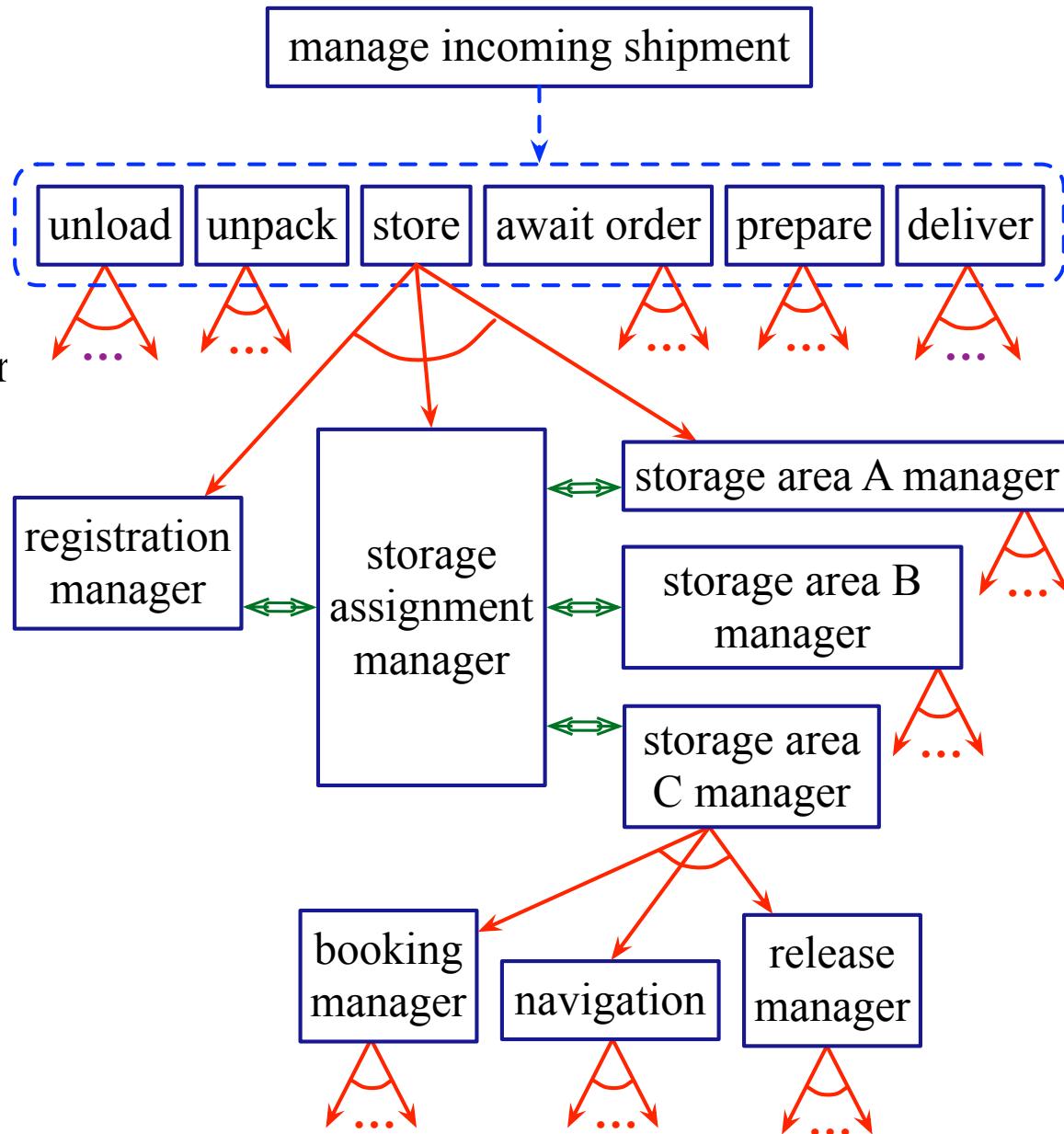


Bremen Harbor



Example: Harbor Management

- Importing/exporting cars
 - ▶ Based on Bremen Harbor
- *Multiple levels of abstraction*
 - ▶ Reflect physical organization of harbor
- *Continual online planning*
 - ▶ Top level can be planned offline
 - ▶ The rest is online, based on current conditions
- *Heterogeneous reasoning*
 - ▶ Different components work in different ways
 - ▶ Online synthesis of automata to control their interactions

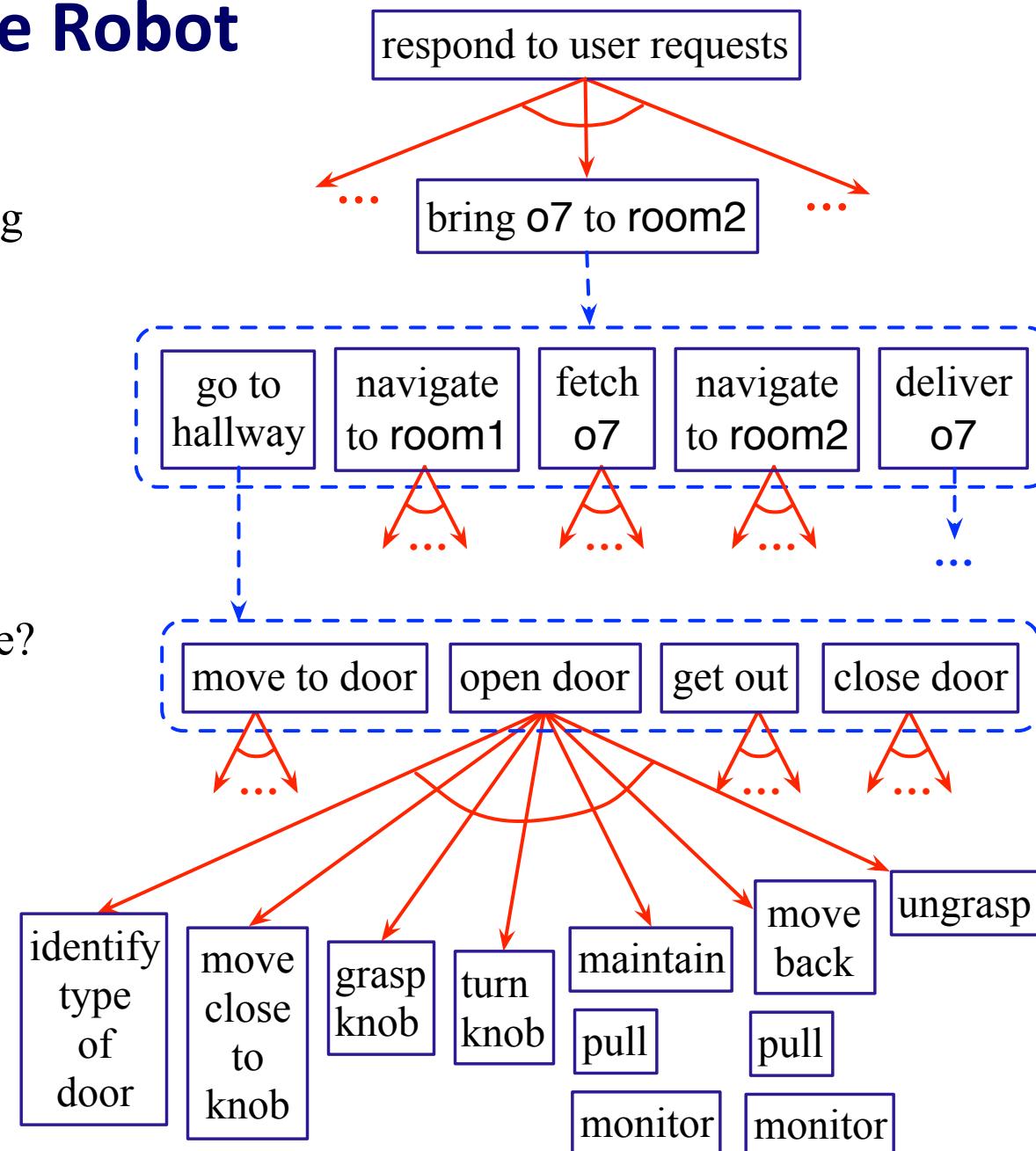


Planning

Acting

Example: Service Robot

- *Multiple levels of abstraction*
 - Higher levels: more planning
 - Lower levels: more acting
- *Continual online planning*
 - What room is o7 in?
 - What route?
 - What kind of door?
 - Close enough to door handle?
- *Heterogeneous reasoning*
 - planning abstract tasks
 - path planning
 - reactive (e.g., open door)



Planning

Acting

Outline of Book

1: *Introduction* (this lecture)

2: *Deterministic models*

- ▶ Conventional (*classical*) AI planning
- ▶ Integrating it with acting

3: *Refinement methods*

- ▶ Acting and planning by refining abstract activities into less-abstract activities

4: *Temporal models*

- ▶ Reasoning about time constraints

5: *Nondeterministic models*

- ▶ Actions with multiple possible outcomes

6: *Probabilistic models*

- ▶ Multiple possible outcomes, with probabilities

7: *Other:*

- ▶ perceiving, monitoring, goal reasoning, learning, hybrid models, ontologies



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Additional Material

- University of Edinburgh's Open Online Course
 - ▶ 1.1. AIPLAN - What Is Planning?
 - ▶ <https://www.youtube.com/watch?v=yCZQ18SPP44>

You have
3 minutes!

Quiz: True or False?

- people only plan *when they have to* because the benefit of an optimal plan does not justify the effort of planning
- for humans, planning is a *subconscious process*, which is why computational planning is so hard
- planning involves a *mental simulation of actions* to foresee future world states and compare them to goals
- in Artificial Intelligence, planning is concerned with the search for *computationally optimal plans*
- domain-specific planning is used when efficiency is vital, whereas domain-independent planning is good for planning from first principles

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Any questions?



Cover image: *The Conjuror*. Hieronymus Bosch (c.1450–1516)