

Advanced Topics Data Science and AI

Automated Planning and

Acting

Introduction

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Organisational Stuff: Lecture

- Module number: CS5070-KP04 (Dataaktuell)
 - Or: Automated Planning and Acting with module number CS5072-KP04
- Topic (summer term):

Automated Planning and Acting

- (winter term lecture on probabilistic differentiable programming by Özgür Özcep)
- Language: English
- Schedule: Thursdays, 10.15-11.45 am



Synchronous or asynchronous?

Organisational Stuff: Exercises

- Schedule: in flux
- Task: Give a presentation on a selected topic
 - 45 minutes
 - Ties to lecture expected
 - How to fill the 45 minutes is up to you!
 - Theory
 - Exercises
 - Programming

Organisational Stuff: Exercises

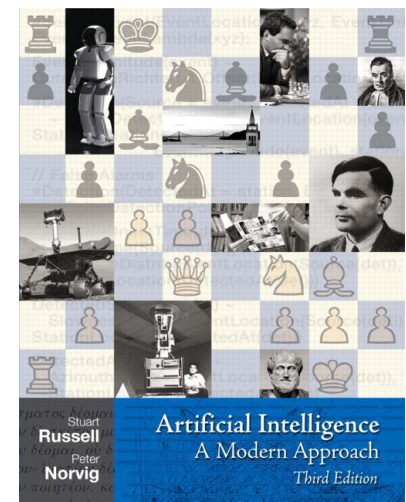
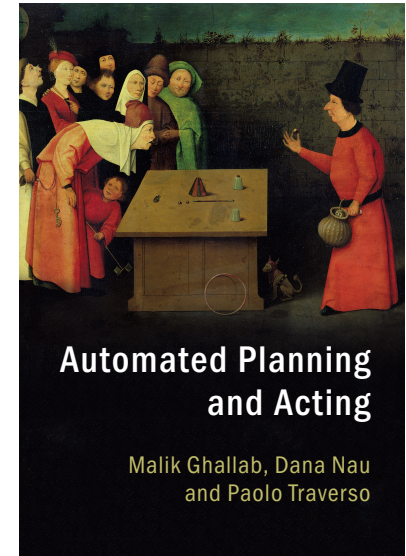
- Assignment of topics in Moodle over the course of next week
- Topic areas
 - Topics 1-2 on deterministic planning
 - Topic 3 on refinement methods
 - Topic 4-6 on nondeterministic planning
 - Topic 7 on probabilistic planning
 - Topics 8-9 on other deliberation methods
- Topics
 1. Hierarchical Task Network Planning
 2. Planning with Control Rules
 3. REAP
 4. Symbolic Model Checking Techniques
 5. Planning based on Search Automata
 6. Acting with Input/Output Automata
 7. First-order MDPs*
 8. Hybrid Models
 9. Ontologies for Planning and Acting

Organisational Stuff: Exam

- **Oral exam** at the end of the semester
- Prerequisites to participate in exam
 - **Registration** in Moodle course
 - Exercise presentation
- Registration for exam via Moodle

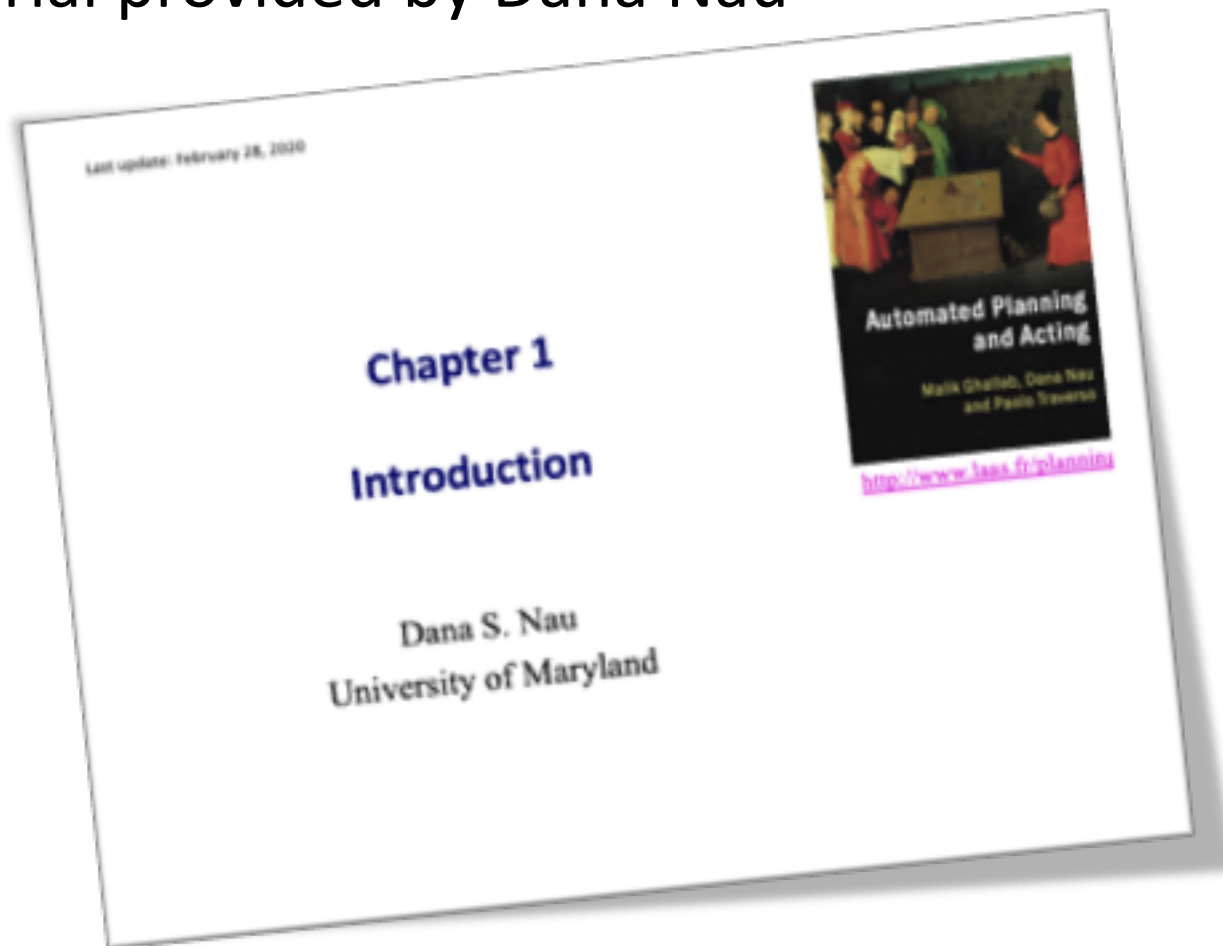
Literature

- Automated Planning and Acting
 - Malik Ghallab, Dana Nau, Paolo Traverso
 - Main source
- Artificial Intelligence: A Modern Approach (3rd ed.)
 - Stuart Russell, Peter Norvig
 - Decision theory
 - Ch. 16 + 17
 - Reinforcement learning
 - Ch. 21
- Further research papers may be announced in lectures



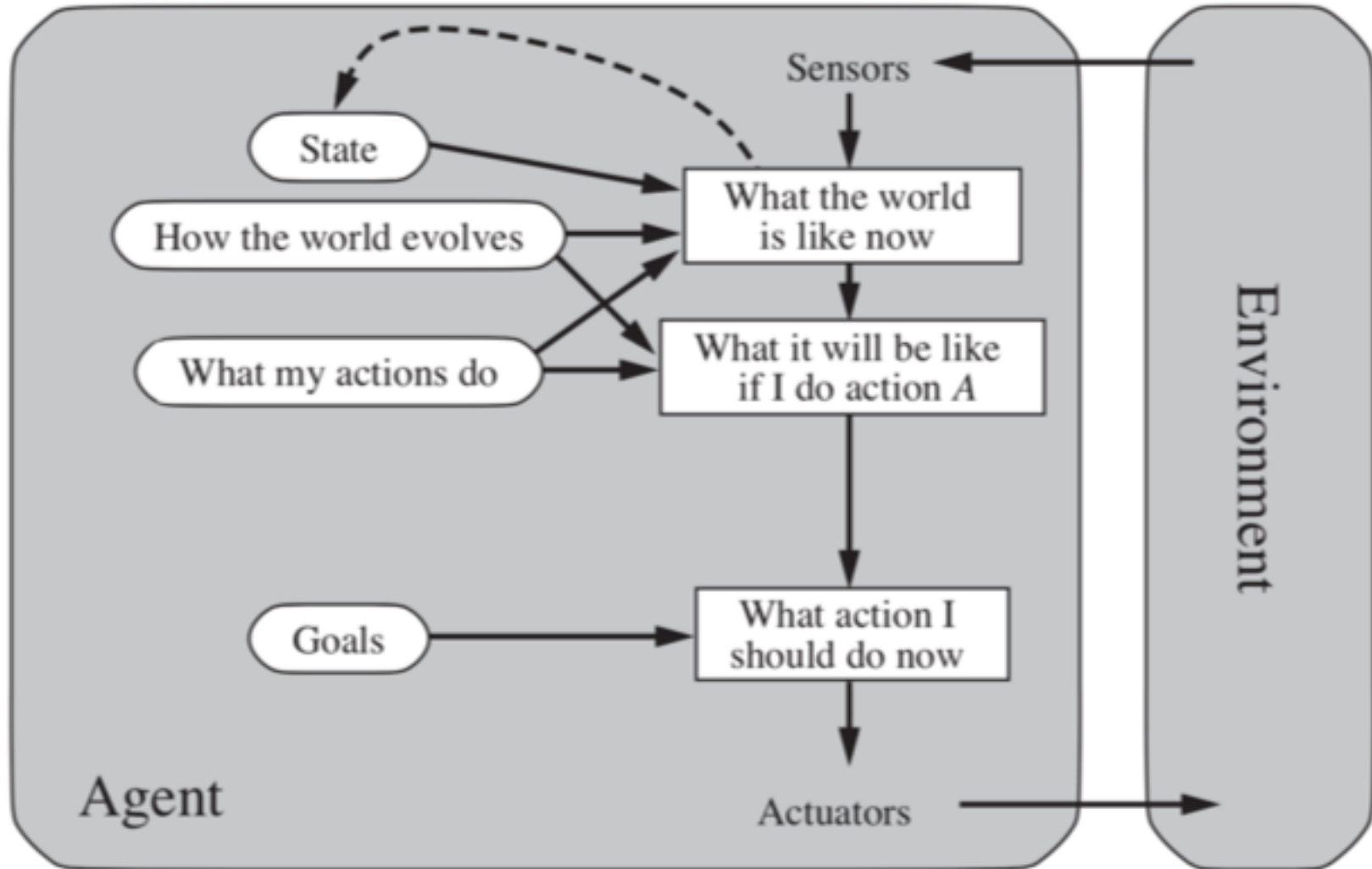
Acknowledgements

- If not stated otherwise, slides are adapted from material provided by Dana Nau



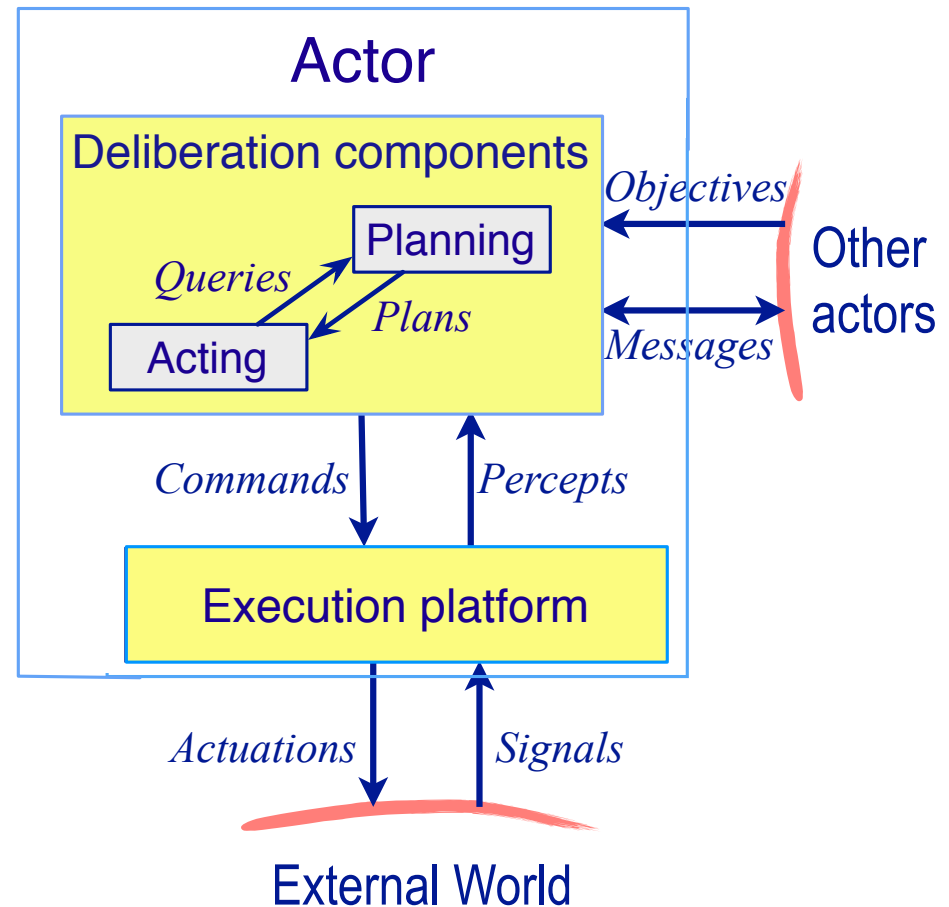
Agent Setting

If you attended last semester's lecture on intelligent agents, this figure should look familiar.



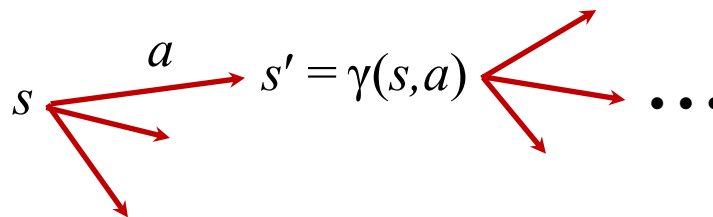
Motivation

- **Actor**: agent that performs actions
- Deliberation functions
 - Planning
What actions to perform
 - Acting
How to perform them



Planning

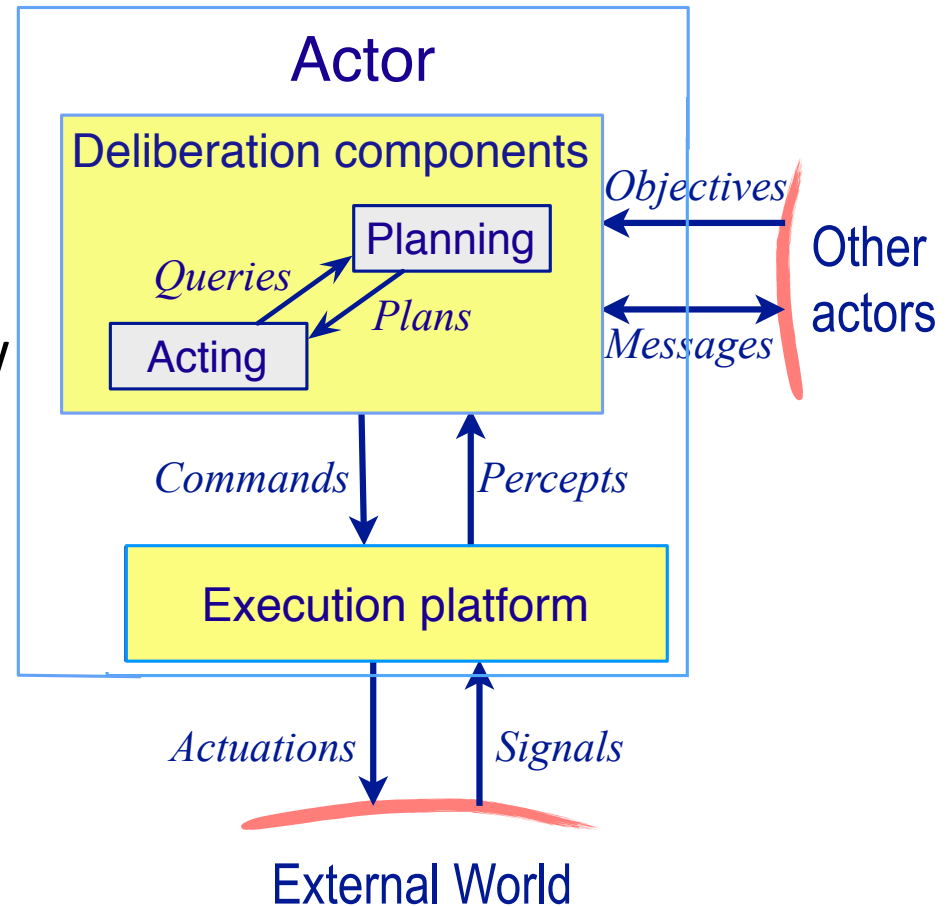
- Relies on **prediction + search**
- Uses **descriptive models** of the actions
 - Predict **what** the actions will do, but don't tell **how** to do them
- Search over **predicted states** and possible organizations of feasible actions
- Different types of actions
 - Different predictive models
 -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



Most AI planning

Acting

- Traditional “AI planning” view:
 - Carrying out an action is just execution
 - Doesn’t require the actor to think about how
- Sometimes that’s true
 - If the environment has been engineered to make it true
- Usually acting is more complicated

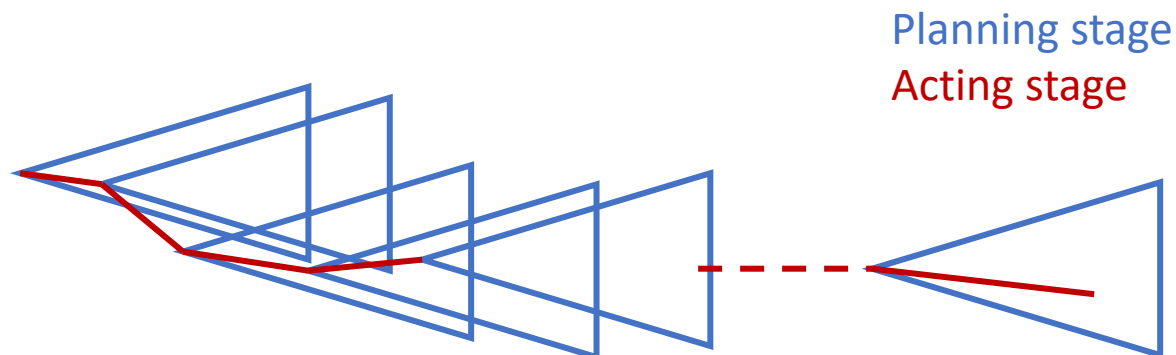


Acting as Execution



Deliberative Acting

- Actor is situated 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**

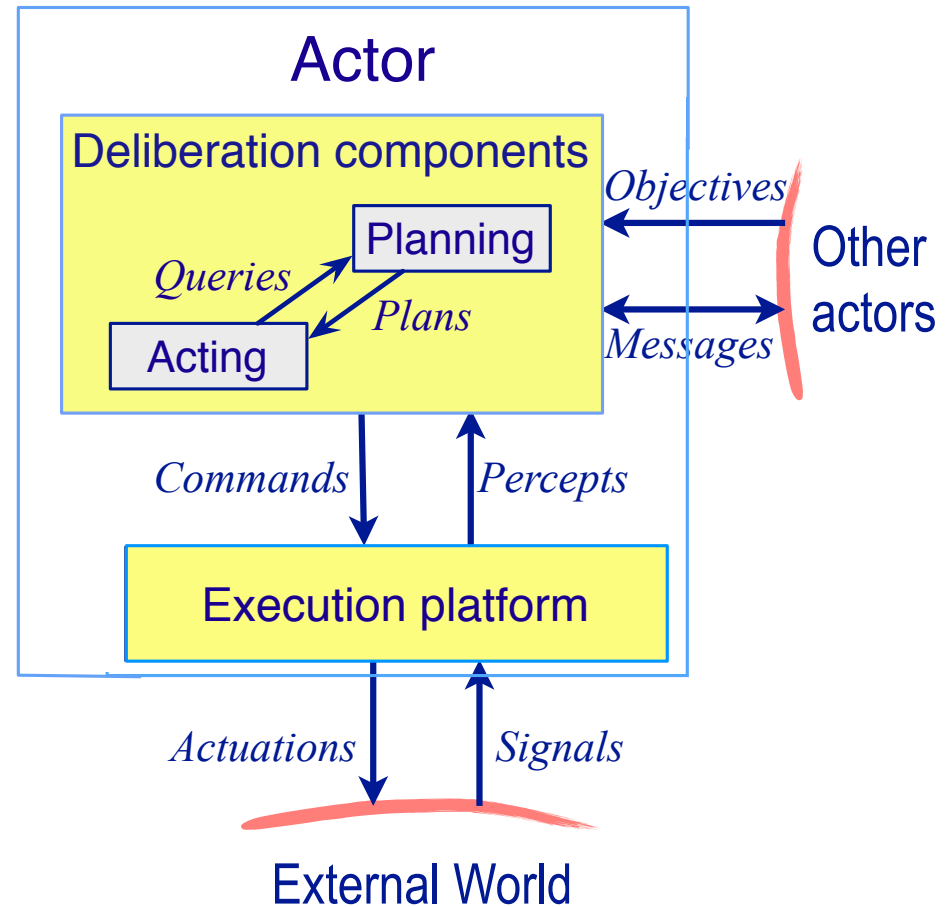


Deliberative Acting



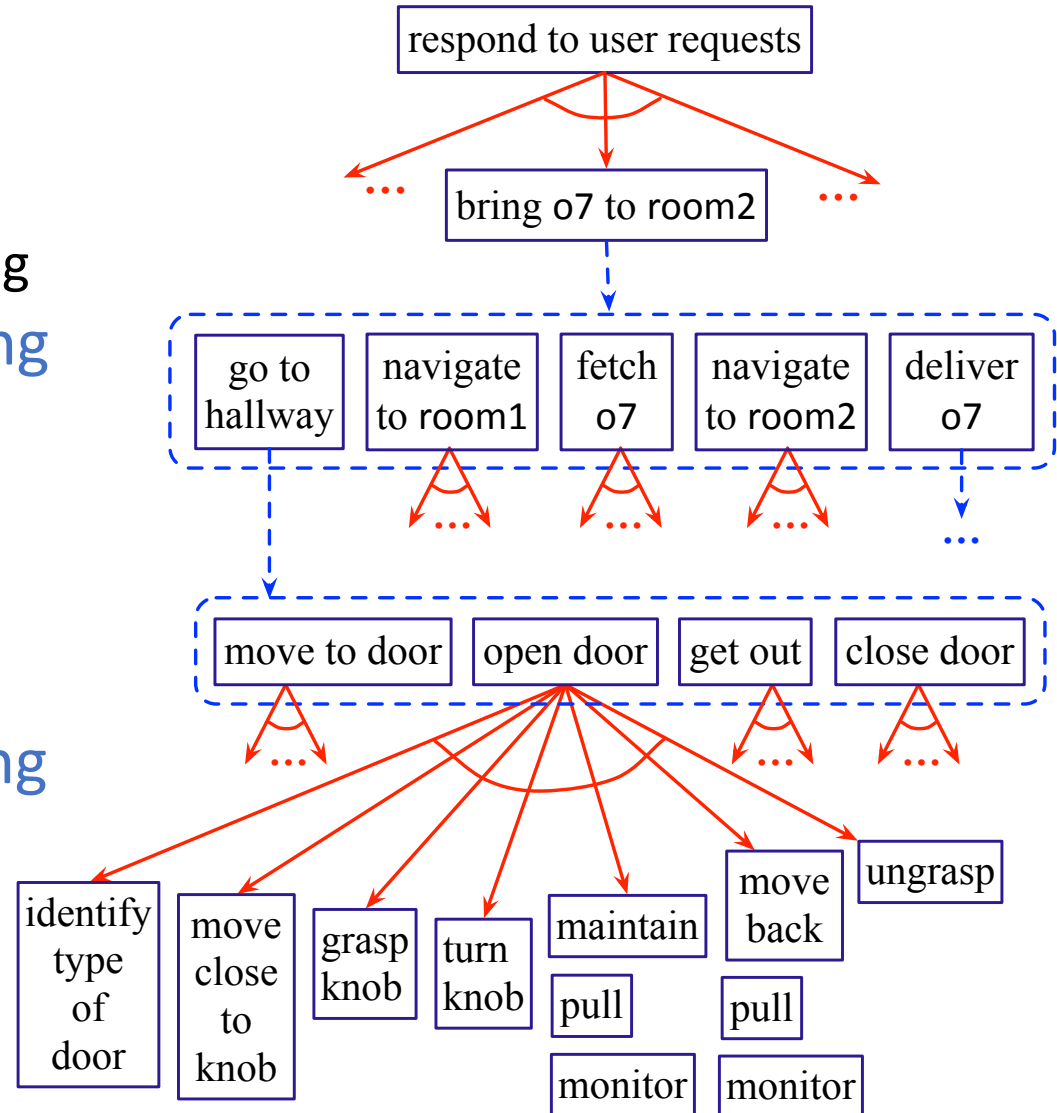
General Characteristics

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



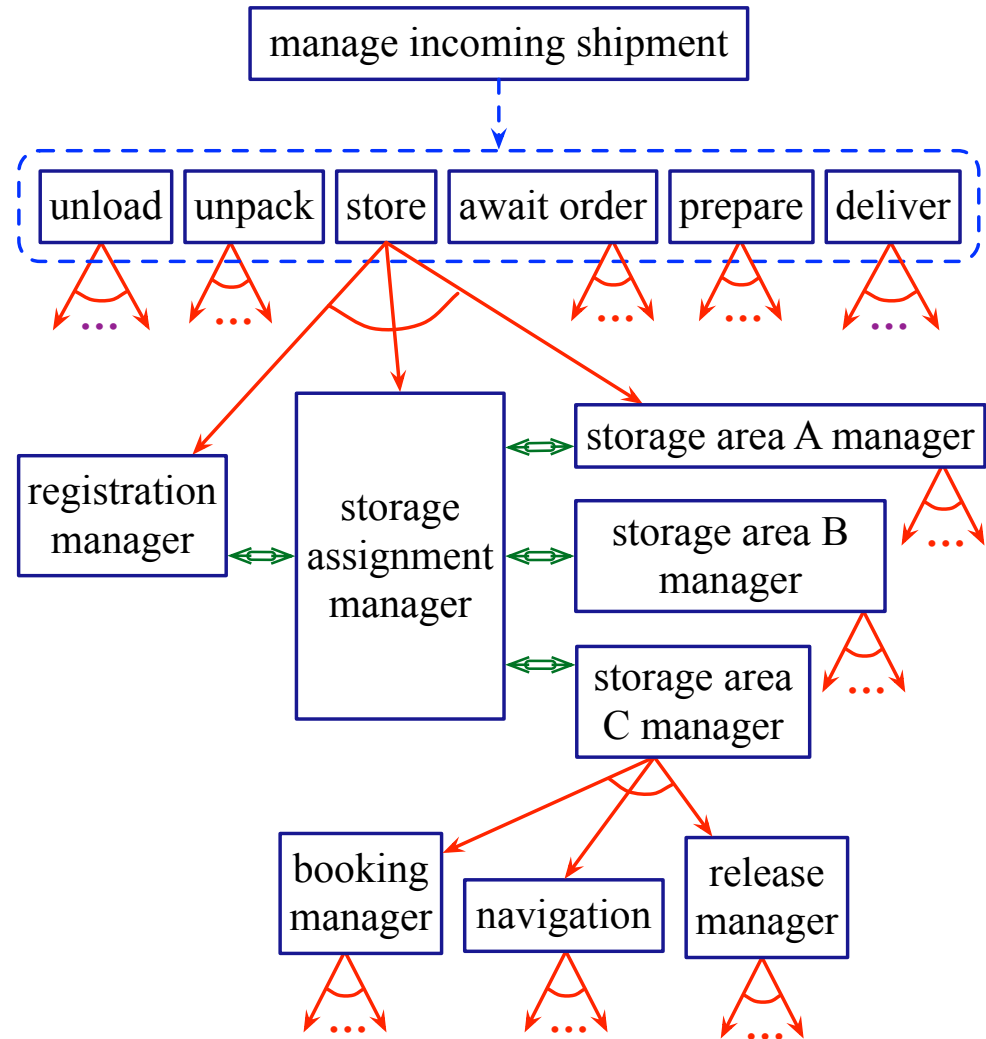
Example: Service Robot

- Multiple levels of abstraction
 - Higher levels: more planning
 - Lower levels: more acting
- Heterogeneous reasoning
 - bring o7 to room2: abstract steps
 - navigate to room1: path planning
 - open door: reactive
- Continual online planning
 - Is o7 really in room1?
 - What kind of door?
 - Close enough to the doorknob?



Example: Harbour Management

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



Content

1. Planning and Acting with **Deterministic** Models
 - Conventional AI planning
2. Planning and Acting with **Refinement** Methods
 - Abstract activities → collections of less-abstract activities
3. Planning and Acting with **Temporal** Models
 - Reasoning about time constraints
4. Planning and Acting with **Nondeterministic** Models
 - Actions with multiple possible outcomes
5. **Standard** Decision Making
 - Utility theory
 - Markov decision process (MDP)
6. Planning and Acting with **Probabilistic** Models
 - Actions with multiple possible outcomes, with probabilities
7. **Advanced** Decision Making
 - Hidden goals
 - Partially observable MDP (POMDP)
8. **Human-aware** Planning
 - Planning with a human in the loop