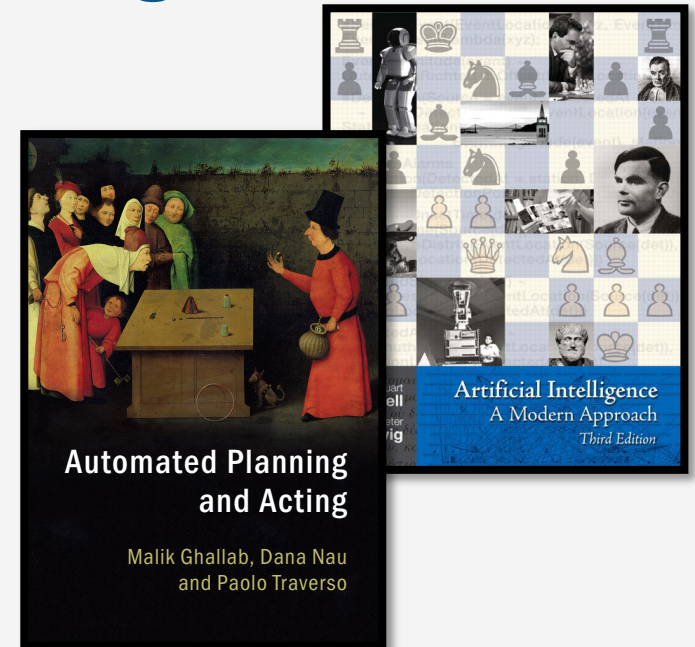


Automated Planning and Acting

Introduction



Organisational Stuff: Lecture

- Topic: Automated Planning and Acting
- Module: Formal Methods (small, 3 + 1)
- Language: English
- Schedule: Tuesdays, 16.15-17.45 pm
Thursdays, 16.15-17.45 am
 - Overview on dates and progress in Learnweb
 - *Every two weeks: last 30 minutes on Thursdays explicitly for Q&A?*
- There are lecture recordings available from last semester (@Uni Lübeck) that I can make available if interested
 - Same content, different layout; a handful of cross references to Uni Lübeck lectures that I would update here
 - Warning: May not correspond one to one regarding progress in presence

Organisational Stuff: Lecture

- Topic: Automated Planning and Acting
- Goal:
 - Get to know a set of deliberation methods for automated planning and acting
 - Bring you up to speed on the foundations of current research
 - Most research on planning and acting is in English → lecture in English
 - So, the goal is at the end of semester to be able to understand and explain
 - what inputs are necessary, what is output, and how does a method proceed on a high level,
 - what advantages and shortcomings exist,
 - when which method works in contrast to other methods.

Organisational Stuff: Exercises → Seminar

- Schedule: *tba* (towards end of semester)
- Task: Give a presentation on a selected topic
 - Ties to lecture expected
 - How to fill the time is up to you!
 - Theory
 - Exercises
 - Programming
- Goal: Practice to talk in English, carry a presentation for an extended period of time, the skill set necessary to understand and present an advanced topic
- Exact setup depends on the number of course participants
 - Duration: *45 minutes*
 - On your own ~~or in teams of two to three people~~

Show of hands who plans to participate as of now? (Not binding!)

Organisational Stuff: Exercises → Seminar

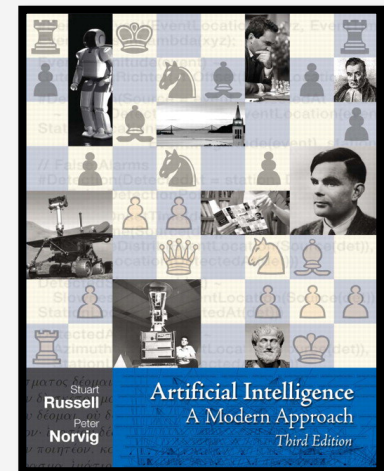
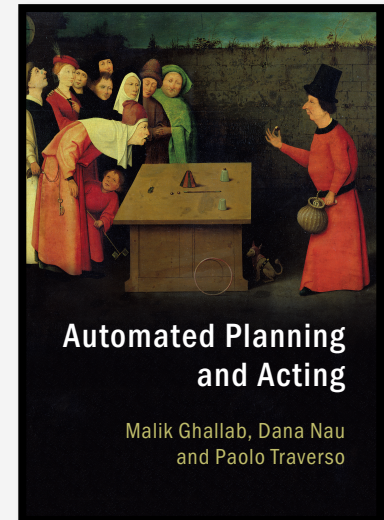
- Assignment of topics in Learnweb over the course of next week
- Topic areas
 - Topics 1-2 on deterministic planning
 - Topic 3 on refinement methods
 - Topic 4-6 on nondeterministic planning
 - Topic 7-8 on probabilistic planning
 - Topics 9-10 on other deliberation methods
- You can find a starting point for each topic in the main book
 - Look at references in book for more info
 - * these topics do not appear in the book but get a paper/article as a starting point
- Topics (selection)
 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. Solution techniques for decentralised MDPs*
 9. Hybrid Models
 10. Ontologies for Planning and Acting

Organisational Stuff: Exam

- **≤20** participants: **Oral** exam at the end of the semester
- **>20** participants: **Written** exam on 7 February, 2022 (Mon)
- Prerequisites to participate in exam
 - Seminar presentation
 - Exam registration

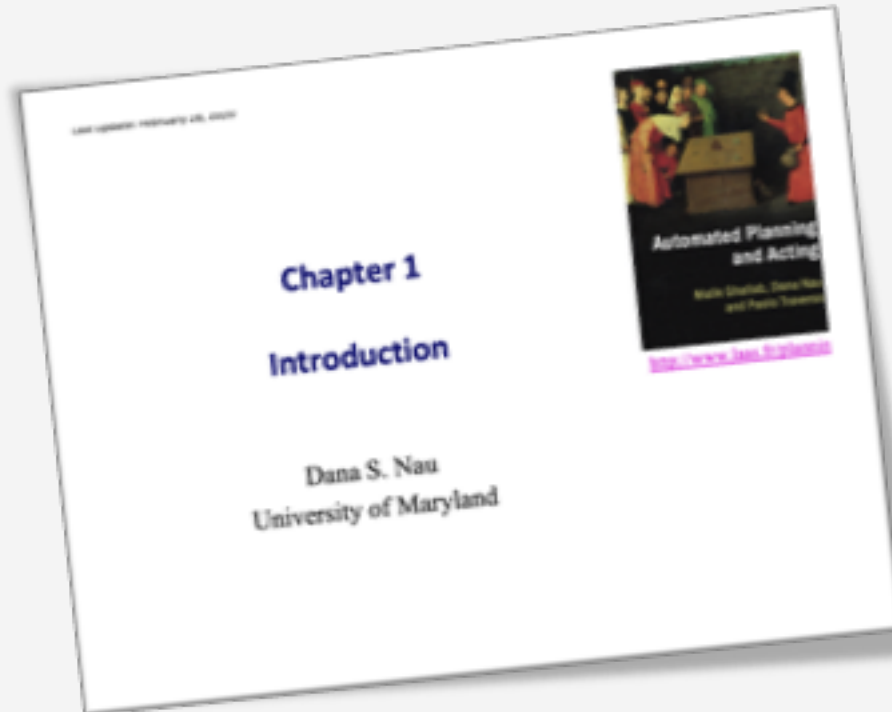
Literature

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

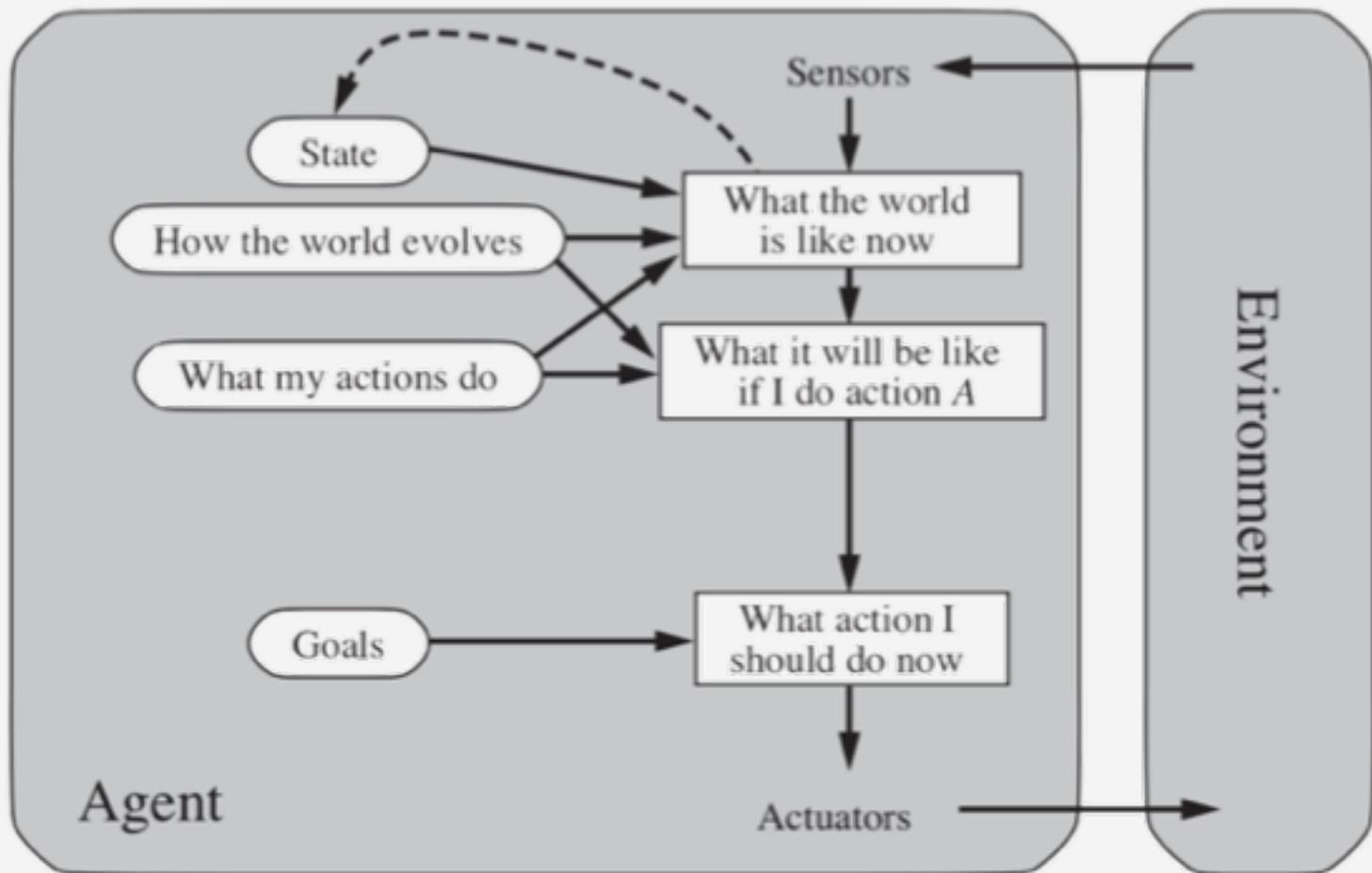


Acknowledgements

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

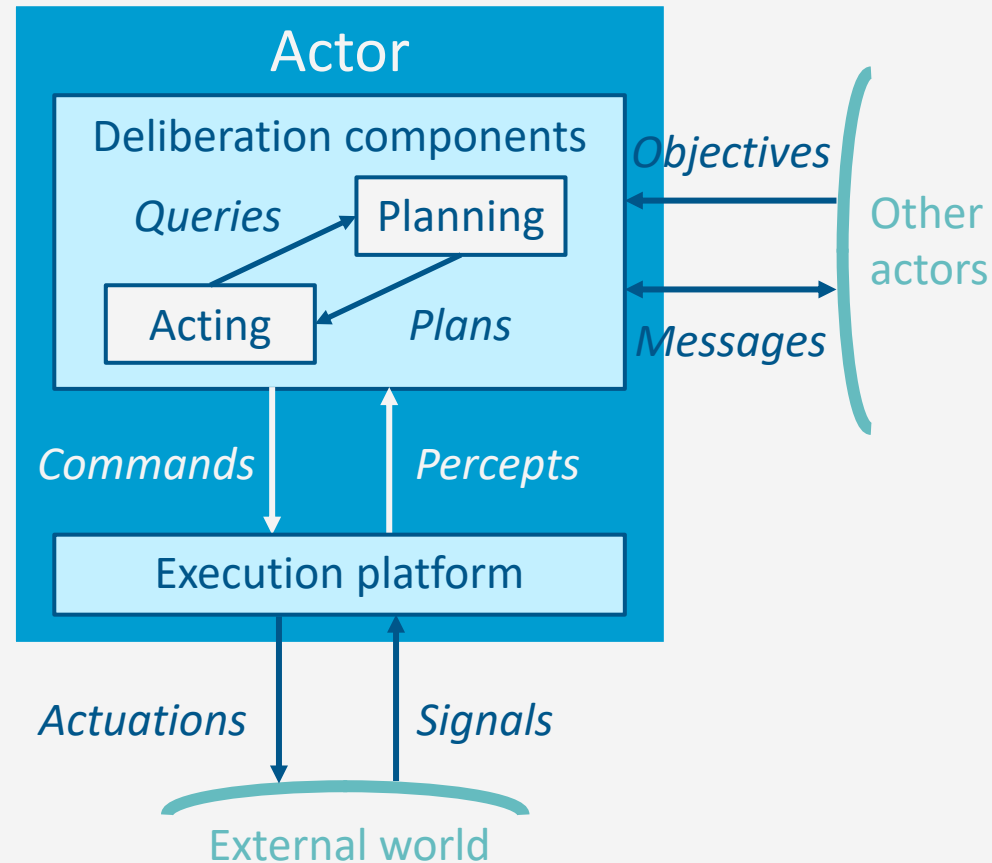


General Agent Setting



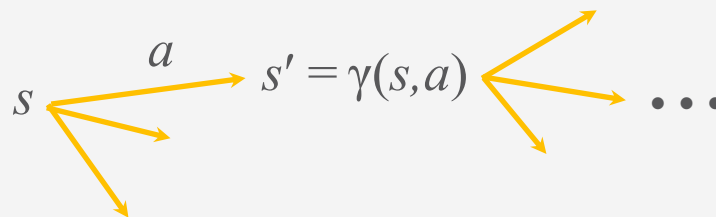
Setting Specific to Planning and Acting

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



Planning

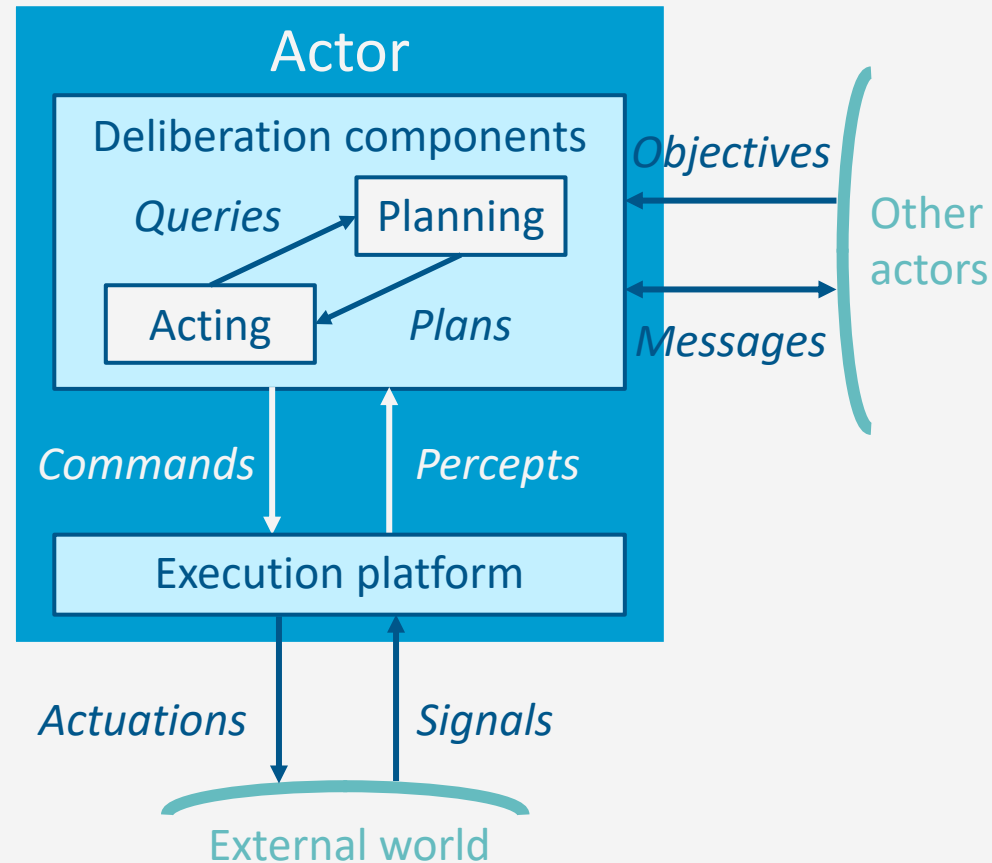
- Relies on **prediction + search**
- Uses **descriptive models** of the actions
 - Predict **what** the actions will do, but don't tell **how** to do them
- Search over **predicted states** and possible organizations of feasible actions
- Different types of actions
 - Different predictive models
 - 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 does not consider acting specially:
 - 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

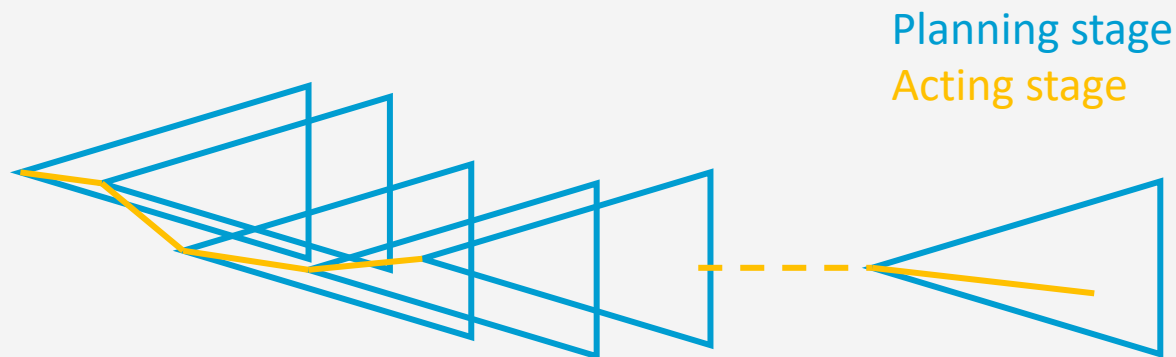


Acting as Execution



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**

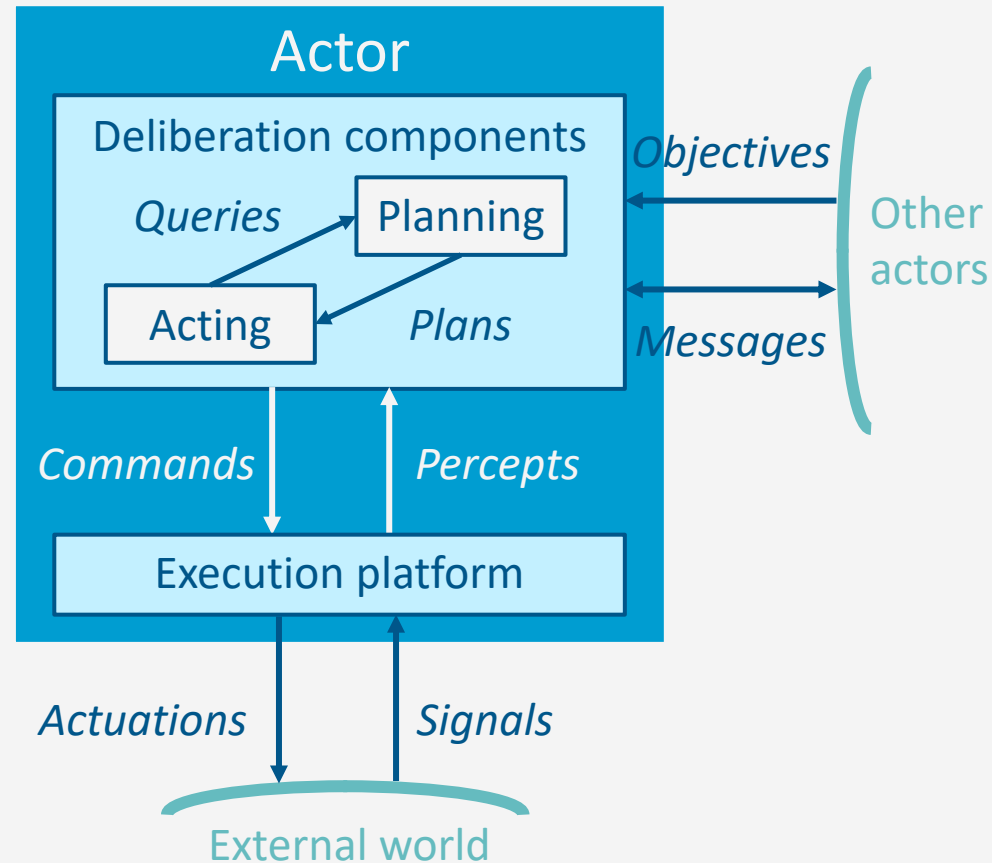


Deliberative Acting



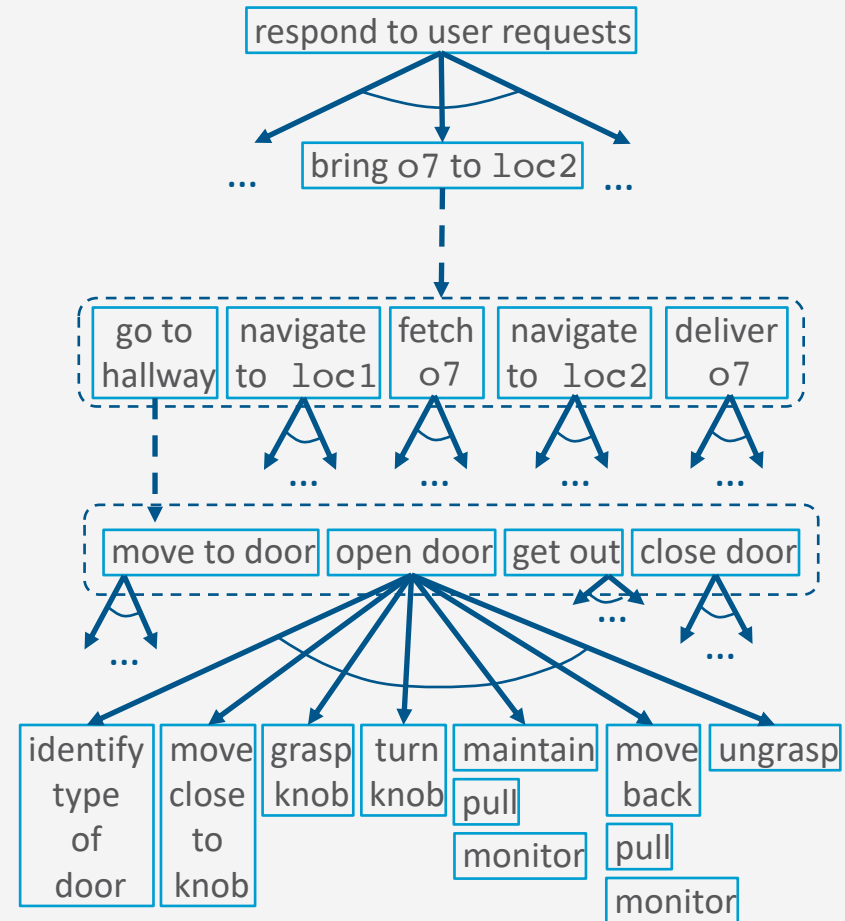
General Characteristics

- **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?

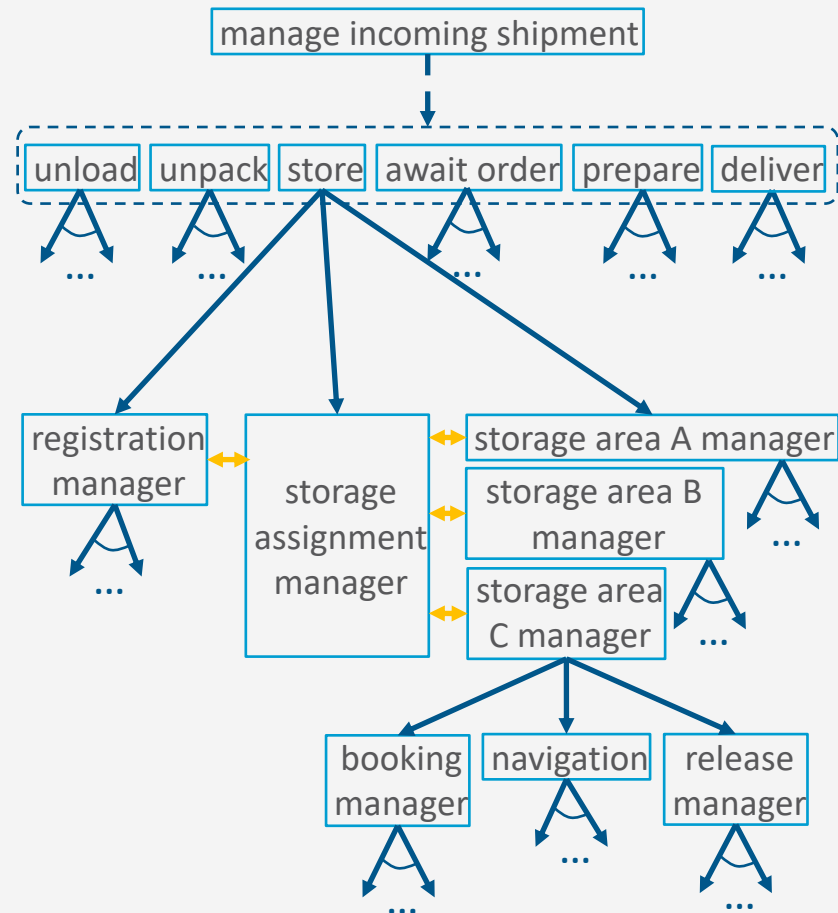


Planning

Acting

Example: Harbour Management

- Importing/exporting cars
 - Based on Bremen Harbour
- Multiple levels of abstraction
 - Reflect physical organization of harbour
- 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



Planning

Acting

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)
 - Decentralised POMDP
8. **Human-aware** Planning
 - Planning with a human in the loop