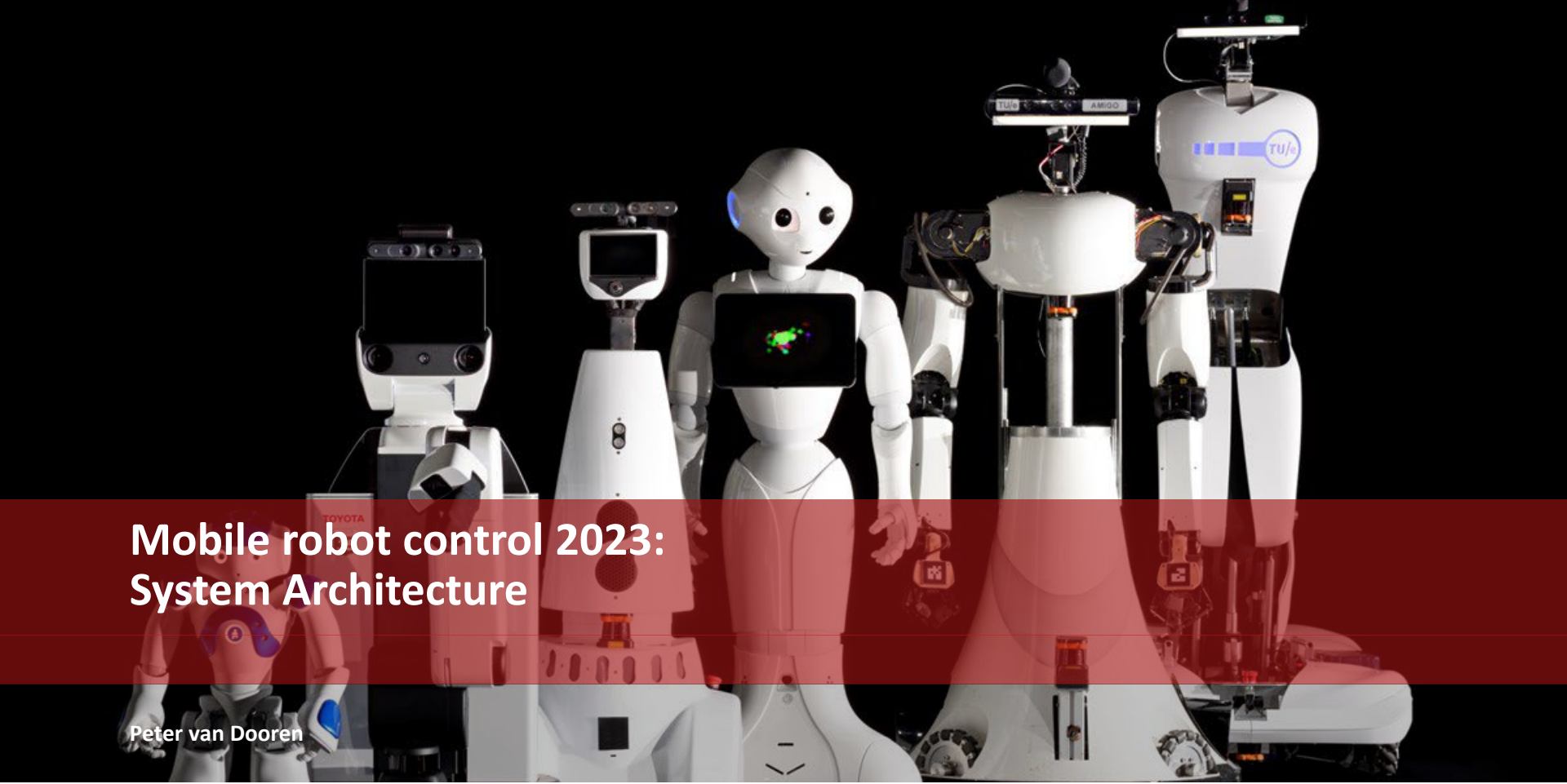

Mobile robot control 2023: System Architecture

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Mechanical engineering, Control Systems Technology

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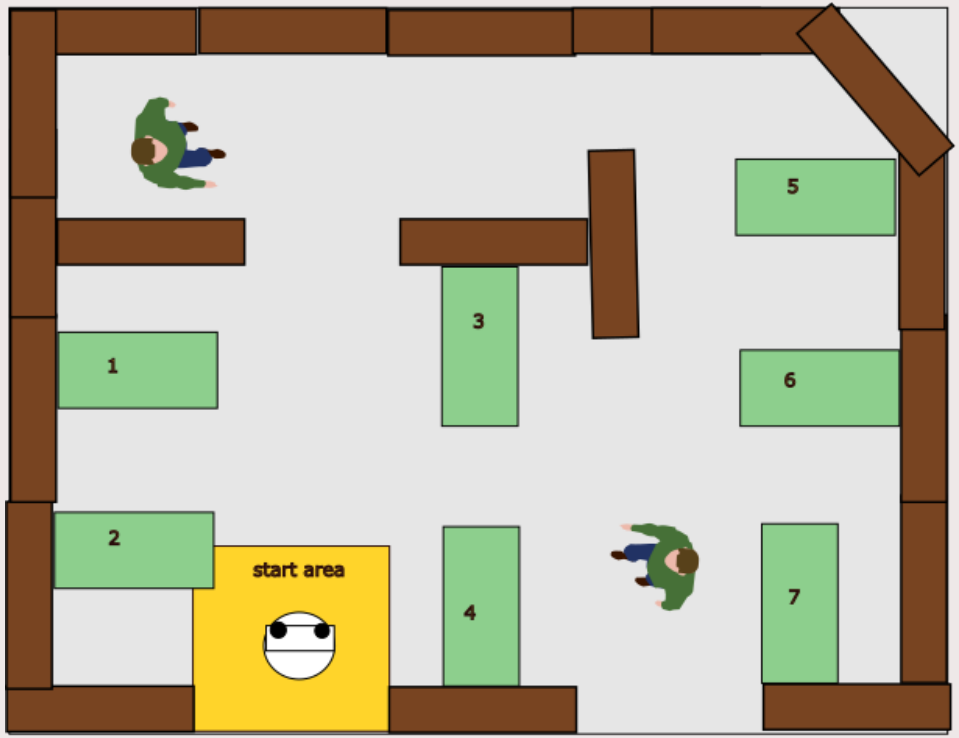
Why though?

Recap final challenge

Goal:

- Visit a number of tables in set order



Recap final challenge

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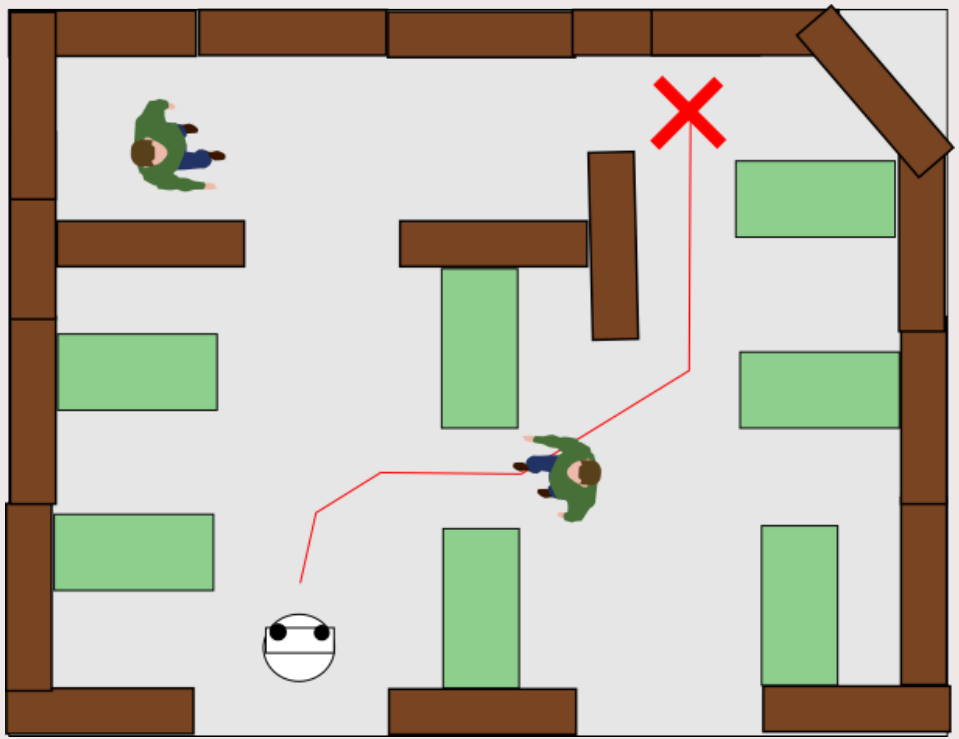

That’s why!

Learning goals

After this lecture you will be able to:

- Design a robotic system given an intended use-case
  - Describe why a system design is needed
  - Formulate design requirements
  - Formulate state flow chart
  - Formulate data flow chart

What Makes a Good Systems Design?

Sound familiar?

The code does not work, and you have no idea why

Sound familiar?

There is a random number in the code and only one group member knows what it does

System design

- High level description of the system
- Outlines components and the way they interact
- Abstracts away from implementation

System design

- Specifies the requirement of the system
  - Requirements can be tested
- Gives an overview of the system
  - New developers can follow decisions made by a previous team.
  - Components can de developed in parallel
- Allows you to engineer the system, rather than the software.
- Allows you to communicate the design

Formulating Requirements

Survey

Our robot can drive at a max speed of 0.22 m/s.

Question: is this a good value?

Who thinks this is:

a) Fast enough
b) Too slow
c) Too fast
d) Cannot be determined

Survey

Our robot can drive at a max speed of 0.22 m/s.

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Task: Follow customer around the store

Running example: ShopBot

Robot shopping cart

Task: follow operator around the supermarket

Requirements

What **should** the system do?

- Speed limits
- Wall clearance
- Driving lanes
- Driving heading
- …

Design decisions

Strict limitations

How to determine their values?

- Safe around humans
- Easy to use
- …

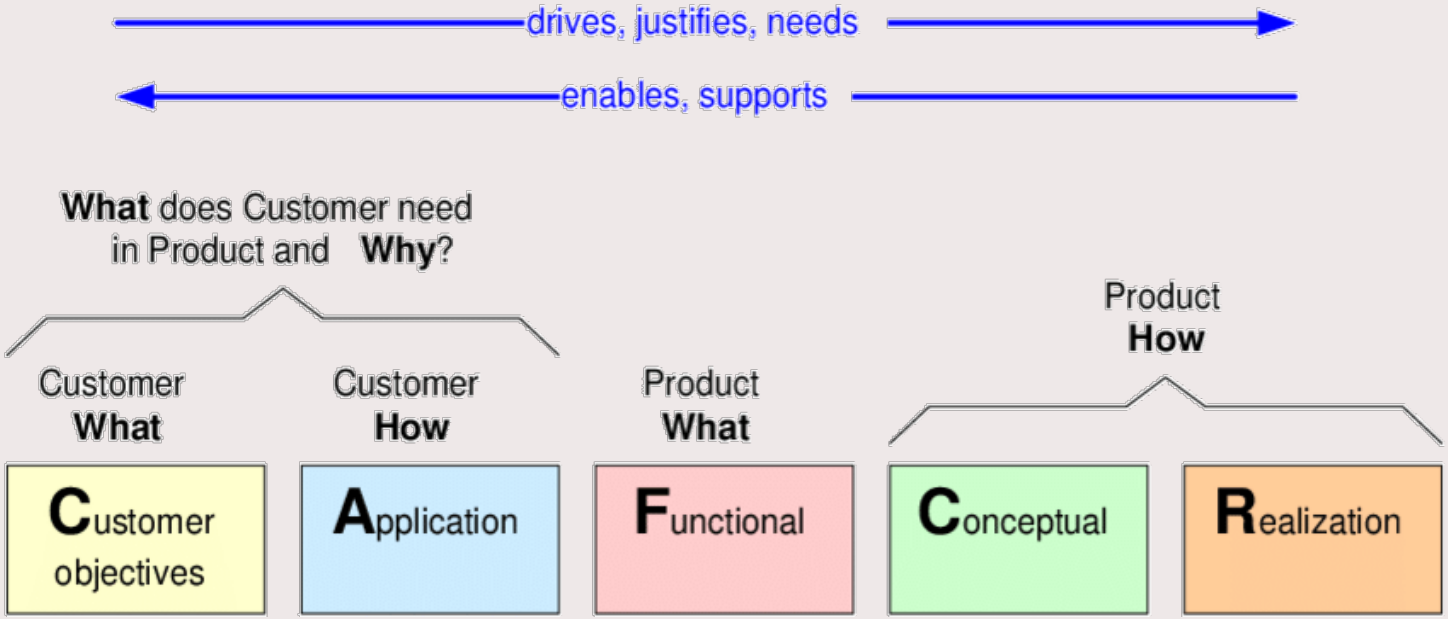
Coming from stakeholders

Often vague statements:
“Safe”, ”Robust”, ”Easy-to-use”

How to measure these?

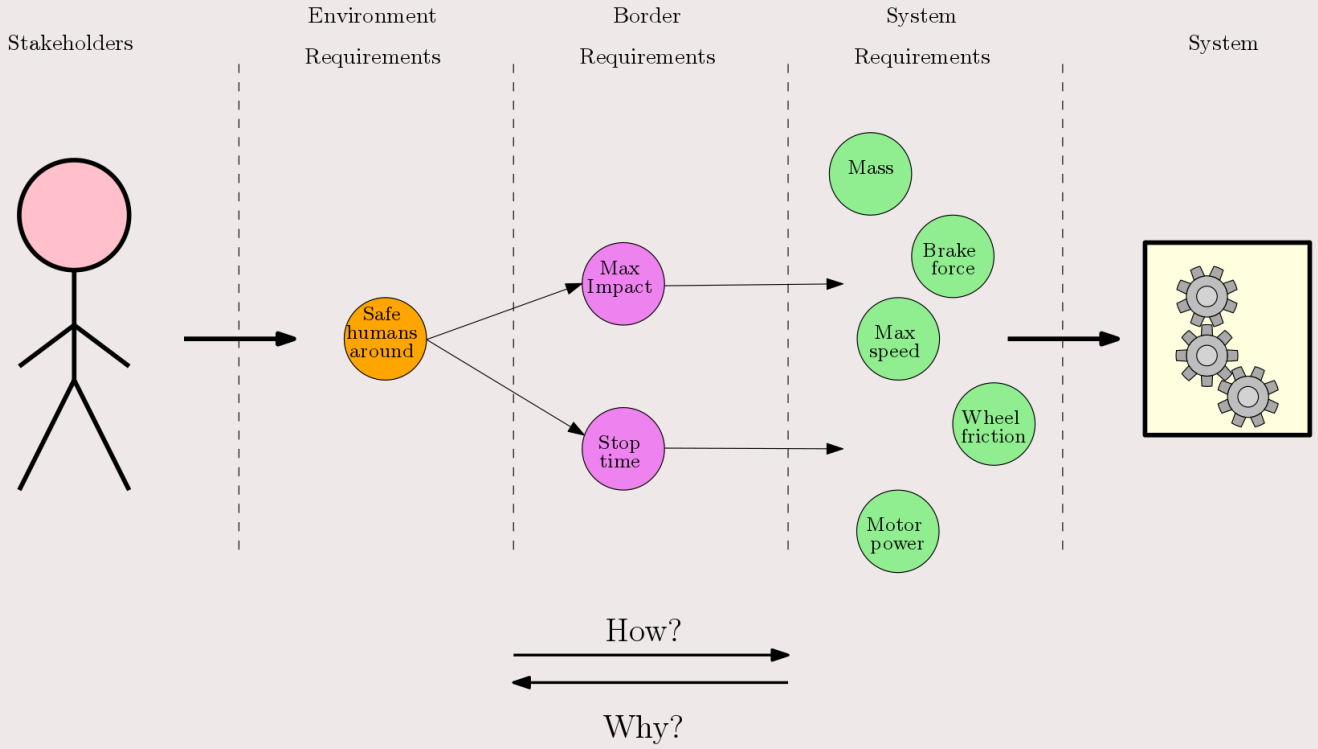
CAFCR

Model to organize different views on the system



https://www.gaudisite.nl/ThesisBook.pdf

From Desires to Specs



From Desires to Specs

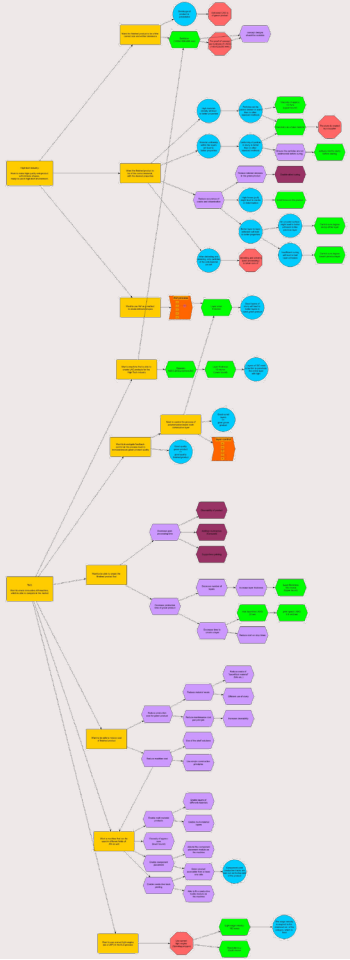
Environment requirement	Border requirements	System requirements
Describe a need without a solution in mind	Link other requirements with each other	Verifiable
Often vague and not measurable	Models	Simple values
Come from stakeholders	Design decisions	

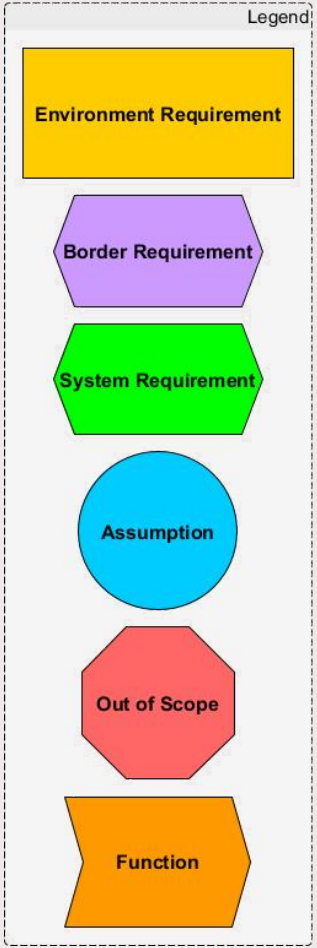
Why is this important?

- Bookkeeping
- Back-traceability
- Insight in conflicts
- Ordering of importance

- Coherence in group
- Discussion points
- Comparing system designs

- NO MORE MAGIC NUMBERS!
  - BUT MODELS



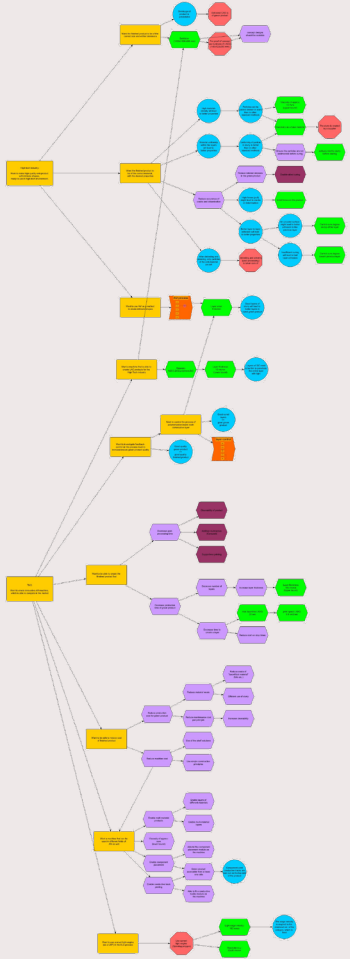


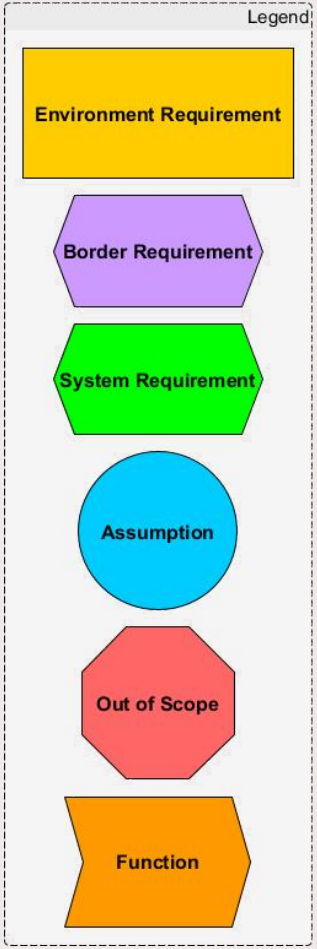
Why is this hard?

- Many stakeholders
- Conflicting desires
- No tangible output (at first)

- Boring (no it is not!)

- Not an exact science!





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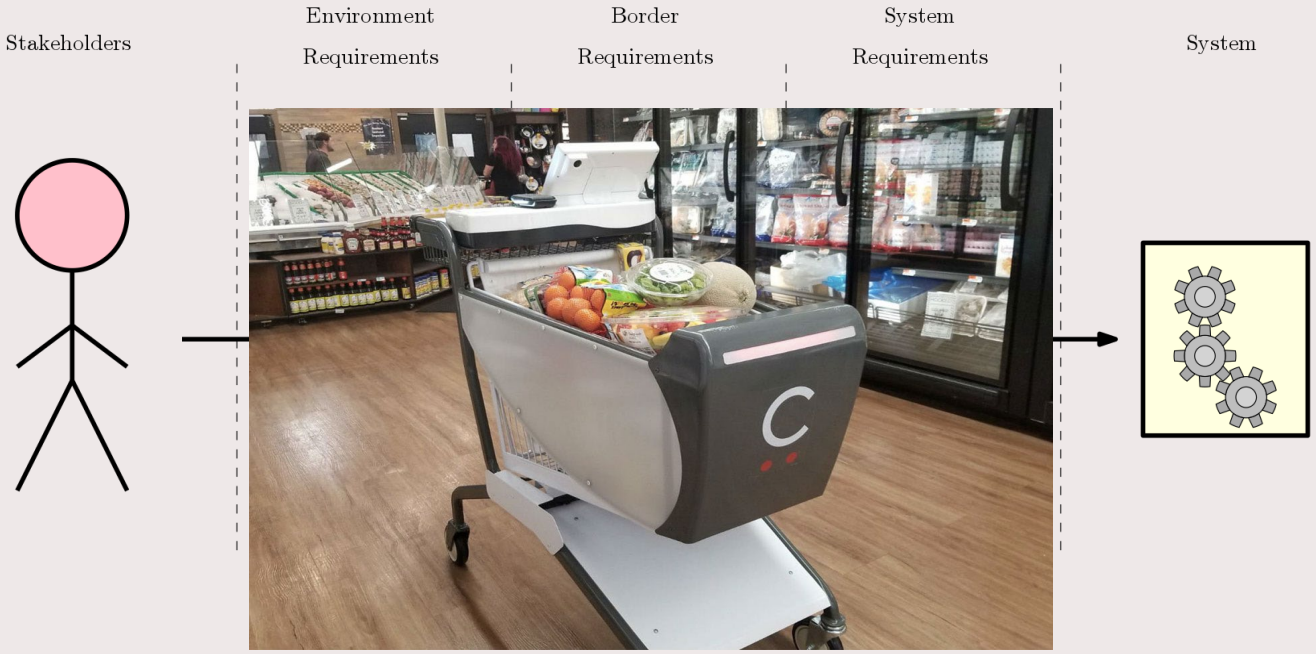

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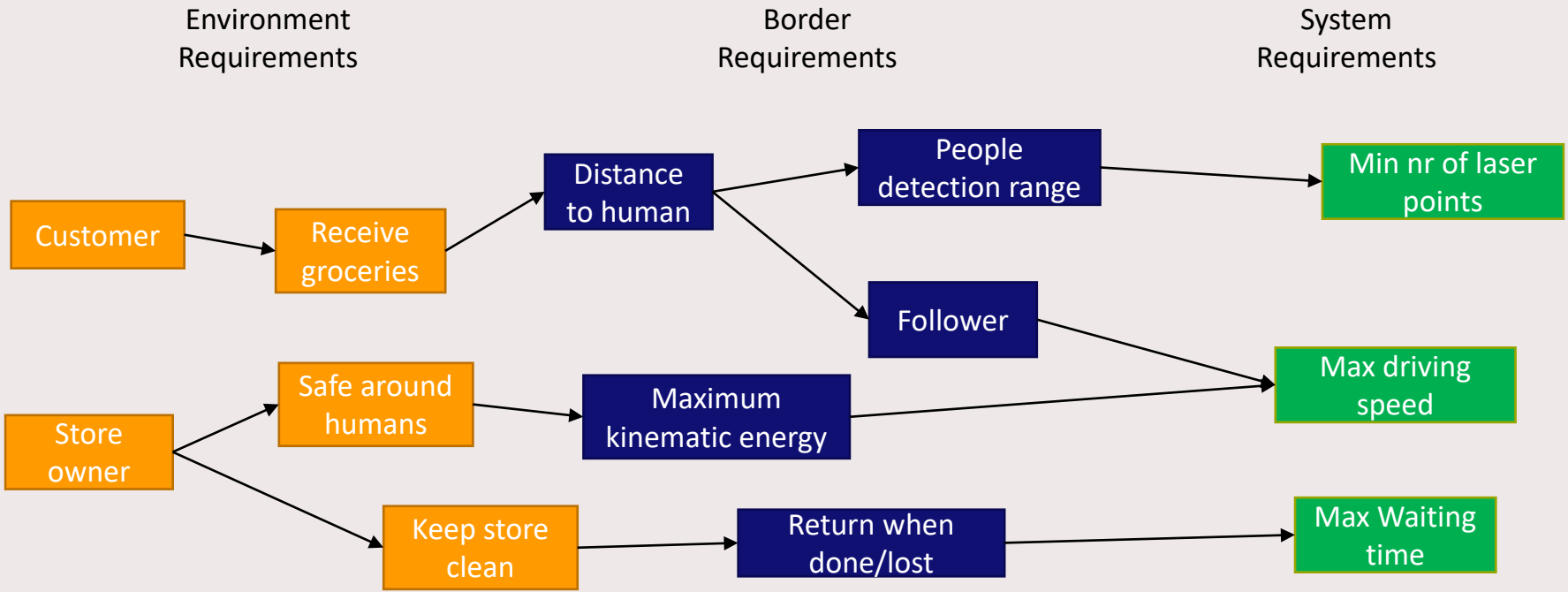


Data Flow Diagram

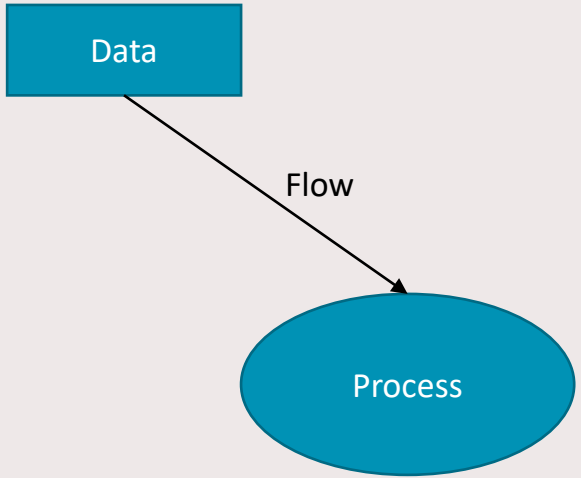
Data Flow Diagram

A form of structured analysis which gives insights into:

- Origin of data
- Interfaces between processes

Consist of:

- **Data**: information
- **Process**: a functional component with inputs and outputs
- **Flow**: specify an input/output relation between process and data



Data Flow Diagram

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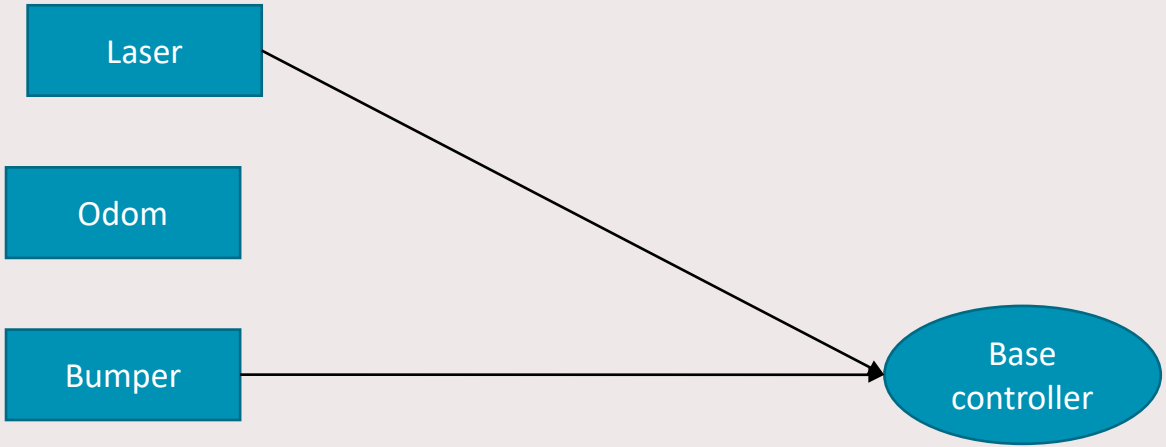
Data Flow Diagram



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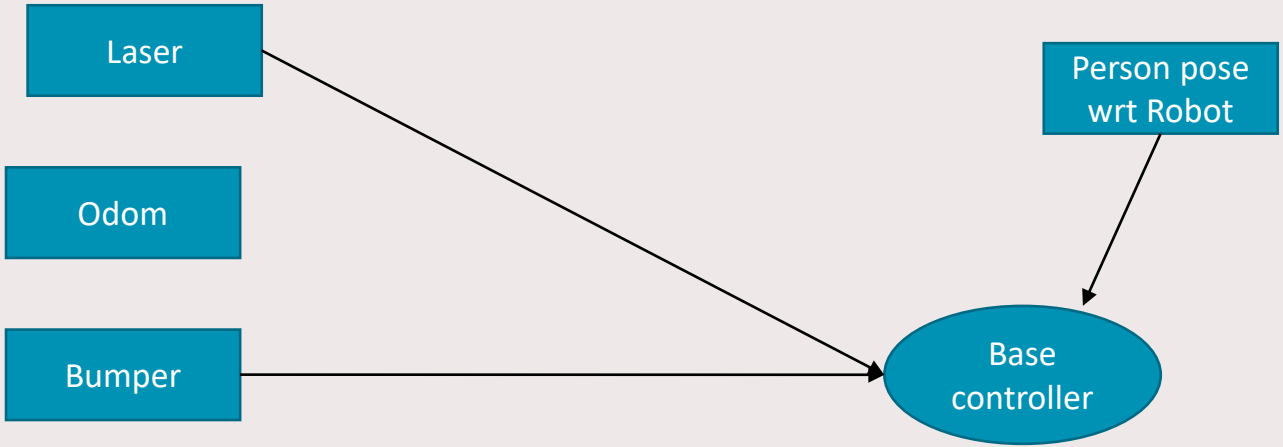

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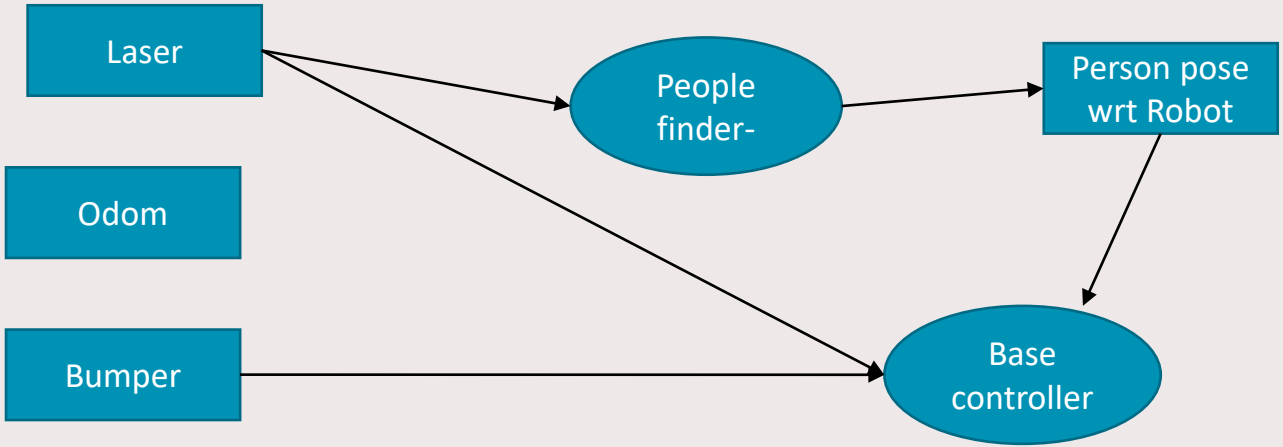

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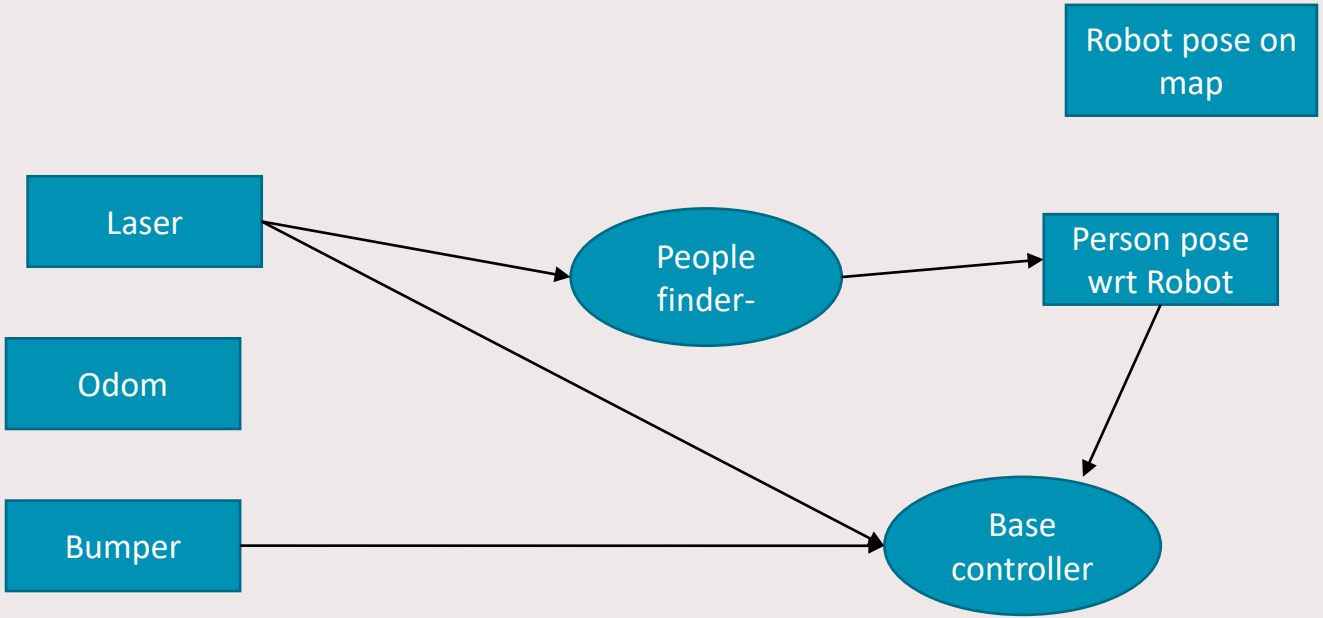

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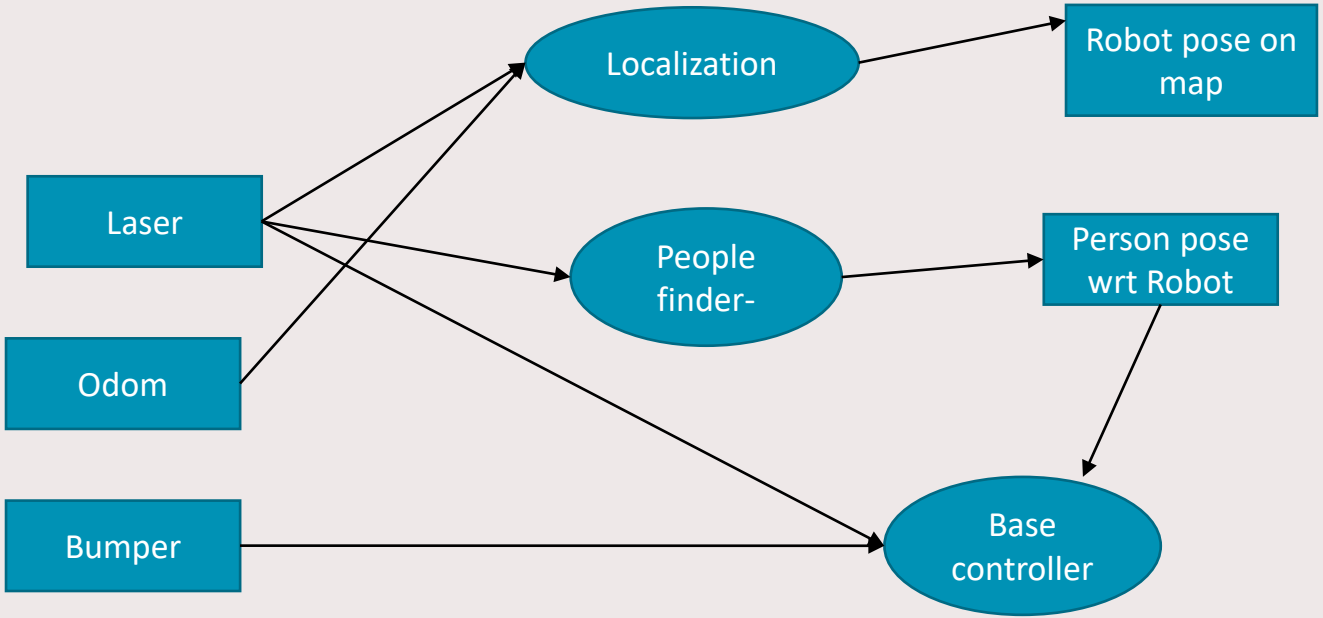
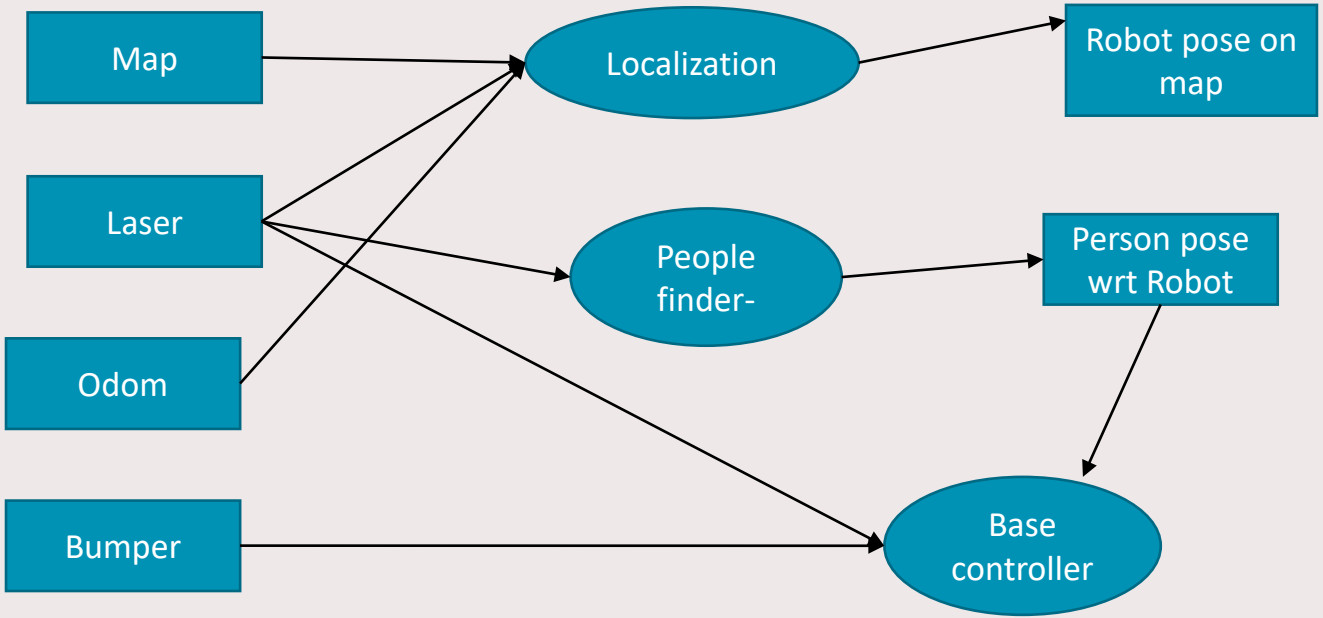


Data Flow Diagram



State Diagram

State diagram

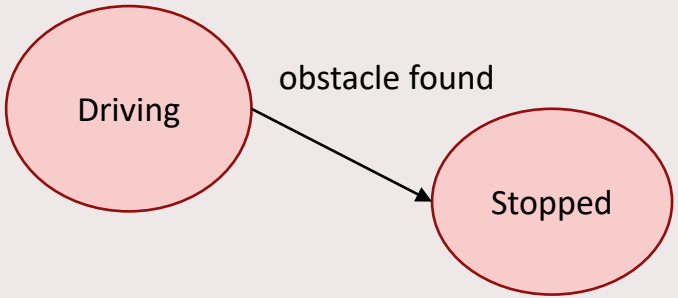
They allow you to design the discrete control of your system

State diagrams can be used to graphically represent finite state machines

https://en.wikipedia.org/wiki/State_diagram

State diagram

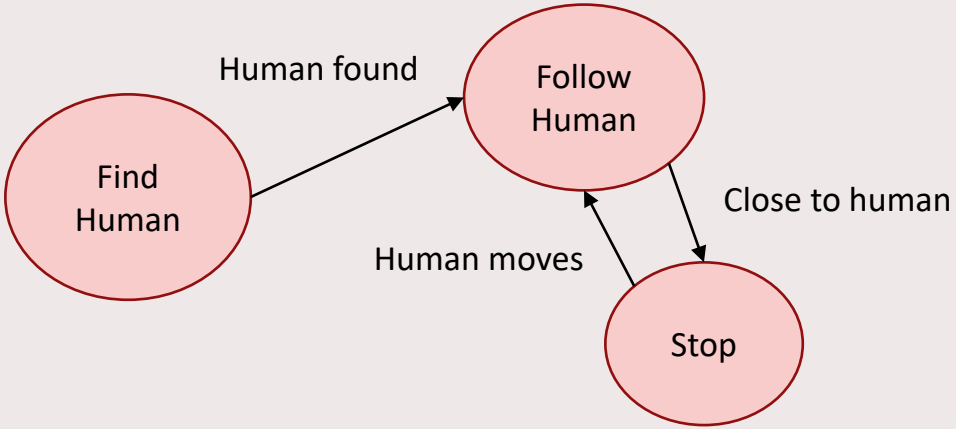
Set of states: {State1, State2,… StateN}
Transition: triple(from_state, event_name, to_state)
Set of transitions: { (S1, E1, S2), (S2, E2, S1), … (…) }



Set of states: {
Driving,
Stopped
}
Set of transitions: {
(Driving, obstacle found, Stopped)
}

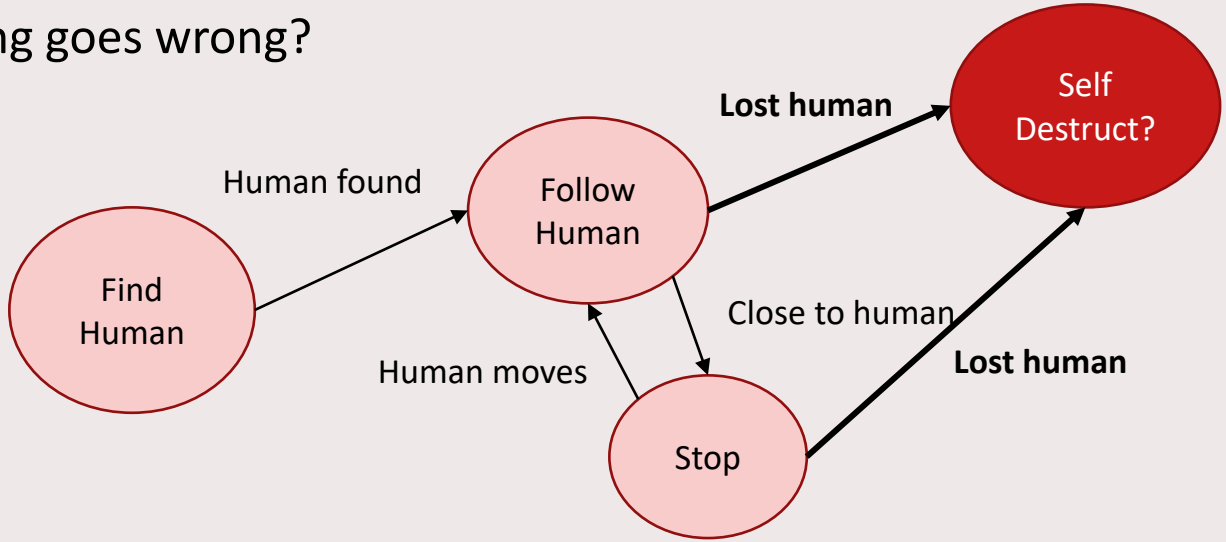
State diagram

Happy flow



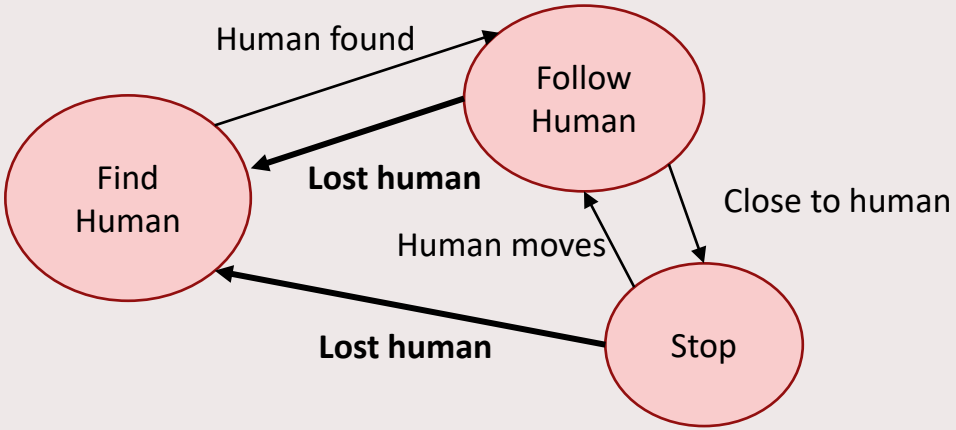
State diagram

What if something goes wrong?



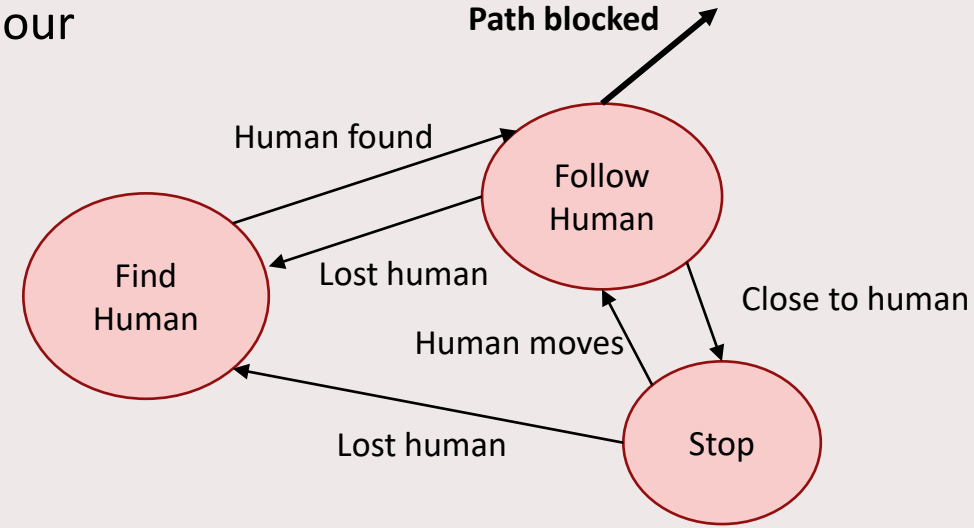
State diagram

Recovery behaviour



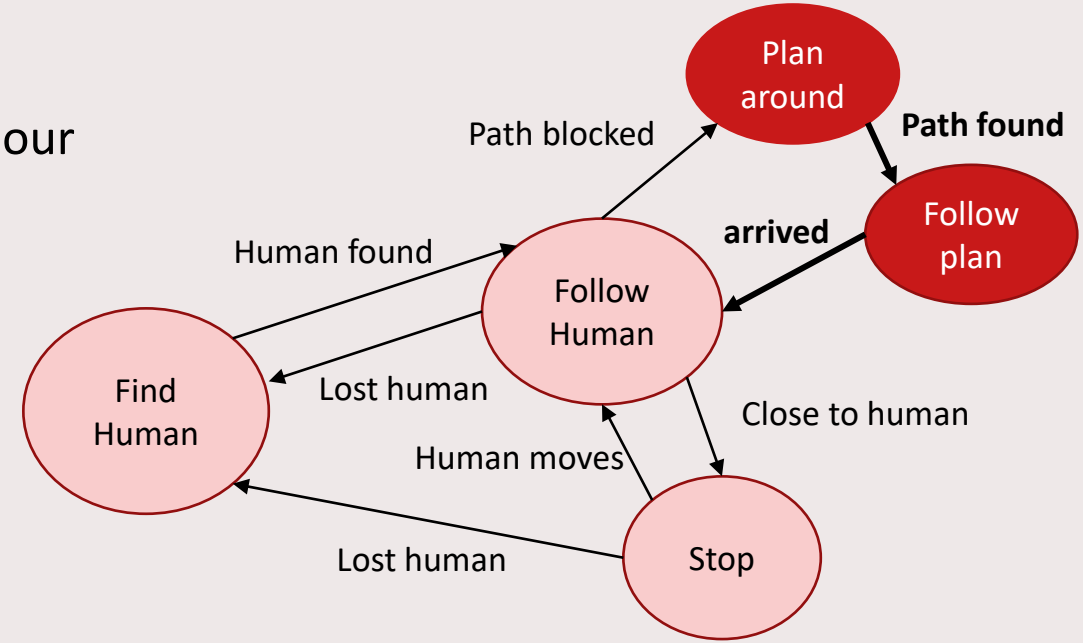
State diagram

Recovery behaviour



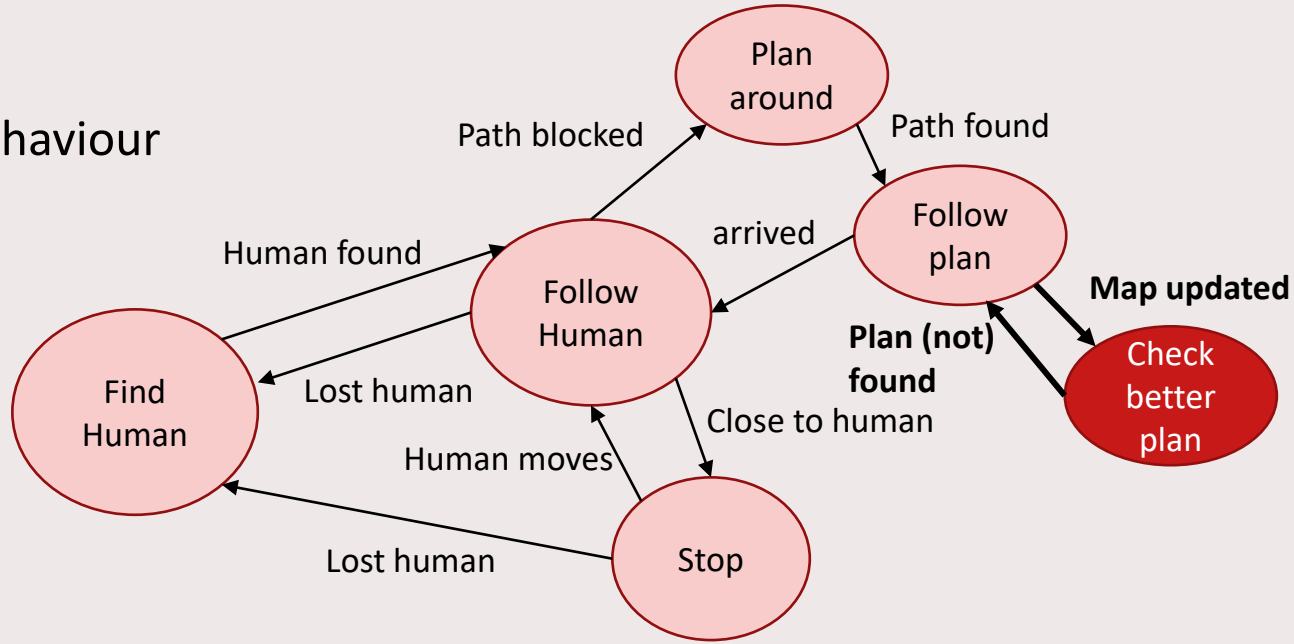
State diagram

Recovery behaviour



State diagram

Opportunistic behaviour



Question

Within a state we may have the following:

1. Functional component, which performs the behaviour
2. Monitors, which detect whether transitions occur
3. Transitions, which determine which state to go to next
4. State, data which persists a cycle of computation

Which of the above does not belong in a state?

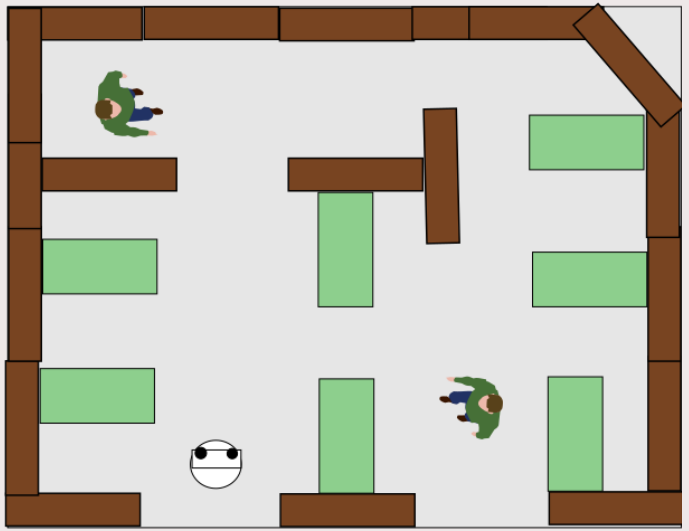
Design Presentations

Design Presentations for Restaurant challenge

- Some requirements already in the challenge description
- Think about how you can use what you have developed in the exercises

- Should contain:
  - Requirements
  - System design including state and data flow
  - Motivation for your design decisions

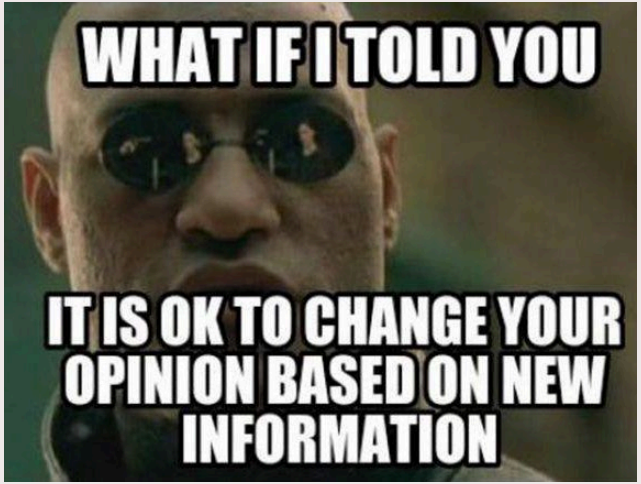
- Presentations: Wednesday June 7



Design for Restaurant challenge

- Upload design to your wiki
- Prepare a 10 min presentation

- Adaptation possible?
  - Absolutely!
  - Show your insights on the final wiki
  - (Don’t throw away initial design!)



Take Home Message

Think before you *do*

- What are the requirements?
- How are these requirements related?
- When should our robot choose to change its behaviour?
- What are the relations between the data structures in our system?
- How will we test if requirements are met?

There is no *best* way to do it. These are tools to help you focus your common sense.

Iterations are inevitable

Take time to think – ask ‘why’!

Questions?

Time for a break

Design Presentation for Restaurant challenge

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- Think about how you can use what you have developed in the exercises

- Should contain:
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  - System design including state and data flow
  - Motivation for your design decisions

- Deadline: Wednesday June 7