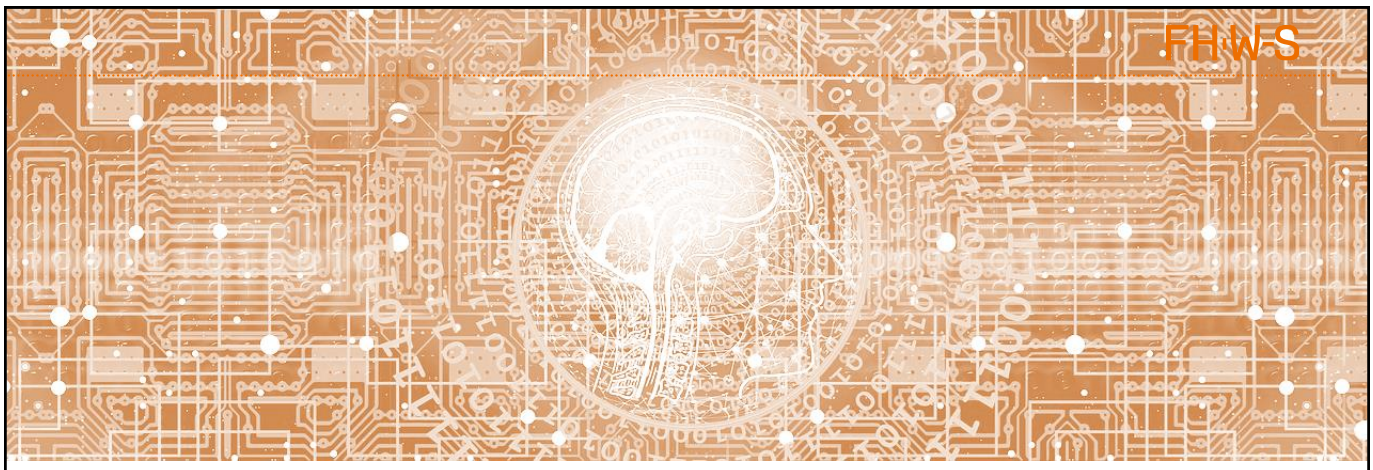

Embedded Systems and Field Buses

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FH·W·S University of Applied Sciences Würzburg-Schweinfurt

Agenda

- Fundamentals
- Structure of Embedded Systems
- Behavior of Embedded Systems
- Design of Embedded Systems
- Communication
- Real-time
- Collaborative Embedded Systems

FH·W-S

Behavior of Embedded Systems

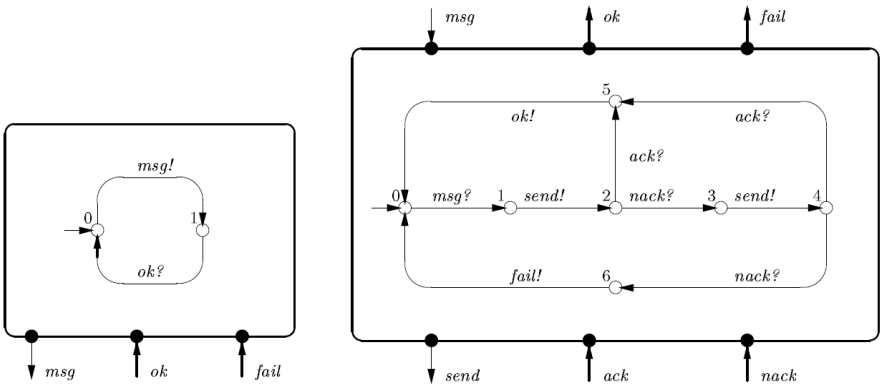
Part B: State-based and Interaction-based Behavior

Interface Automata

Exercise

Read: Interface Automata by Luca de Alfaro and Thomas A. Henzinger

Interface Automata Communicate

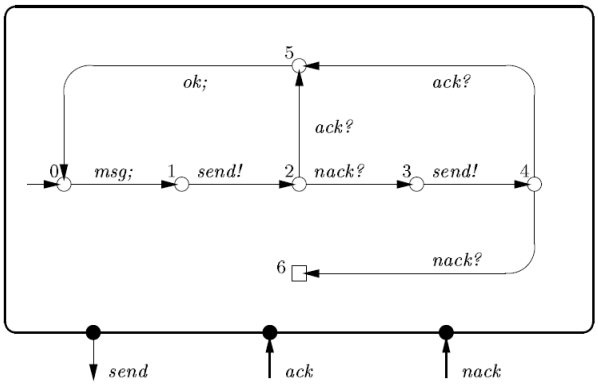


(a) Interface automaton *User*

(b) Interface automaton *Comp*

[Alfaro & Henzinger 2001]

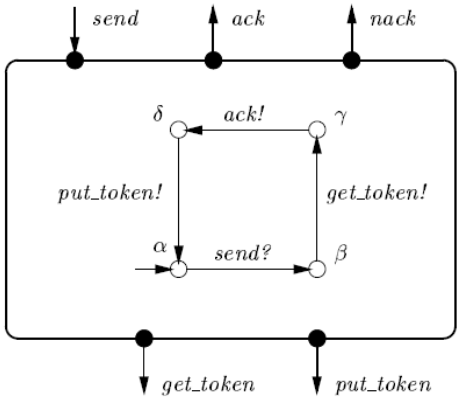
Product of Two Automatons



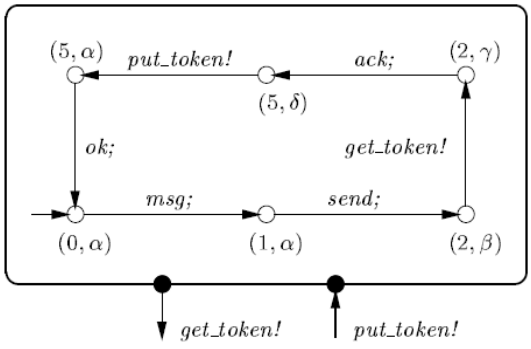
(c) *User* ⊗ *Comp*. The illegal state of the product is depicted as a square.

[Alfaro & Henzinger 2001]

Legal Environment



(a) *Channel*



(b) *User* ⊗ *Comp* ⊗ *Channel*

[Alfaro & Henzinger 2001]

Exercise

Model a Traffic Light using Interface Automata

Group Discussion

What are Advantages of Interface Automata?
What are Disadvantages?

Sequence Diagrams

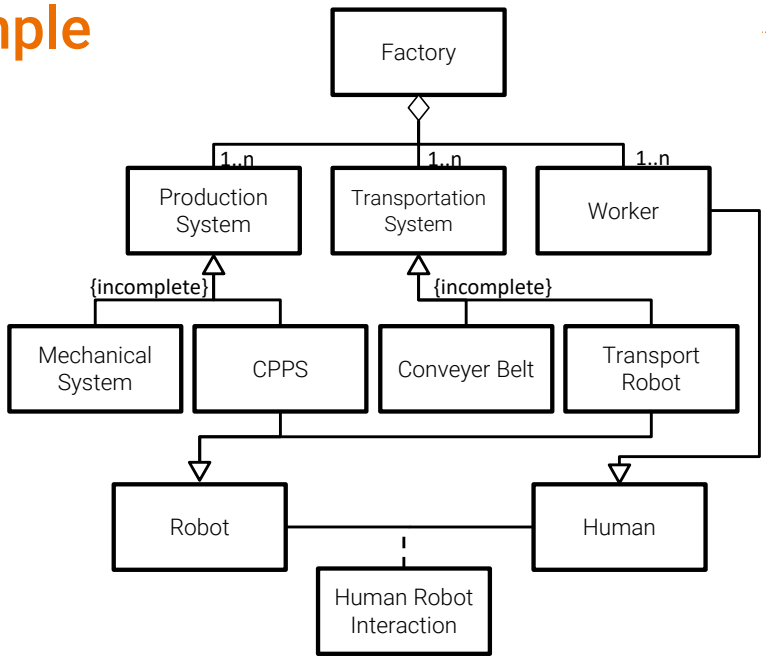
Interaction-based Behavior

Sequence Diagrams are commonly used to
- Model **Scenarios** (Requirements Engineering)
- Define the **Interaction-based Behavior** of Embedded Systems

Sequence Diagrams do **NOT focus on states** (*almost* have no states at all)

Describe Interactions (i.e. message or **signal exchange**) between systems or components

Example



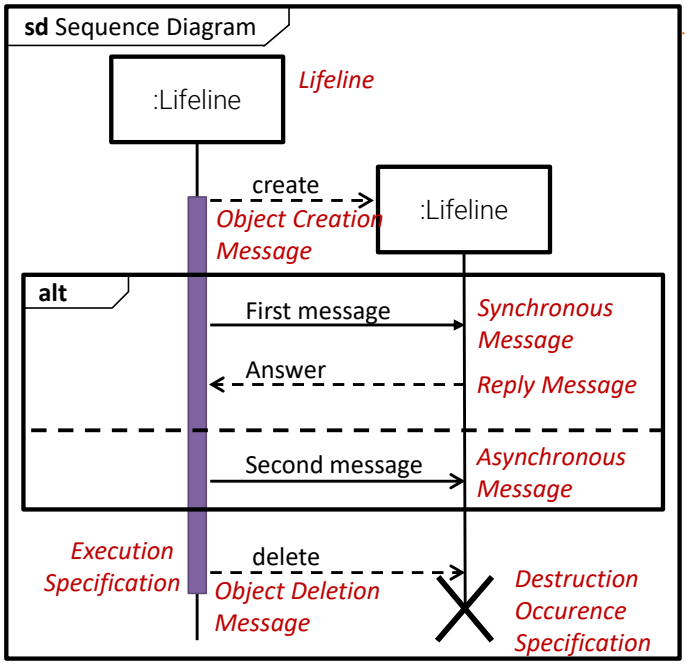
Sequence Diagram

Menschen sind spezielle „Objekte"
- Keine Erzeugung, keine Zerstörung
- Keine Methodenaufrufe, -ausführungen

Ähnlich für Roboter

Außerdem: Modellwirkung bei vielen unterschiedlichen Modellelementen

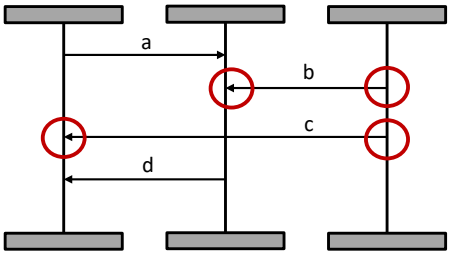
In der Regel keine
- Object Creation
- Object Deletion/Destruction
- Execution Specification



Synchronous vs. Asynchronous Communication

Main assumptions of asynchronous data exchange:

Sending and receiving of a message are different events.



Asynchronous Communication

Message b is sent before message c, but message c can be received before message b is received. Thus, there are several possible orders of events:

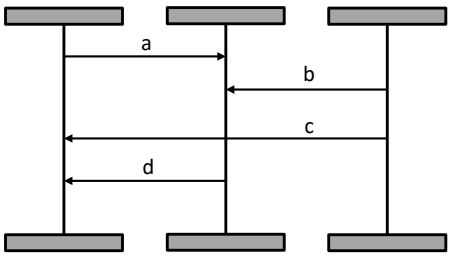
1.) s(b) < r(b) < s(c) < r(c)

2.) s(b) < s(c) < r(b) < r(c)

3.) s(b) < s(c) < r(c) < r(b)

Visual vs. Causal Order

Causal order means, events are not ordered according to their visual arrangement, but according to their logical occurrence.



Visual Order:

a < b < c < d

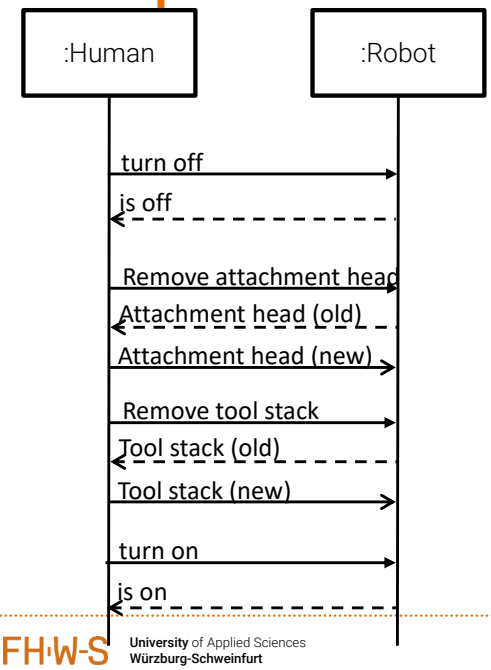
Causal Order:

(a < d) & (b < d) & (b < c)

Following possibilities arise:

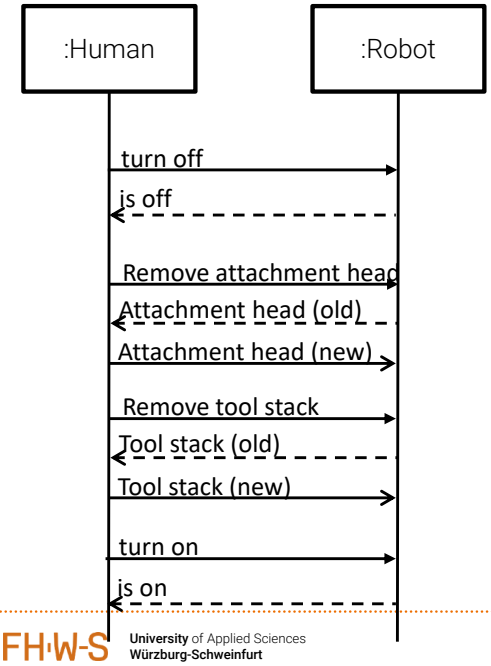
1.) a < b < c < d
2.) b < a < c < d
3.) a < b < d < c
4.) b < a < d < c
5.) b < c < a < d

Example



Changing the attachment head and the tool stack of a production robot

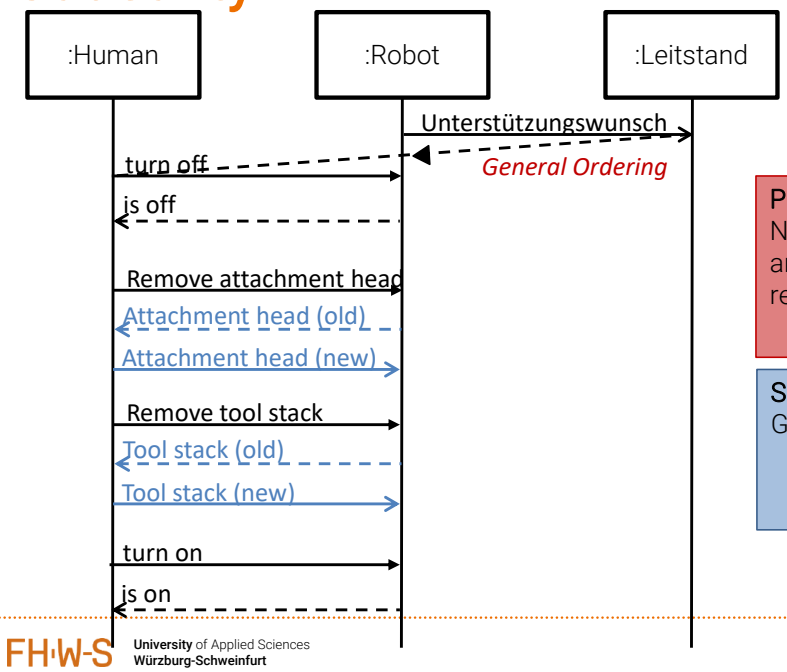
Material and Data Flow



Problem
How to differ between virtual data flow and physical material flow?

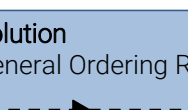
Possible Solutions
- Profiles
  - Syntax definitions
  - Stereotyping
- Pragmatic approach
  - Coloring

Causality

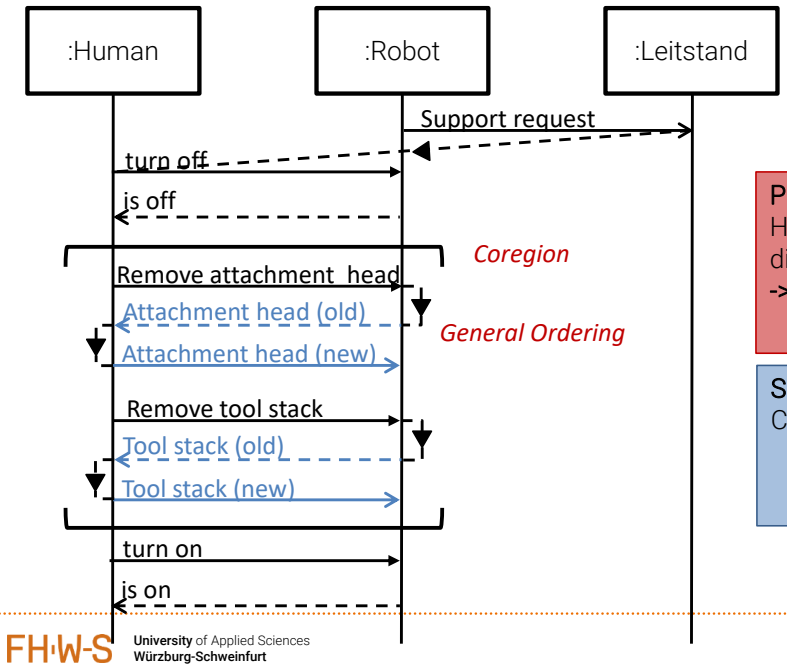


Problem
No interaction between the robot and the human but causal relation

Solution
General Ordering Relation

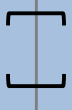


Human Behavior



Problem
Humans solve problems in different ways
-> No order of human interactions with a robot

Solution
Coregion



Exercise

Model the Interaction-based Behavior with Sequence Diagrams of:

- A Cobot
- A Transport Robot

Exercise

Model the Interaction-based Behavior of a Traffic Light Controller with

- Interface Automata
- Sequence Diagrams

(Take care for consistency)