

Literature

- Hermann Kopetz: Real-Time Systems (2011)
- Jane Liu: Real-Time Systems (2000)
- Cottet et.al.: Scheduling in Real-Time Systems (2002)

Real-Time Systems

- “A real-time computer system is a computer system where the correctness of the system behavior depends not only on the logical results of the computations, but also on the physical time when these results are produced.” (Hermann Kopetz: Real-Time Systems, 2011, p. 2)
- “. . . a real-time system is required to complete its work and deliver its services on a timely basis.” (Jane Liu: Real-Time Systems, 2000, p. 1)

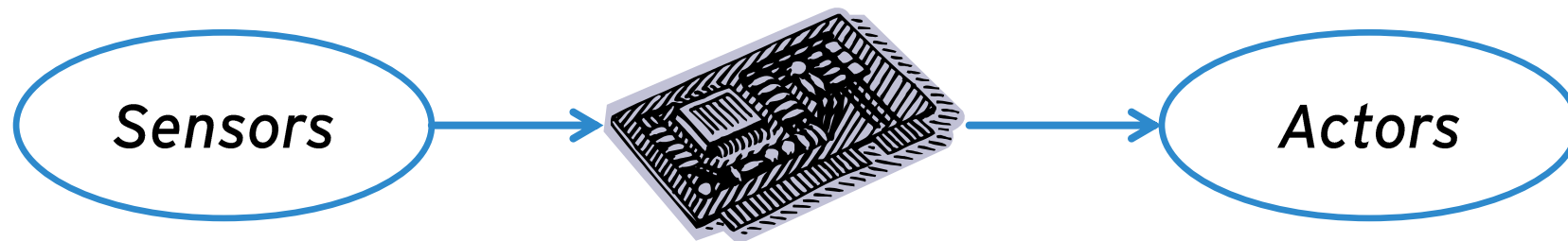


Real-Time Systems

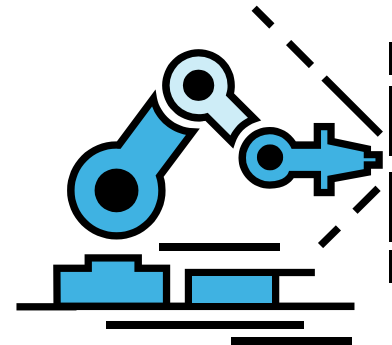
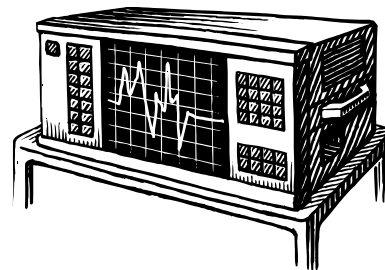
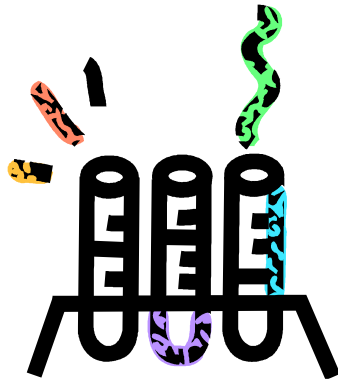
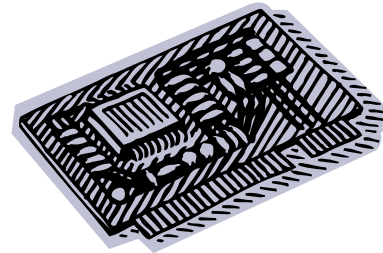
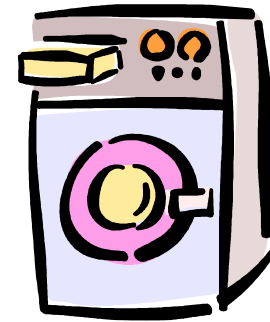
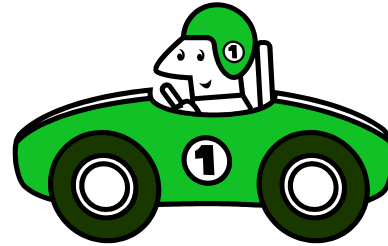
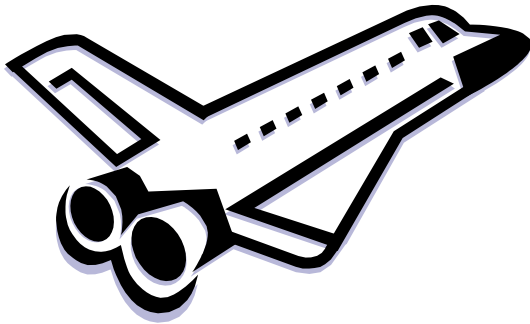
- Control and supervise technical processes
- Often embedded in technical systems
 - *Embedded Systems*
 - Not directly visible for the user
- Computer systems for special tasks
 - Hardware and software match in a harmonic way

Real-Time Systems

- Requirements
 - Correct reaction
 - Reaction in time
- Important properties: Safety, security, availability, usability
- Structure

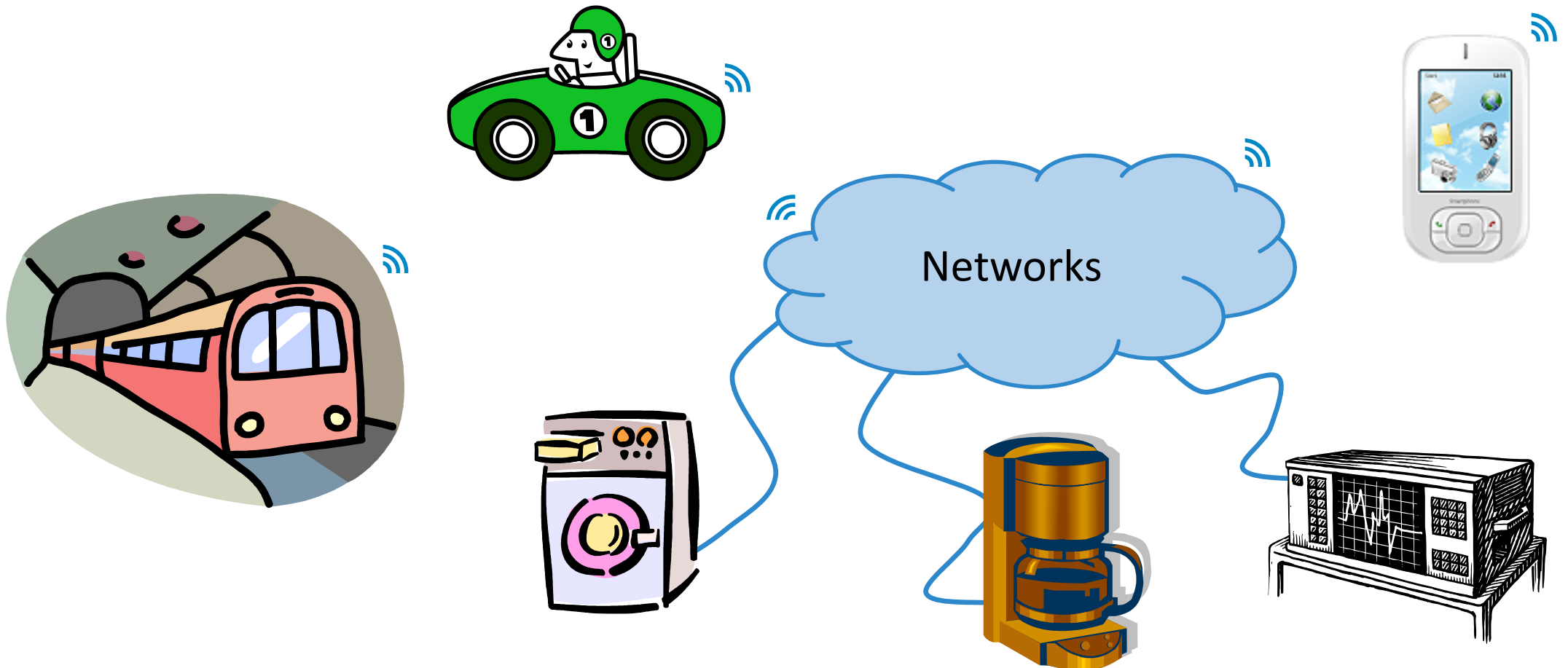


Examples for Real-Time Systems



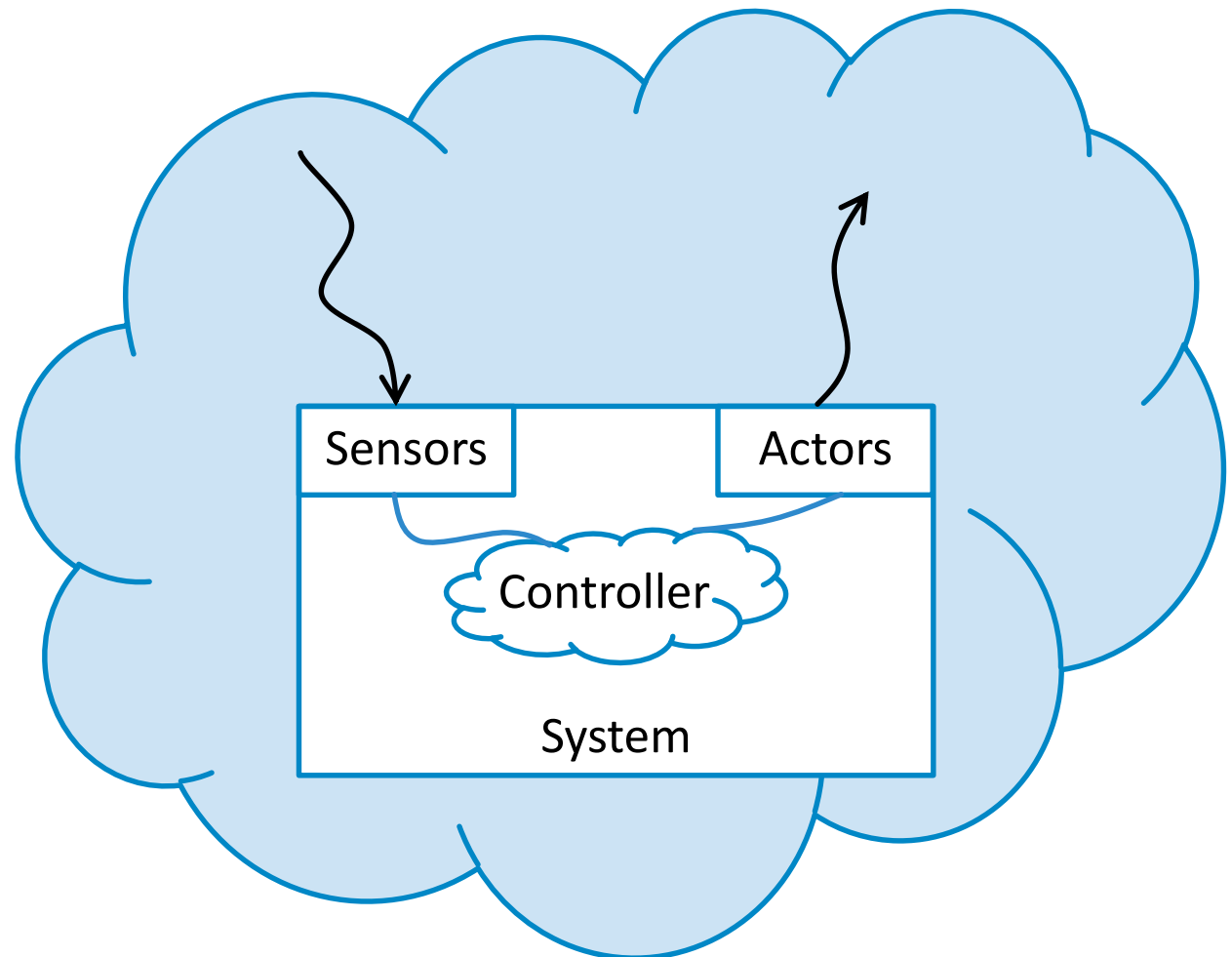
Cyber Physical Systems

- Connection of embedded systems with networks


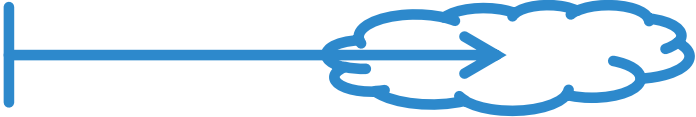


Terminology


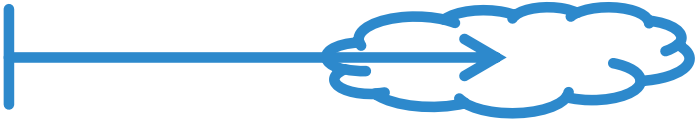
- (System-)Environment
- Event
- Stimulus
- Reaction
- Deadline



Real-Time Requirements

- *Hard* Real-Time 
 - Untimely reactions lead to unacceptable consequences (for humans, the environment, ...)
 - Often a reaction in milliseconds is necessary
 - Hard real-time does not necessarily mean *fast reaction*
- *Soft* Real-Time 
 - Reaction should be normally in time
 - The system can deal with untimely reactions, often with lower quality of service

Real-Time Requirements in a Vehicle

- *Hard* Real-Time 
 - Vehicle dynamics: Stabilization of the vehicle
 - Firing the airbag
 - Navigation system: Driving direction hints
- *Soft* Real-Time 
 - Multimedia: Audio and video
 - System settings: Switching between screens

Classification of Real-Time Systems

- Hard Real-Time System vs. Soft Real-Time System
- Fail-Safe vs. Fail-Operational
- Event-Triggered vs. Time-Triggered

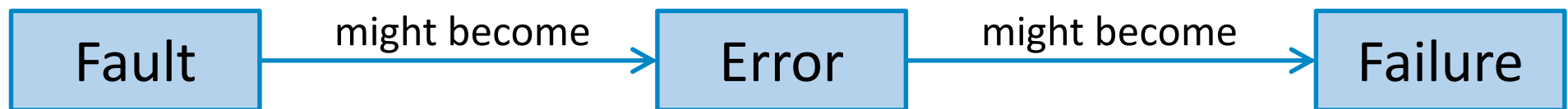
Hard Real-Time System vs. Soft Real-Time System

Characteristic	Hard Real-Time	Soft Real-Time
<i>Response time</i>	Required	Desired
<i>Peak-load performance</i>	Predictable	Degraded
<i>Control of pace</i>	Environment	Computer
<i>Safety</i>	Often critical	Non-critical
<i>Redundancy-type</i>	Active	Checkpoint-recovery
<i>Error detection</i>	Autonomous	User assisted

Source: (Hermann Kopetz: Real-Time Systems, 2011, p. 14)

Fault, Error, Failure?

- Fault
 - Abnormal condition that might cause an element to fail
- Error
 - Discrepancy between *computed or measured* and the *specified or theoretically correct* value or condition
- Failure
 - Termination of the ability to perform the functionality



Fail-Safe vs. Fail-Operational

- A system is called *fail-safe*, if at least one *safe state* exists and can be reached in case of a failure in acceptable time
- A system is called *fail-operational*, if it is able to continue its operation in case of a failure, perhaps with limited functionality

Event-Triggered vs. Time-Triggered



- A system is called *event-triggered*, if events are propagated to the system when they happen
 - Some interrupt mechanism required to realize that
 - The controller must handle the event at that time

- A system is called *time-triggered*, if it checks for events at defined points in time



- Based on the schedule
- *Polling*