AVA

Universität Rostock

Traditio et Innovatio

Distributed Algorithms

Organizational Matters

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Course Organization

Dates

- Monday, 11-13
  - Lecture consultation, irregular
- Thursday, 11-13
  - Exercises, irregular

- Announced in advance on Stud.IP

Lecture and Exercises

- Lecture videos & exercises in German
- Slides in English
- English videos available on Stud.IP
- Focus is on lectures this semester
- For each slide set there is a bibliography for self-study
- Read papers to gain full knowledge!
- Exercises aim at getting a deeper understanding of the lectures' content and preparing for the exam
- Voluntary assignments
  will be available via Stud.IP

Prerequisites and Exams

Prerequisites

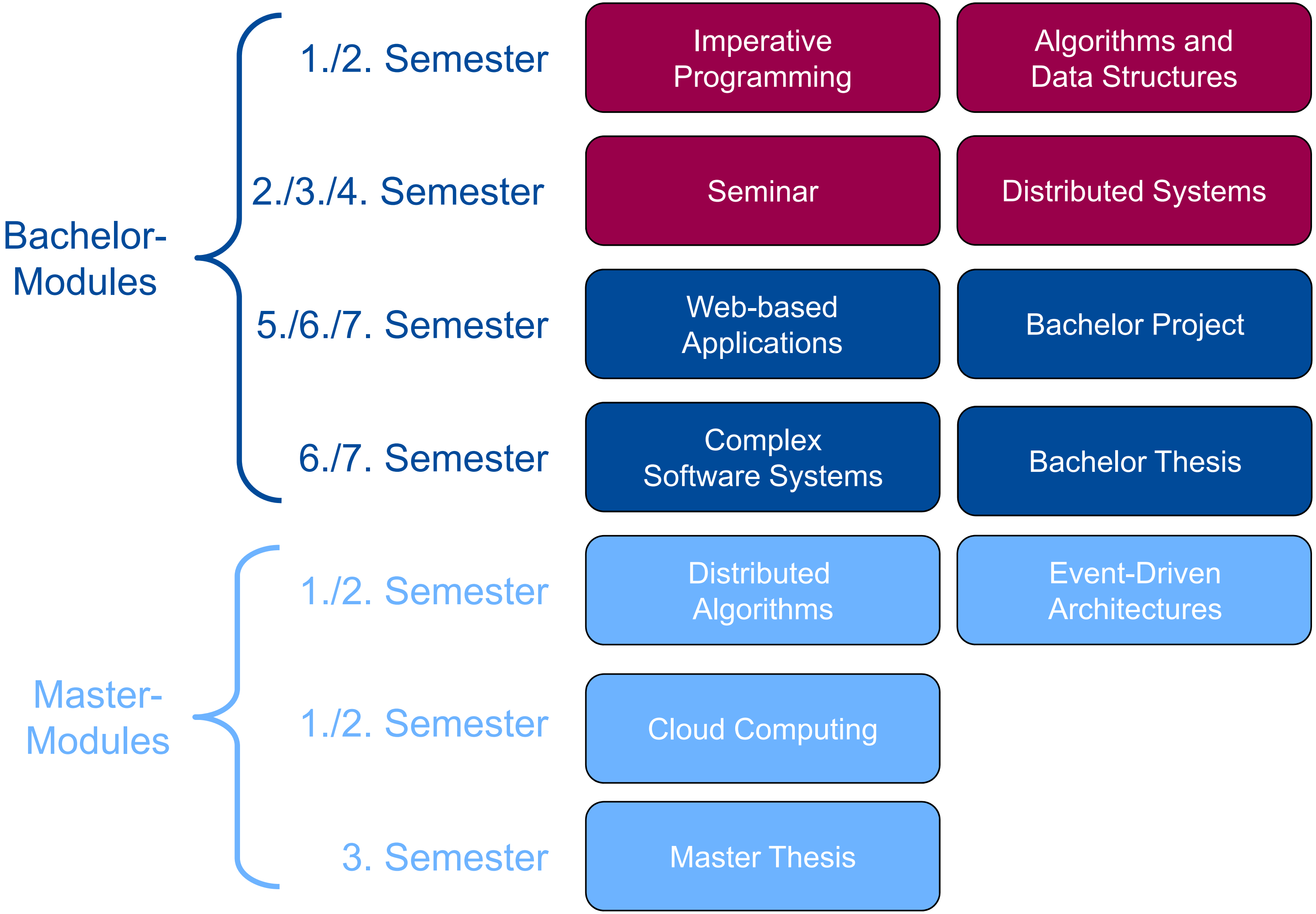
- Bachelor in computer science or in a related discipline
- Basic knowledge in the field of distributed systems

Oral exams

- At the end of the term
- Survey ca. 2 months prior to exams to determine possible dates of exam
- Can be part of a Komplexprüfung

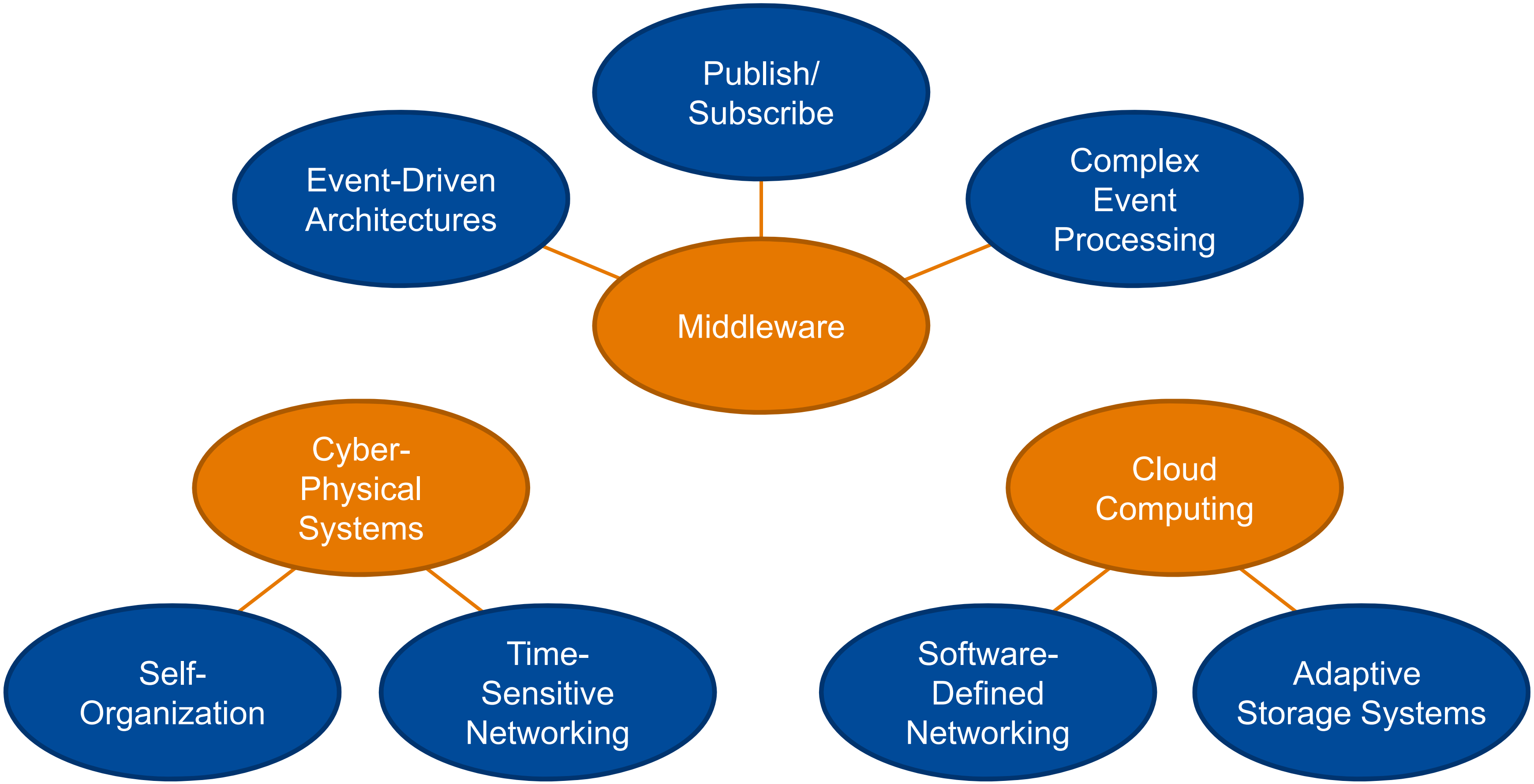
How does the course *Distributed Algorithms* fit into the curriculum?

Bachelor- and Master-Courses @ AVA



Bachelor-Modules	1./2. Semester	Imperative Programming	Algorithms and Data Structures
	2./3./4. Semester	Seminar	Distributed Systems
	5./6./7. Semester	Web-based Applications	Bachelor Project
	6./7. Semester	Complex Software Systems	Bachelor Thesis
Master-Modules	1./2. Semester	Distributed Algorithms	Event-Driven Architectures
	1./2. Semester	Cloud Computing	
	3. Semester	Master Thesis	

Research @ AVA

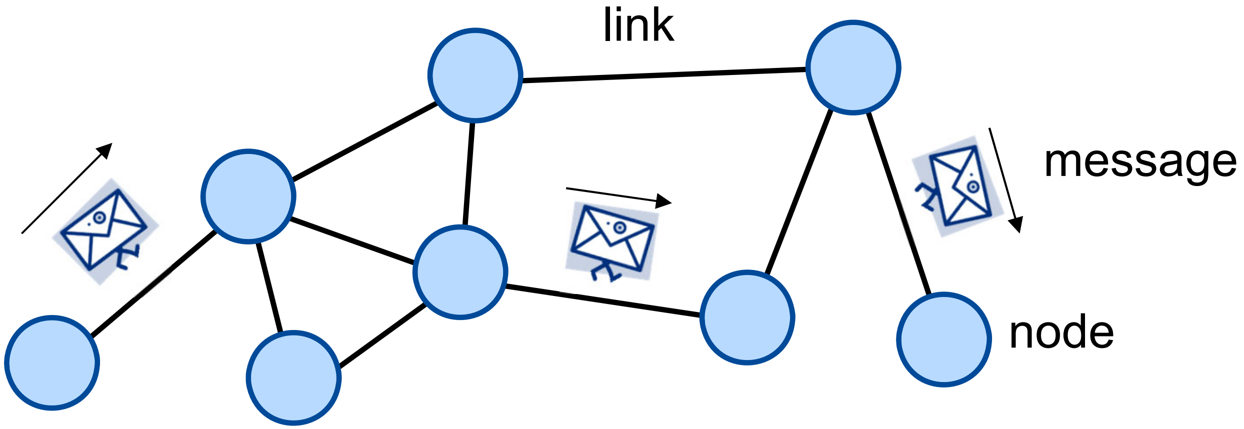


Bachelor and Master Thesis @ AVA

- Bachelor and master theses are related to the research topics relevant to AVA
- Task description is developed jointly based on the interests and the previous knowledge of the student
- Applying scientific methods to the problem is the main task
- Visiting modules offered by AVA is helpful but not a prerequisite for doing a thesis at AVA
- Exemplary thesis topics are available at
  - http://wwwava.informatik.uni-rostock.de/ava_studarb.html

Motivation

- A distributed system consists of several computing nodes that
  - do *not* share primary memory,
  - are loosely connected by a network, and
  - communicate by message to achieve a common functionality.



- “Distributed Systems” is an important subarea of “Practical Computer Science”.

Motivation

- A distributed algorithm is an algorithm that is distributed to some or all nodes of a distributed system.
- In a distributed algorithm, state and control are both distributed to nodes and the implementation is parallelized.
- Because of the characteristics of distributed systems, engineering a distributed algorithm is much more complex than for a centralized algorithm with a similar functionality.

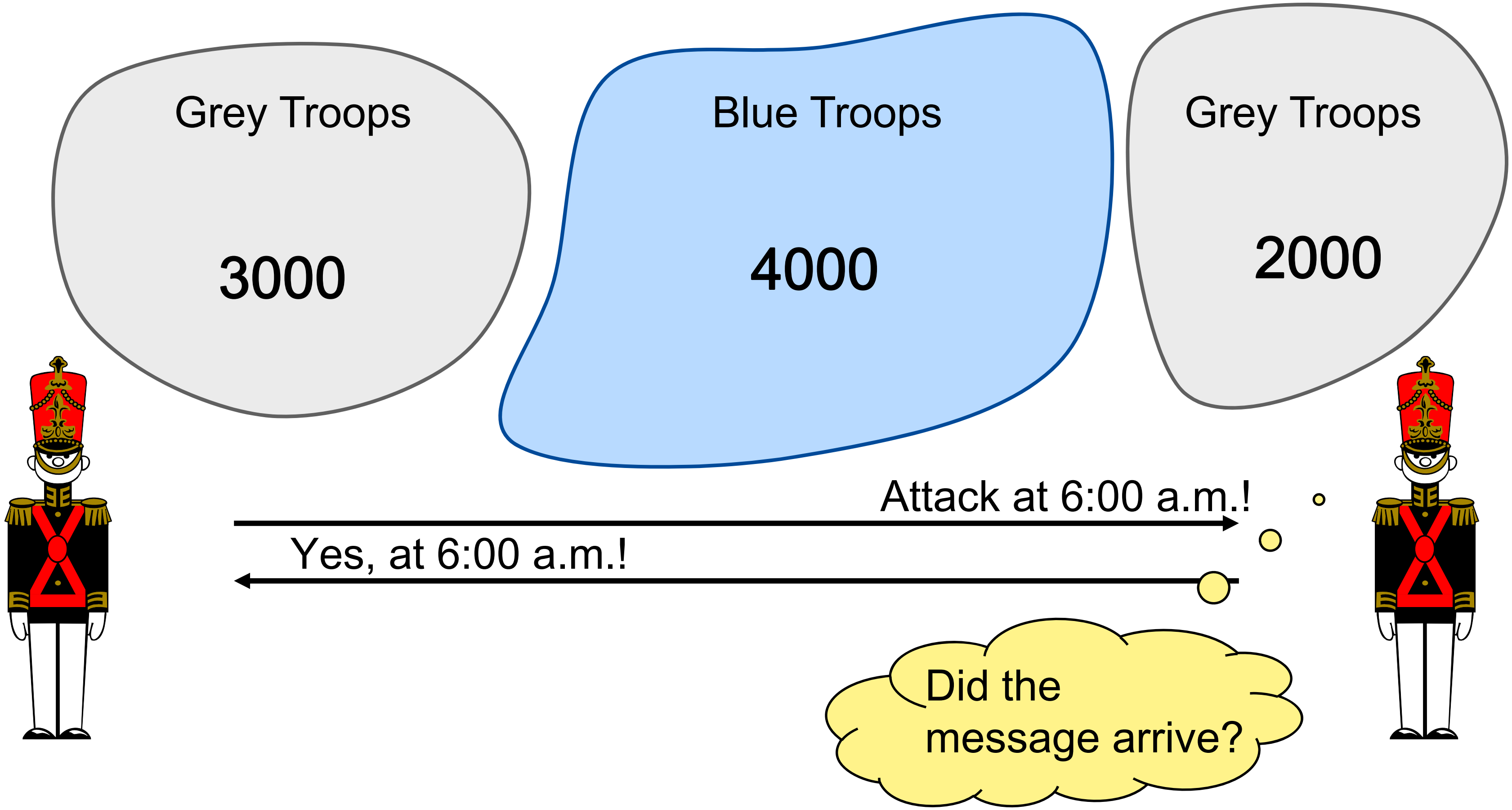
Characteristics of Distributed Systems

- Processes execute independently and concurrently
- Speed of processes varies
- No shared primary memory
- Communication only through message exchange
- Message delay varies a lot
- Communication is error-prone and insecure
- Diverging speeds of the nodes’ clocks
- Computers and network connections fail independently
- Different administrative domains
- Heterogeneity of components
- …

Conceptual Problems in Distributed Systems

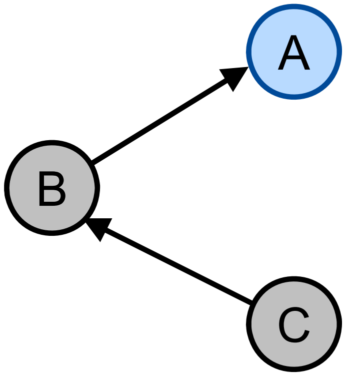
- Distributed consensus
- Clock synchronization
- Deadlock detection
- Causality preserving observations
- Snapshot problem
- Global termination recognition
- Distributed garbage collection
- Mutual exclusion
- Consistent data replication
- Confidential communication
- …

Problem of the Two Armies

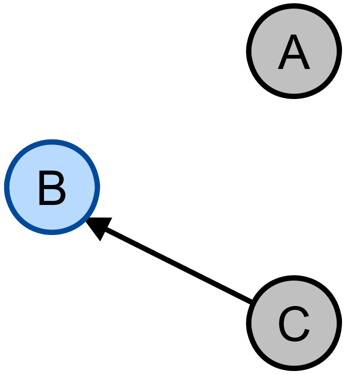


Phantom-Deadlocks

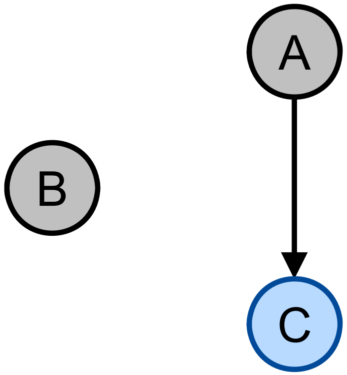
t = 1, observe *B*
⇒ *B* waits for *A*



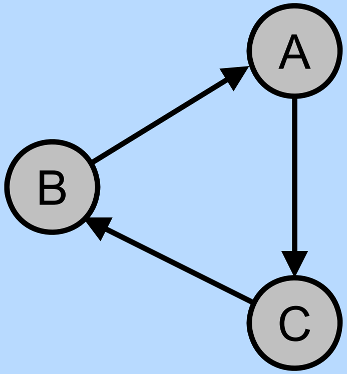
t = 2, observe *C*
⇒ *C* waits for *B*



t = 3, observe *A*
⇒ *A* waits for *C*

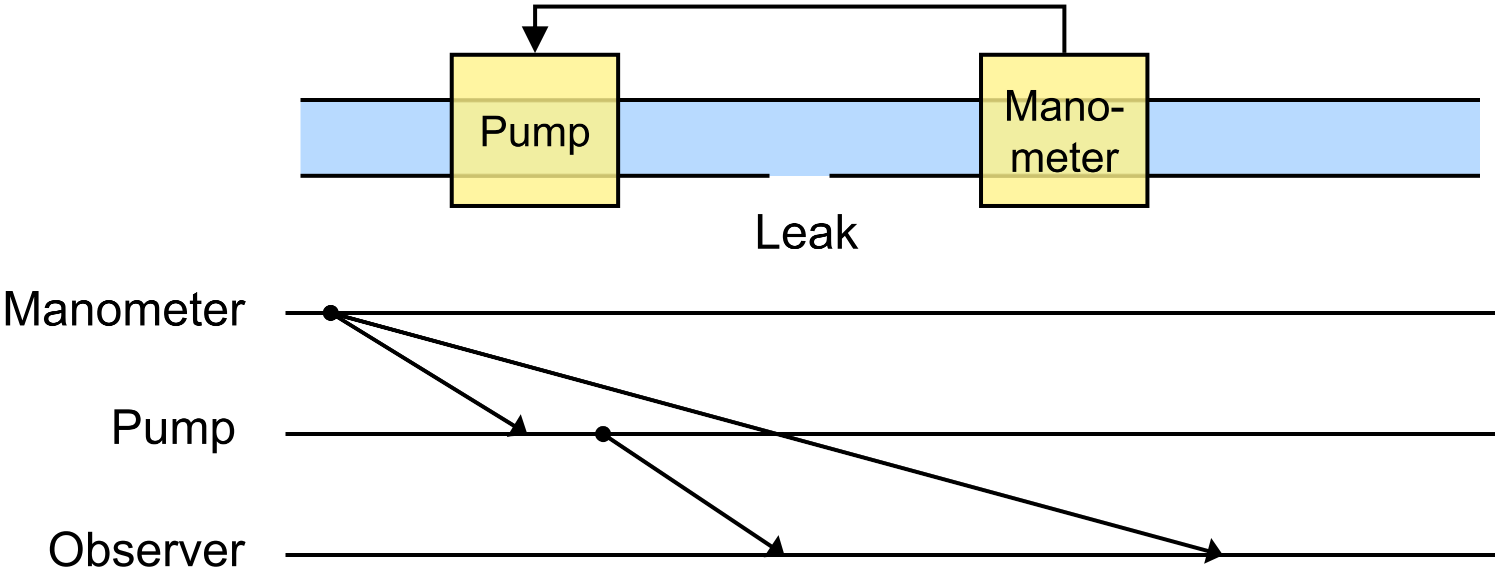


Wrong conclusion:
Cyclic waiting graph
→ deadlock



Causally Inconsistent Observations

- A causally inconsistent observation leads to a wrong conclusion
- Due to the order of the received messages, the observer thinks that an unjustified activity of the pump increased the pressure, until the pipeline burst, then oil leaked which was indicated by pressure loss!
- In reality, a leak occurred in the pipeline and to keep the flow constant, the pump increased the supply pressure



Content and Teaching Goals

- Content
  - Lecture gives an overview of conceptual problems occurring in distributed systems and how they can be solved algorithmically.
- Teaching Goals
  - get to know the most important basic distributed algorithms
  - develop an understanding of the structure of distributed algorithms, their complexity, their scalability, and their fault tolerance features,
  - choose convenient distributed algorithms while drafting distributed systems and
  - understand the possibilities, limits and risks of distributed systems.

Outline

1. Organizational Matters
2. Models
3. Flooding, Broadcast, Echo
4. Election
5. Termination Detection
6. Garbage Collection
7. Mutual Exclusion
8. Clock Synchronization
9. Logical Clocks
10. Consistent Snapshots
11. Fault Tolerance
12. Consensus
13. Self-stabilization
14. Multicast Communication

Literature

1. **G. Coulouris, J. Dollimore, and T. Kindberg. *Distributed Systems: Concepts and Design*. Addison-Wesley, 4th edition, 2005.**
   [auch in Deutsch erhältlich]
2. **F. Mattern. *Verteilte Basisalgorithmen*. Springer-Verlag, 1989.**
3. **G. Tel. *Introduction to Distributed Algorithms*. Cambridge University Press, 2nd edition, 2000.**
4. S. Mullender, editor. *Distributed Systems*. Addison-Wesley, 2nd edition, 1993.
5. N. Lynch. *Distributed Algorithms*. Morgan Kaufmann, 1996.
6. A. S. Tanenbaum and M. van Steen. *Distributed Systems: Principles and Paradigms*. Prentice Hall, 2nd edition, 2006.
   [auch in Deutsch und als Taschenbuch erhältlich]

Thank you for your kind attention!

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