Systems, Networks & Concurrency 2018

Uwe R. Zimmer - The Australian National University

Organization & Contents

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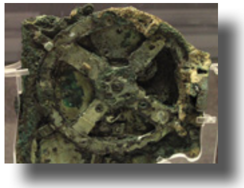
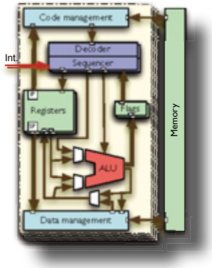
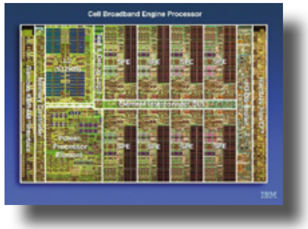
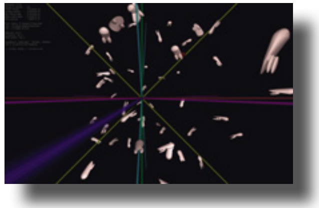
Organization & Contents

what is offered here?

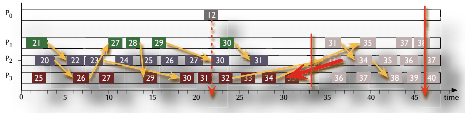




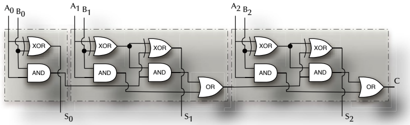


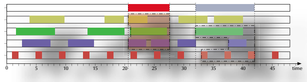


Fundamentals & Overview

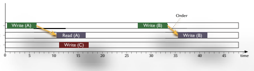


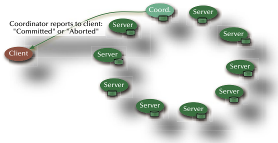
as well as perspectives, paths, methods, implementations, and open questions

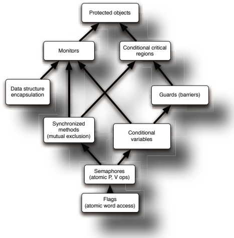




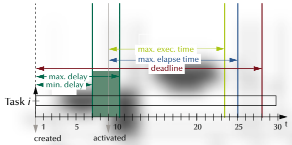
of/into/for/about

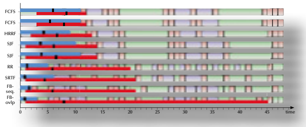


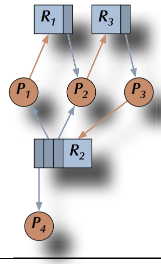


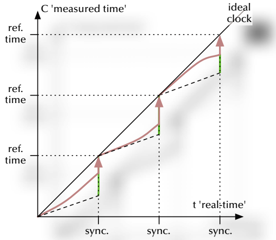

Protected objects
Monitors
Conditional critical regions
Data structure encapsulation
Guards (barriers)
Synchronized methods (mutual exclusion)
Conditional variables
Semaphores (atomic P, V ops)
Flags (atomic word access)

Concurrent & Distributed Systems









Organization & Contents

who could be interested in this?

anybody who …

… wants to work with **real-world scale** computer systems

… would like to learn how to
analyse and design operational and robust systems

… would like to understand more about the existing trade-off between *theory*, *the real-world*, *traditions*, and *pragmatism* in computer science

… would like to understand why *concurrent systems* are an **essential basis** for most contemporary devices and systems

Organization & Contents

who are these people? – introductions

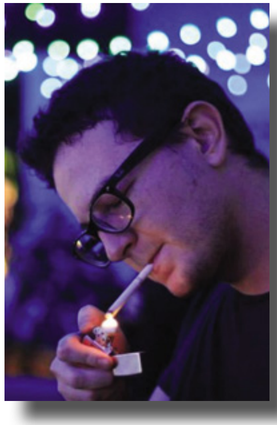
This course will be given by

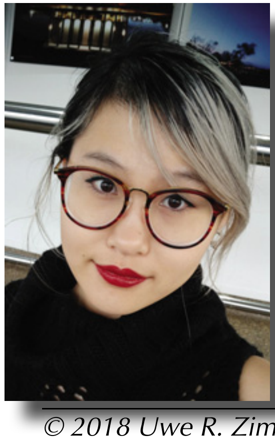
Uwe R. Zimmer & Alistair Rendell

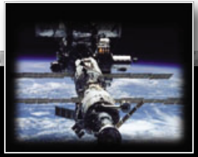
Your individual tutors are

Abigail Thomas, Alex Smith, Ian Mallett,

Michael Bennett, Robin Monro, Yaya Lu, Zara Kay







Organization & Contents

how will this all be done?

☞ Lectures:

- 2 x 1.5 hours lectures per week … all the nice stuff
  Tuesday & Thursday 16:30 (both in R.N. Robertson - which is: *here*)

☞ Laboratories:

- 2 hours per week … all the rough and action stuff
  time slots: on our web-site
  -enrolment: https://cs.anu.edu.au/streams/ (open since last Friday)

☞ Resources:

- Introduced in the lectures and collected on the course page:
  https://cs.anu.edu.au/courses/comp2310/ … as well as schedules, slides, sources, links to forums, etc. pp. … keep an eye on this page!

☞ Assessment (for discussion):

- Exam at the end of the course (50%)
  plus one hurdle lab in week 4 (5%)
  plus two assignments (15% + 15%)
  plus one mid-semester exam (15%)

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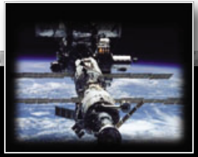
Text book for the course

[Ben-Ari06]
M. Ben-Ari
Principles of Concurrent and Distributed Programming
2006, second edition, Prentice-Hall, ISBN 0-13-711821-X

☞ Many algorithms and concepts for the course are in there
- *but not all!*

☞ *References for specific aspects of the course are provided during the course and are found on our web-site.*

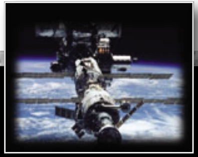


Organization & Contents

Topics

Language refresher [3]

1. Concurrency [3]
2. Mutual exclusion [2]
3. Communication & Synchronization [4]
4. Non-determinism [2]
5. Data Parallelism [1]
6. Scheduling [2]
7. Safety and liveness [2]
8. Distributed systems [4]
9. Architectures [1]



Organization & Contents

Topics

1. Concurrency [3]

1.1. Forms of concurrency [1]

- Coupled dynamical systems

1.2. Models and terminology [1]

- Abstractions
- Interleaving
- Atomicity
- Proofs in concurrent and distributed systems

1.3. Processes & threads [1]

- Basic definitions
- Process states
- Implementations

2. Mutual exclusion [2]

3. Condition synchronization [4]

4. Non-determinism in concurrent systems [2]

5. Scheduling [2]

6. Safety and liveness [3]

7. Architectures for CDS [1]

8. Distributed systems [7]

Organization & Contents

Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*

2.1. by shared variables [1]

- Failure possibilities
- Dekker's algorithm

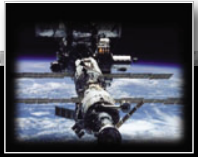
2.2. by test-and-set hardware support [0.5]

- Minimal hardware support

2.3. by semaphores [0.5]

- Dijkstra definition
- OS semaphores

3. *Condition synchronization [4]*
4. *Non-determinism in concurrent systems [2]*
5. *Scheduling [2]*
6. *Safety and liveness [3]*
7. *Architectures for CDS [1]*
8. *Distributed systems [7]*



Organization & Contents

Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*
3. *Condition synchronization [4]*

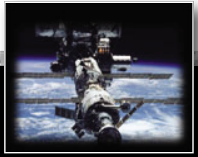
3.1. Shared memory synchronization [2]

- Semaphores
- Cond. variables
- Conditional critical regions
- Monitors
- Protected objects

3.2. Message passing [2]

- Asynchronous / synchronous
- Remote invocation / rendezvous
- Message structure
- Addressing

4. *Non-determinism in concurrent systems [2]*
5. *Scheduling [2]*
6. *Safety and liveness [3]*
7. *Architectures for CDS [1]*
8. *Distributed systems [7]*



Organization & Contents

Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*
3. *Condition synchronization [4]*
4. *Non-determinism in concurrent systems [2]*

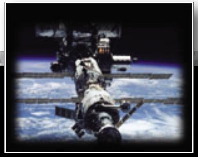
4.1. Correctness under non-determinism [1]

- Forms of non-determinism
- Non-determinism in concurrent/ distributed systems
- Is consistency/correctness plus non-determinism a contradiction?

4.2. Select statements [1]

- Forms of non-deterministic message reception

5. *Scheduling [2]*
6. *Safety and liveness [3]*
7. *Architectures for CDS [1]*
8. *Distributed systems [7]*



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Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*
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4. *Non-determinism in concurrent systems [2]*
5. *Scheduling [2]*

5.1. Problem definition and design space [1]

- Which problems are addressed / solved by scheduling?

5.2. Basic scheduling methods [1]

- Assumptions for basic scheduling
- Basic methods

6. *Safety and liveness [3]*
7. *Architectures for CDS [1]*
8. *Distributed systems [7]*

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5. *Scheduling [2]*
6. *Safety and liveness [3]*

6.1. Safety properties

- Essential time-independent safety properties

6.2. Livelocks, fairness

- Forms of livelocks
- Classification of fairness

6.3. Deadlocks

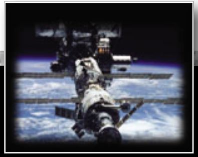
- Detection
- Avoidance
- Prevention (& recovery)

6.4. Failure modes

6.5. Idempotent & atomic operations

- Definitions

7. *Architectures for CDS [1]*
8. *Distributed systems [7]*



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6. *Safety and liveness [3]*
7. *Architectures for CDS [1]*

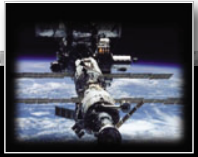
7.1. Hardware architecture

- From switches to registers and adders
- CPU architecture
- Hardware concurrency

7.2. Language architecture

- Chapel
- Occam
- Rust
- Ada
- C++

8. *Distributed systems [7]*



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7. *Architectures for CDS [1]*
8. *Distributed systems [7]*

8.1. Networks [1]

- OSI model
- Network implementations

8.2. Global times [1]

- synchronized clocks
- logical clocks

8.3. Distributed states [1]

- Consistency
- Snapshots
- Termination

8.4. Distributed communication [1]

- Name spaces
- Multi-casts
- Elections
- Network identification
- Dynamical groups

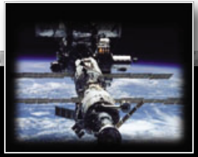
8.5. Distributed safety and liveness [1]

- Distributed deadlock detection

8.6. Forms of distribution/ redundancy [1]

- computation
- memory
- operations

8.7. Transactions [2]



Organization & Contents

24 Lectures

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8.5. Distributed safety and liveness [1]
- Distributed deadlock detection

8.6. Forms of distribution/redundancy [1]
- computation
- memory
- operations

8.7. Transactions [2]

Laboratories & Assignments

Laboratories

1. Concurrency language support basics (in Ada) [3]

1.1. **Structured, strongly typed** programming
- Program structures
- Data structures

1.2. **Generic, re-usable programming**
- Generics
- Abstract types

1.3. **Concurrent processes:**
- Creation
- Termination
- Rendezvous

2. Concurrent programming [3]

2.1. **Synchronization**
- Protected objects

2.2. **Remote invocation**
- Extended rendezvous

2.3. **Client-Server architectures**
- Entry families
- Requeue facility

3. Concurrency in a multi-core system[3]

3.1. **Multi-core process creation, termination**

3.2. **Multi-core process communication**

Assignments

1. Concurrent programming [15%]

Ada programming task involving:
- Mutual exclusion
- Synchronization
- Message passing

2. Concurrent programming in multi-core systems [15%]

Multi-core programming task involving:
- Process communication

Examinations

1. Mid-term check [10%]

- Test question set [not marked]

2. Final exam [55%]

- Examining the complete lecture

Marking

The final mark is based on
the assignments [30%]
plus the examinations [65%]
plus the lab mark [5%]