Systems, Networks & Concurrency 2020

Uwe R. Zimmer - The Australian National University

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Organization & Contents

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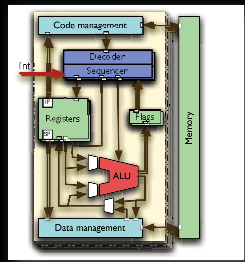
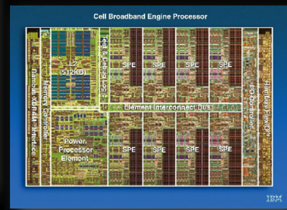
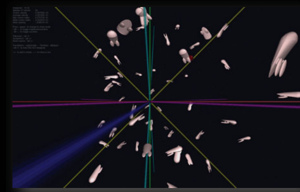
Organization & Contents

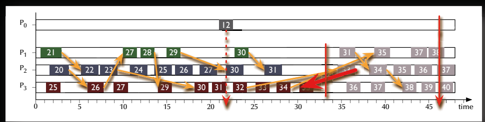
what is offered here?



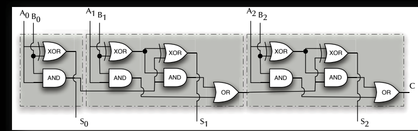


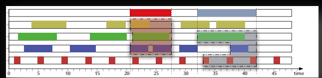


Fundamentals & Overview

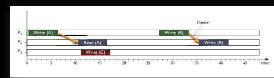


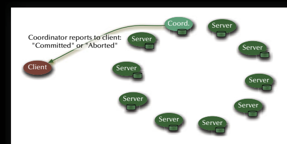
as well as perspectives, paths, methods, implementations, and open questions

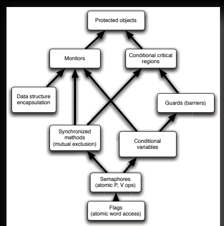




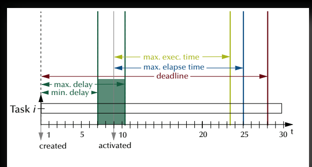
of/into/for/about

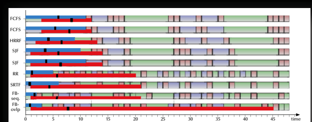


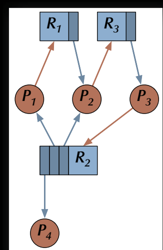


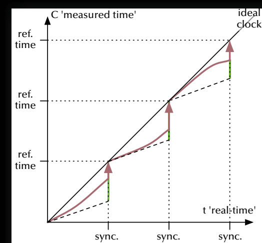


Concurrent & Distributed Systems









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

who are these people? – introductions

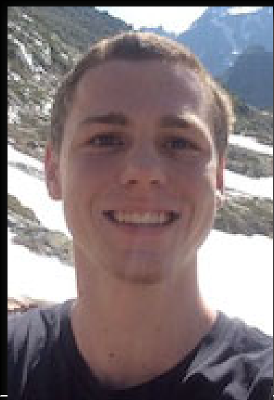
Uwe R. Zimmer & Charles Martin

Abigail (Abi) Thomas, Aditya Chilukuri,
Brent Schuetze, Calum Snowdon, Chinmay Garg, Felix Friedlander
Johannes (Johnny) Schmalz, Nicholas Philip Miehlbradt,
Tommy Liu, William (Will) Cashman & Yaya Lu










Organization & Contents

how ***will this all be done?***

☞ Lectures:

- 2 x 1.5 hours lectures per week … all the nice stuff
  Tuesday 12:00 & Friday 11:00 (all live on-line)

☞ Laboratories:

- 3 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 Monday, more slots today)

☞ 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. *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]

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

Organization & Contents

Topics

Organization & Contents

Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*
3. *Condition synchronization [4]*
4. *Non-determinism [2]*
5. *Data Parallelism [1]*
6. *Scheduling [2]*

6.1. Problem definition and design space [1]

- Which problems are addressed / solved by scheduling?

6.2. Basic scheduling methods [1]

- Assumptions for basic scheduling
- Basic methods

7. *Safety and liveness [2]*
8. *Distributed systems [4]*
9. *Architectures [1]*

Organization & Contents

Topics

1. *Concurrency [3]*
2. *Mutual exclusion [2]*
3. *Condition synchronization [4]*
4. *Non-determinism [2]*
5. *Data Parallelism [1]*
6. *Scheduling [2]*
7. *Safety and liveness [2]*

7.1. Safety properties

- Essential time-independent safety properties

7.2. Livelocks, fairness

- Forms of livelocks
- Classification of fairness

7.3. Deadlocks

- Detection
- Avoidance
- Prevention (& recovery)

7.4. Failure modes

7.5. Idempotent & atomic operations

- Definitions

8. *Distributed systems [4]*
9. *Architectures [1]*

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1. *Concurrency [3]*
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6. *Scheduling [2]*
7. *Safety and liveness [3]*
8. *Distributed systems [4]*

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]

9. *Architectures [1]*

Organization & Contents

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1. *Concurrency [3]*
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6. *Scheduling [2]*
7. *Safety and liveness [2]*
8. *Distributed systems [4]*
9. *Architectures [1]*

9.1. Hardware architecture

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

9.2. Language architecture

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

Organization & Contents

24 Lectures

1. Concurrency [3]

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- Is consistency/correctness plus non-determinism a contradiction?

4.2. Select statements [1]
- Forms of non-deterministic message reception

5. Data Parallelism [1]

5.1. Data-Parallelism
- Vectorization
- Reduction
- General data-parallelism

5.2. Examples
- Image processing
- Cellular automata

6. Scheduling [2]

6.1. Problem definition and design space [1]
- Which problems are addressed / solved by scheduling?

6.2. Basic scheduling methods [1]
- Assumptions for basic scheduling
- Basic methods

7. Safety and liveness [2]

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9. Architectures [1]

9.1. Hardware architecture
- From switches to registers and adders
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- Hardware concurrency

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- Rust
- Ada
- C++

Laboratories & Assignments

Laboratories [11]

1. Structured Programming [2]

- Program structures
- Data structures

2. Tasks [1]

- Generics
- Abstract types

3. Protection [1]

- Memory based synchronization

4. Task Lifetimes [1]

- Creation
- Termination

5. Communicating Tasks [1]

- Rendezvous

6. Distributing Server [1]

- Entry families
- Requeue facility

7. Implicit Concurrency [1]

8. Synchronized Data [1]

9. Distribution [1]

- Multi-core process creation, termination
- Multi-core process communication

10. Pipelines [1]

Assignments [2]

1. Concurrent programming [15%]

Programming task involving:

- Mutual exclusion
- Synchronization
- Message passing

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

Multi-core programming task involving:

- Process communication

Examinations [3]

1. Hurdle check [5%]

- Week 4 lab exam

2. Mid-semester check [15%]

- Exam or Self-test

3. Final exam [50%]

- Examining the complete course

Marking

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