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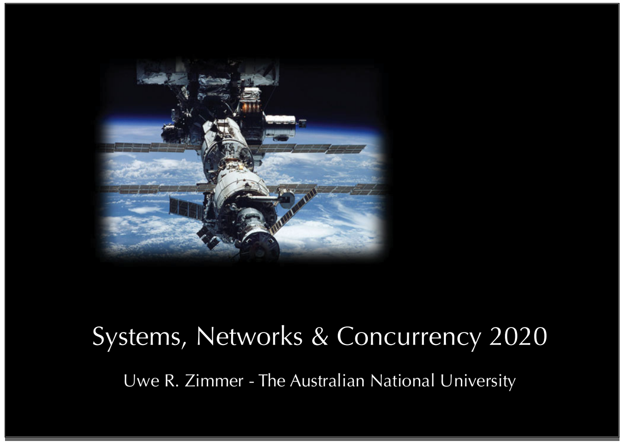

Systems, Networks & Concurrency 2020

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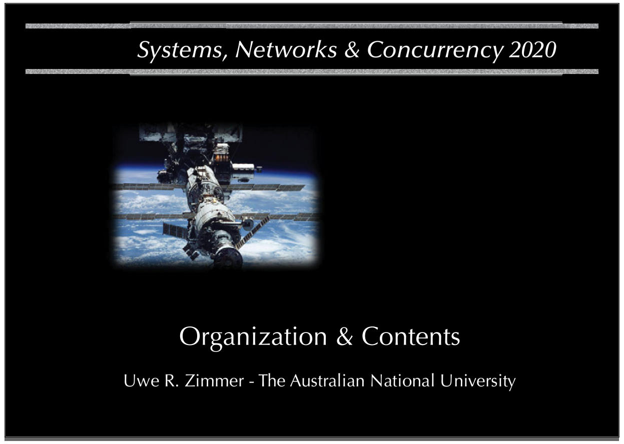

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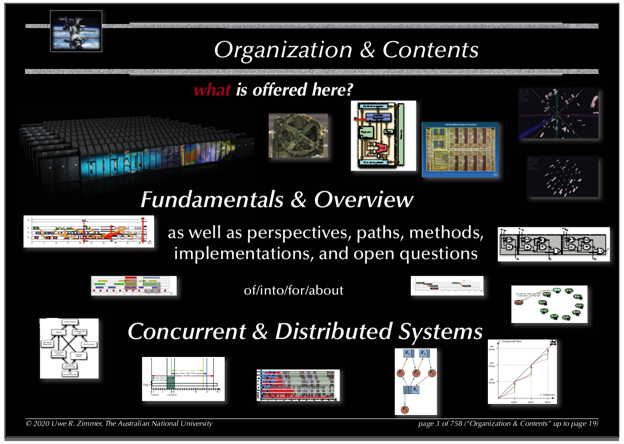

Organization & Contents

what is offered here?

Fundamentals & Overview

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

of/into/for/about

Concurrent & Distributed Systems

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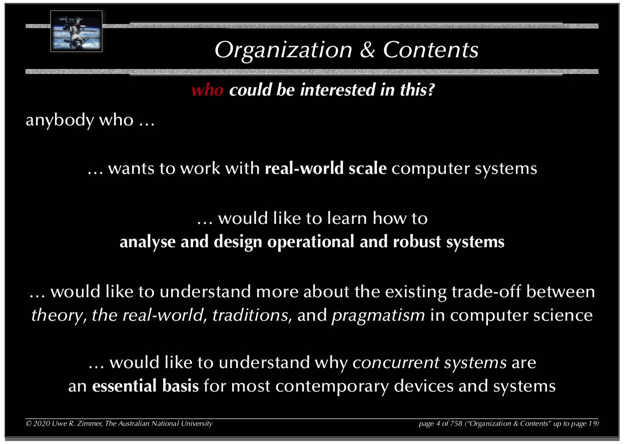

Organization & Contents

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

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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

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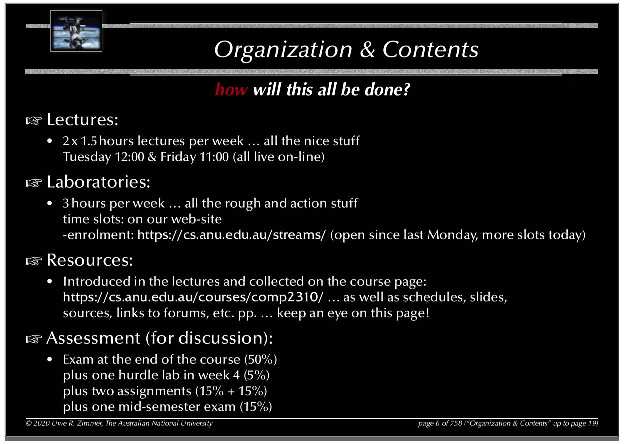

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how will this all be done?

☞ 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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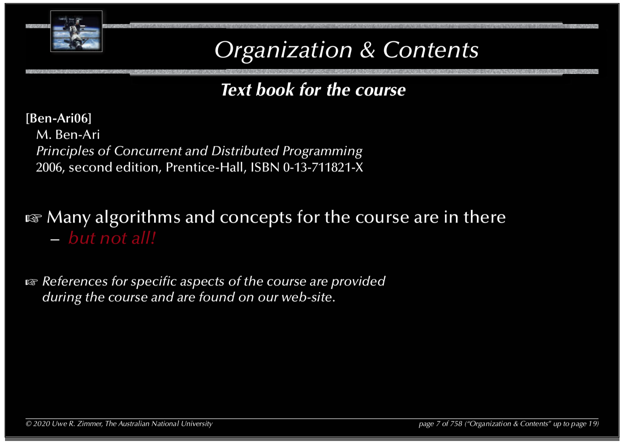

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Text book for the course

[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.*

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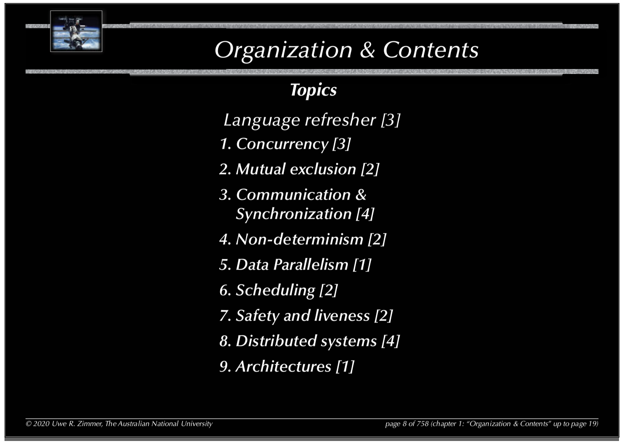

Organization & Contents

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]

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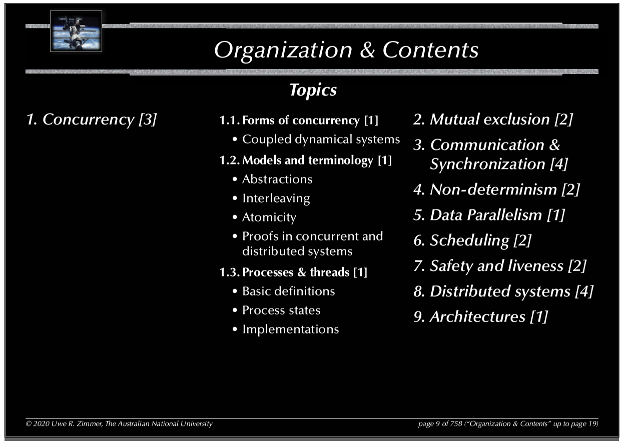

Organization & Contents

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]

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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]

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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]

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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]

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Organization & Contents

Topics

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

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

5.2. Examples
- Image processing
- Cellular automata

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

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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]

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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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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 [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]

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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]
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++

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Organization & Contents

24 Lectures

1. Concurrency [3]

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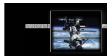

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Laboratories & Assignments

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%]