CS 6868: Concurrent Programming

01 Introduction

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Spring 2026, IIT Madras

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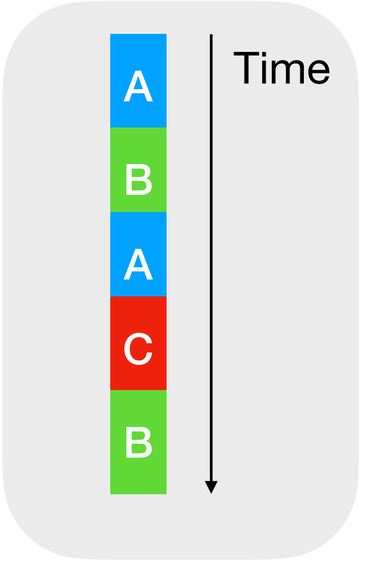
- **“Concurrency”**
  - ***Interleaved*** executions of tasks in time
  - Examples — Asynchronous I/O, GUI in JavaScript, interrupt-driven embedded systems, etc.
  - ***No need for multiple cores!***
  - ***Challenges*** — non-determinism, many different schedules complicate reasoning, and efficiency, etc.

Concurrency



Interleaved execution

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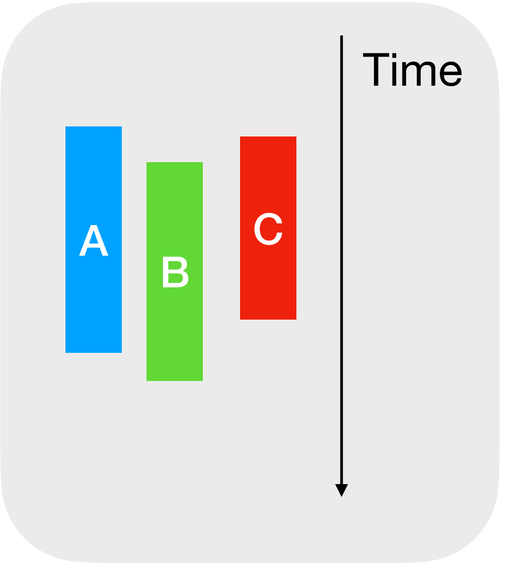
- **Parallelism**
  - Multiple ***hardware execution units*** — Multicore CPUs, GPUs, parallelism across machines (such as supercomputers, GPU farms)
  - Goal is ***speed*** with correctness
  - ***Challenges*** — all the concurrency challenges + relaxed memory behaviours, performance scaling challenges, and debugging challenges.

Parallelism



Simultaneous execution

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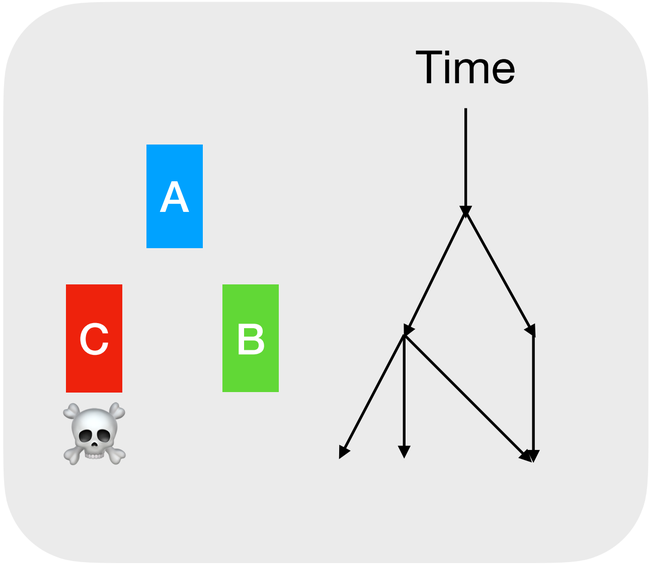
- **Distribution**
  - Execution is distributed across many ***loosely-coupled*** machines
    - There is often ***no shared global clock*** across computations
    - A subset of computations may ***crash/fail.***
  - **Goal** — performance, resilience in the presence of partial failures.
  - Examples — the Internet, blockchains, etc.
  - ***Challenges*** — All the problems of concurrency + failures + performance scaling + debugging

Distribution



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- Concurrency is ***everywhere***
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  - **Models:** Histories, Linearizability, Memory Models, Data races
  - **Mechanisms:** Mutual Exclusion, Atomics, Lockfree Algorithms, Strong type systems
  - **Abstractions:** Concurrency Monads, Effect Handlers, Structured Concurrency
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- The course will not cover
  - Distribution
  - Performance optimisations

Course Outline

- **Parallelism**
  - Mutual Exclusion, Concurrent Objects, Relaxed Memory Models, Spin Locks, Contention, Blocking Synchronisation, Fine-grained Concurrent Data Structures

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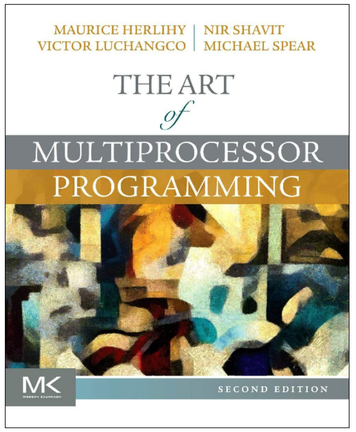

2nd Edition

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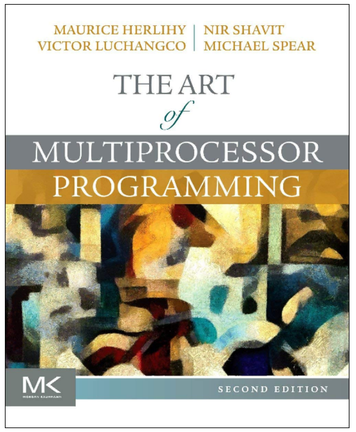

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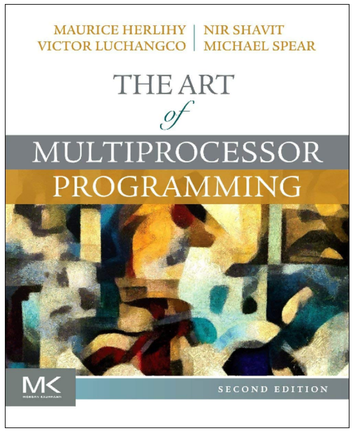

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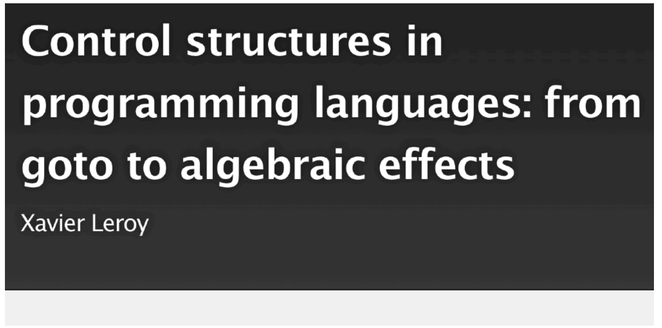

https://xavierleroy.org/control-structures/

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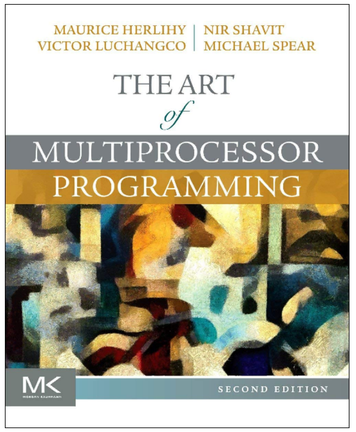

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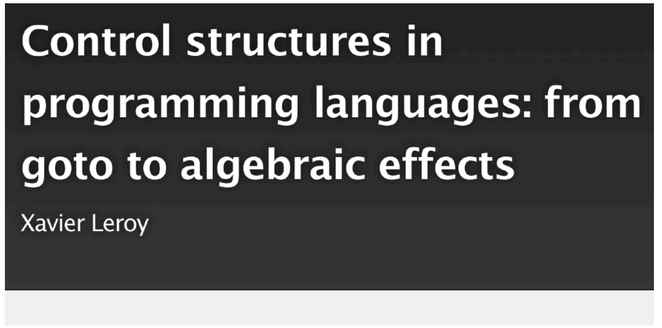

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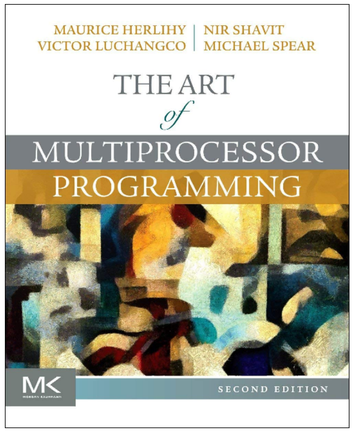
- **First iteration of the course**
  - Course content neither sound nor complete



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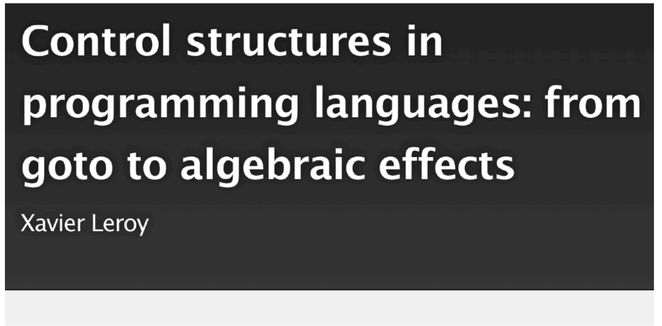

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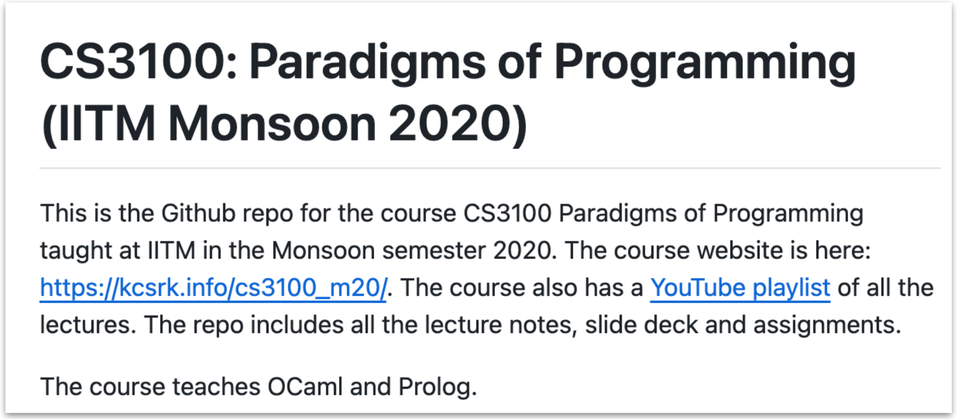
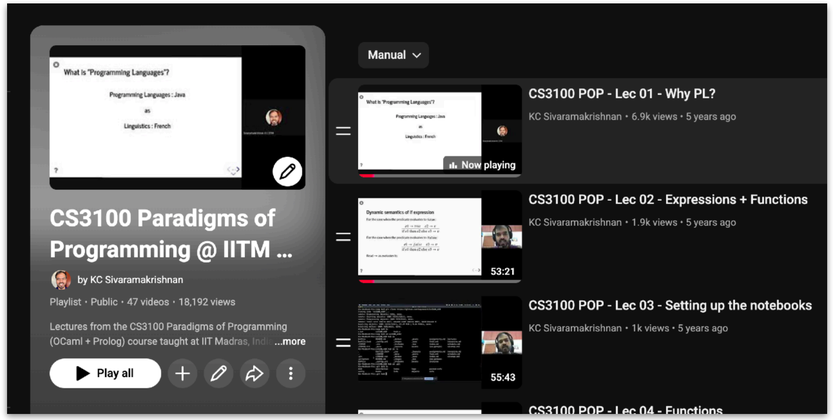
- OCaml Resources — CS3100 @ IITM, CS3110 book from Cornell U



https://github.com/kayceesrk/cs3100_m20



YouTube PlayList

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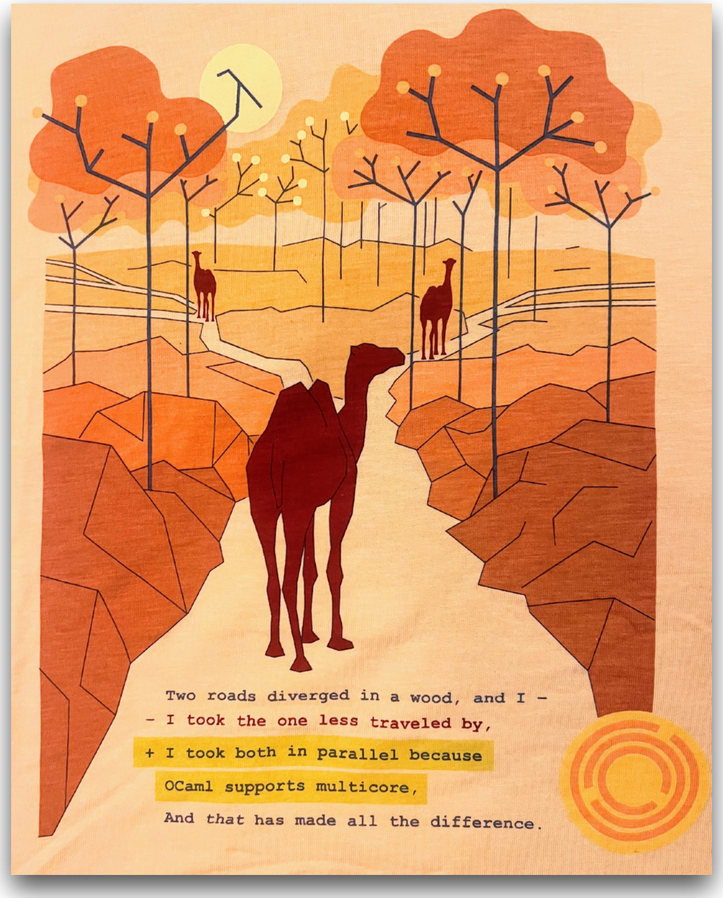

OCaml 5 — concurrency & parallelism

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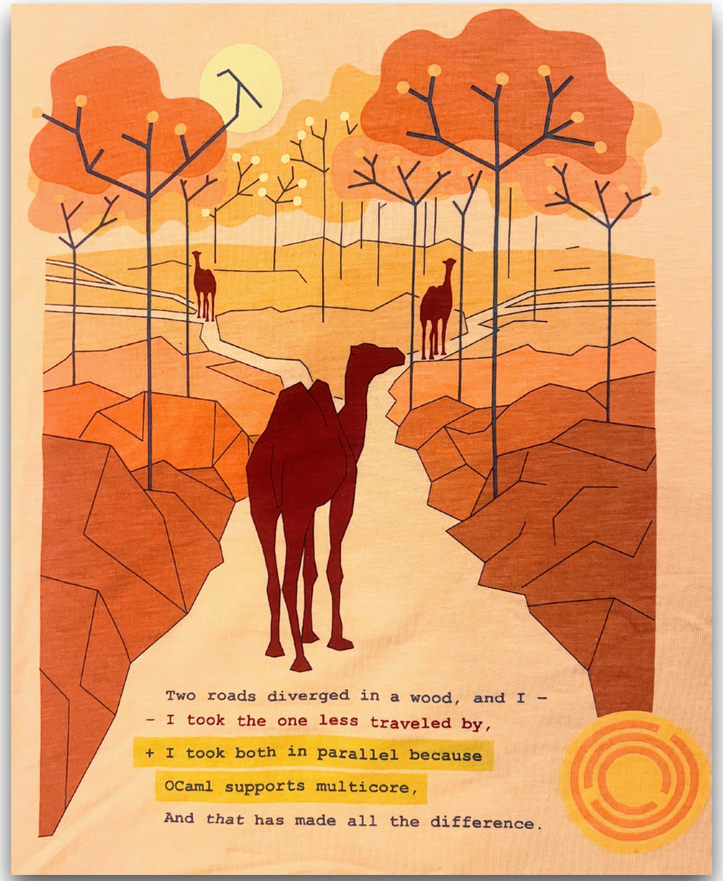

OCaml 5 — concurrency & parallelism

OxCaml — safe, performance-oriented extension of OCaml

Evaluation Plan

- 6 in-class short quizzes **(20%)**
  - 15 minutes each, announced
  - 2 each — before quiz 1, before quiz 2, before end sem
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Don’t use LLM; they hinder learning

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Use LLM; they make you productive*

Parallelism

Modern Multicore Processors