C340 Concurrency: Introduction

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Course Overview

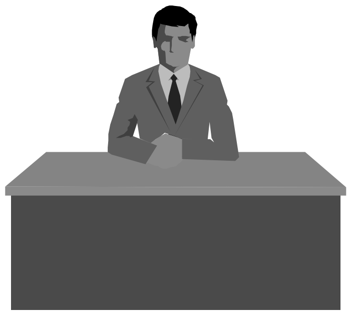
First half:

- *by me*
- *Introduction to Concurrency*
- *Problems*
- *Process Algebras*
- *Analysis of LTS*
- *Concurrent program-ming in Java*

Second half:

- *by Mark Levene*
- *Parallel & Concurrent Algorithms*
- *Concurrency Control in Databases*
- *Probabilistic Algo-rithms*
- *Non-deterministic Algorithms*

How to reach me?



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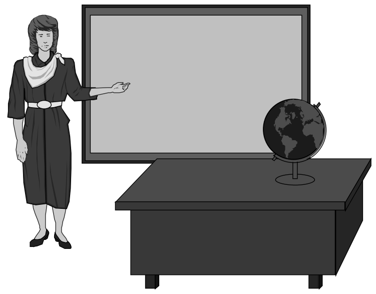
Organisation



- **Lectures**
  - ***Mon 11-12 (212)***
  - ***Thu 3-4 (Anatomy LT)***
  - ***Fri 1-2 (G22)***
- **Tutorials/Labs**
- **Reading**

Bibliography

- *J. Kramer & J. Magee. Concurrent Programming. Wiley. 1998 (to appear)*
- *A. Burns & G. Davis. Concurrent Programming. Addison Wesley - International Computer Science Series 1993*
- *G.R. Andrews. Concurrent Programming: Principles and Practice. Benjamin/Cummings, 1991*
- *D. Lea. Concurrent Programming in Java™: Design Principles and Patterns. The Java Series, Addison-Wesley, 1996*
- *David Flanagan.Java in a Nutshell. O'Reilly & Associates Inc. 1996*

What are you going to learn?

- Problems that occur when writing concurrent programs
- Formalisms to specify concurrency
- Analysis techniques to reason about correctness of specifications
- Implementation of concurrency in Java
- Practical experience (specification, analysis, implementation) in exercises and coursework

Lecture Plan

1 Introduction
2 Modelling Processes
3 Modelling Concurrency in FSP
4 FSP Tutorial
5 LTSA Lab
6 Programming in Java
7 Concurrency in Java
8 Lab: Java Thread Programming
9 Mutual Exclusion
10 Lab: Synchronization in Java
11 Semaphores and Monitors
12 Conditional Synchronization
13 Fairness & Liveness
14 Safety
15 Tutorial: Model Checking

Why Concurrent Programming?

- ***Performance gain from multiprocessing hardware***
  - ***(parallelism)***
- ***Increased application throughput***
  - ***(I/O call only blocks one thread)***
- ***Increased application responsiveness***
  - ***(high priority thread for user requests).***
- ***More appropriate structure***
  - ***(for programs which control multiple activities and handle multiple events)***

Engineering of Concurrent Systems

- **Concurrency in safety-critical Systems**
  - Therac-25 failed due to race conditions
- **Concurrency in mission-critical Systems**
  - Increasing amount of business applications uses concurrency
- **Availability of concurrency in mainstream programming languages**
  - e.g. Java and Ada-95

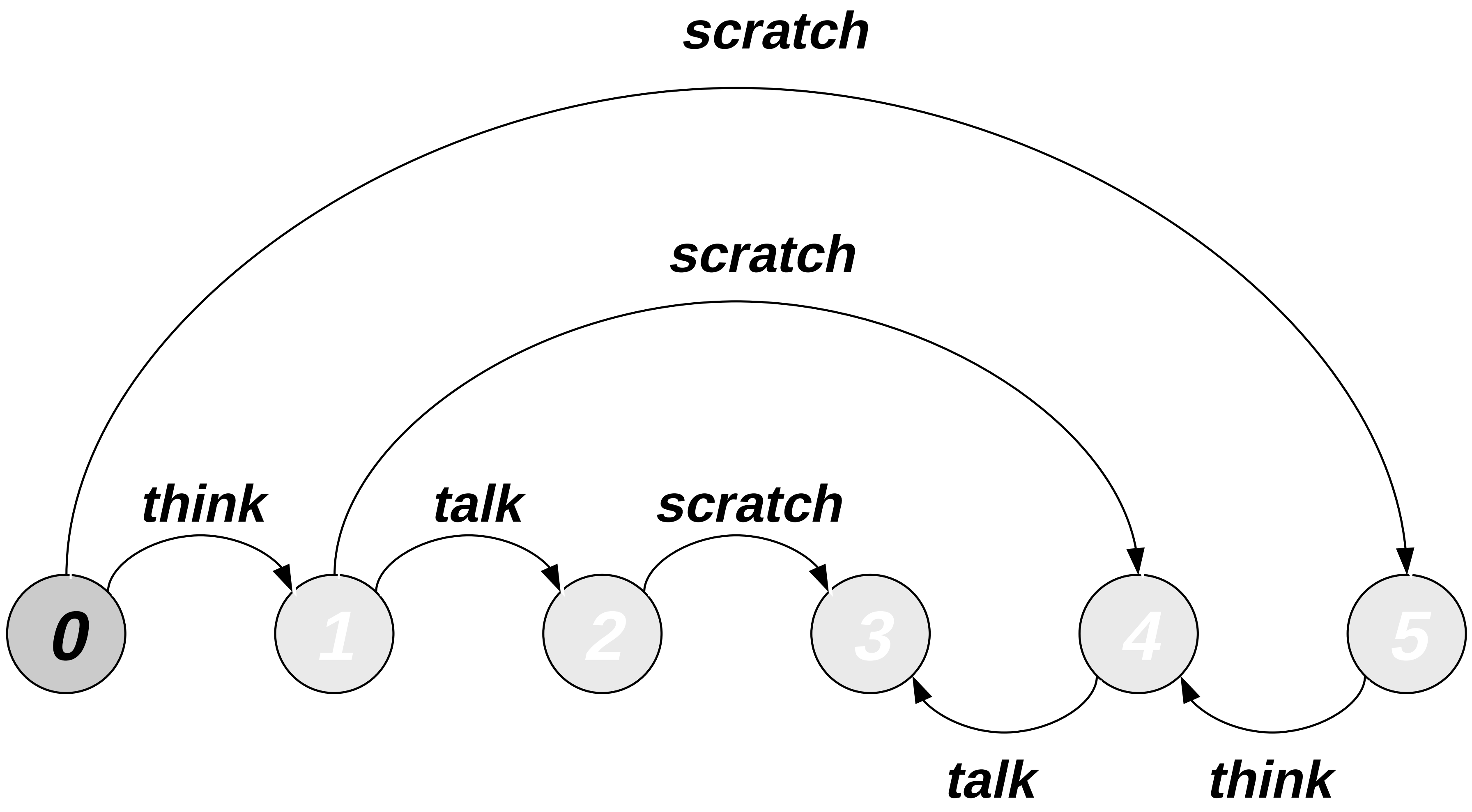
Modelling Concurrency

- ***Analogy to Models in Engineering***
- ***Modelling Concurrency***
  - ***Process Algebras in FSP***
- ***Analysis of Models***
  - ***Using Labelled Transistion System Analysis***
- ***Transformation of Models***
  - ***into Java Implementations using Threads***

FSP Example

```
ITCH =                (scratch->STOP).
CONVERSE =            (think->talk->STOP).
||CONVERSE_ITCH = (ITCH || CONVERSE).
```

LTS Example

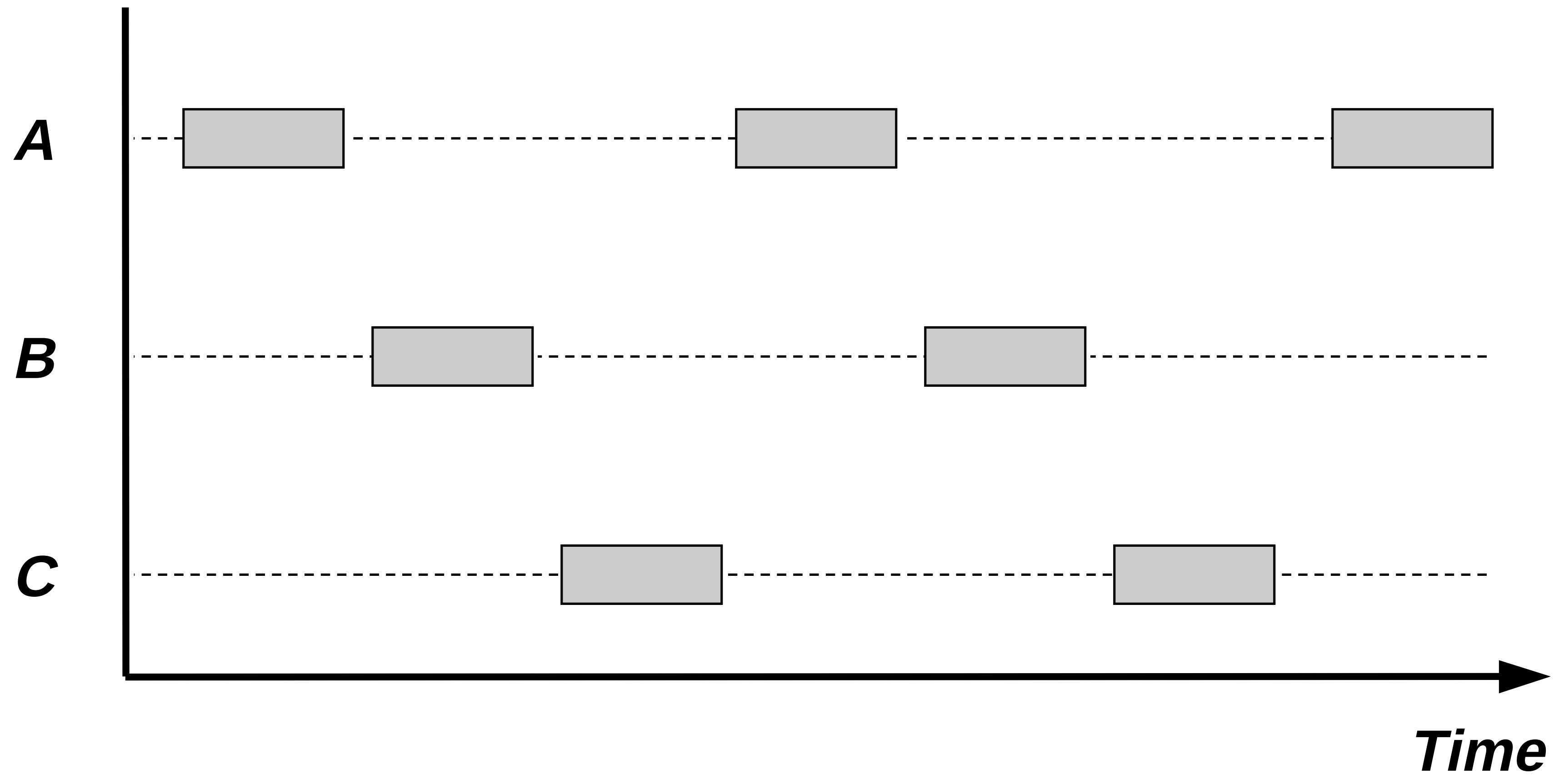


Definitions

- <u>***Parallelism***</u>
  - ***Physically simultaneous processing***
  - ***Involves multiple PEs and/or independent device operations.***
- <u>***Concurrency***</u>
  - ***Logically simultaneous processing***
  - ***Does not imply multiple processing elements (PEs).***
  - ***Requires interleaved execution on single PE.***

Interleaved Model of Concurrency

- **_Executing 3 processes on 1 processor:_**



Summary

- Motivation for concurrent programs
- Engineering approach to concurrency
- Finite State Processes
- Labelled Transition Systems
- Parallelism vs. concurrency
- Interleaved model of concurrency
- Next Lecture: modelling processes in FSP