CPDS

Concurrency
Parallelism
Distributed Systems

Course Presentation

Facultat d'Informàtica de Barcelona (FIB)
Universitat Politècnica de Catalunya (UPC)
2019/2020 Q1

FIB

Course coordinator

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- Office Hours: Wednesday 11:00am — 13:00pm
  Wednesday 15:00pm — 17:00pm
  Friday 15:00pm — 17:00pm
  Arrange an appointment by mail

Objectives

- Overall goal:
  - Present computing as a collection of tasks that execute simultaneously and potentially interacting with each other
- Competences:
  - Provide the foundations
  - Understand the challenges
  - Learn about models, algorithms, systems

Objectives

- Focus on three main aspects, which are organized as three **elective** modules:

A. Module 1: Concurrency

- Multiple simultaneous computations interacting with each other

B. Module 2: Parallelism

- Execution on multiple cores or processors

C. Module 3: Distributed Systems

- Execution on multiple independent computers across a network

Structure

A. Introductory part for all the students (6h)
   - Understanding Concurrency
   - Understanding Parallelism
   - Concepts of Distributed Systems

B. Elective parts are presented as 3 different itineraries of 2 modules each (20h+20h)
   1. **Concurrency + Parallelism**
   2. **Concurrency + Distributed Systems**
   3. **Parallelism + Distributed Systems**
   - Each student must choose and follow one itinerary

Structure

- The three modules are scheduled in parallel in the same time slot
- Modules can run once or twice per semester (in one or two sequential iterations)
- Each module will run in one iteration during one semester and two iterations during the next one
- M2 and M3 will run in two iterations in Q1
- M1 will run in two iterations in Q2

Itinerary selection

- After the introductory part, students must express their preference for a given itinerary
- Coordinators of each specialization have recommended some itineraries for their students, as some modules provide relevant concepts for them
- Some topics in the modules overlap with subjects in the FIB bachelor degree
  a) Module 2 overlaps with PAR subject
  b) Module 3 has some overlap with SDX subject

Itinerary selection

- 'Advanced Computing'
  $\Rightarrow$ Itinerary 1 is recommended
- 'Computer Graphics & Virtual Reality'
  $\Rightarrow$ Itinerary 1 or 3 is recommended
- 'Computer Networks & Distributed Systems'
  $\Rightarrow$ Itinerary 2 or 3 is recommended
- 'High Performance Computing' (no FIB)
  $\Rightarrow$ Itinerary 3 is recommended
- 'Data Science', 'High Performance Computing' (FIB), non-MIRI students can take any itinerary

Itinerary selection

- Number of students per module and iteration is limited
- Students will be distributed between the two iterations of the 3 itineraries depending on:
  - Number of student requests for each itinerary
  - Maximum capacity of each module
  - Student's specialization
  - Student's origin university and degree
  - Student's expertise

Itinerary selection

- Send an e-mail to jguitart@ac.upc.edu

A. State in the subject your preferred itinerary:
   - *CPDS itinerary selection: Itinerary X - Your Name*

B. Write in the body of the message:
   - Your MIRI specialization
   - Your origin university and degree
   - Your expertise (regarding the chosen itinerary)
   - Why you selected that itinerary

- Deadline: September 24th

Course organization

- Each module iteration includes lectures and practical classes
- Lecture classes
  - Objective: Acquisition of theoretical knowledge
  - Slide-based lectures
  - Exercises (from previous exams)
  - Online quizzes: **Quizizz**
    - http://quizizz.com/
    - Register if you want to keep your history of quizzes

Course organization

- Practical sessions
  - Objective: Apply in practice theoretical concepts
  - Preparation: Read assignment and additional docs
  - You will use your own laptops to do the practicals
  - Lab work in teams
- Each module has an exam preparation class and an exam (common for the two iterations)
  - M1 exam preparation: 10/12 ; exam: 17/01
  - M2 exam preparation: 13/12 ; exam: 10/01
  - M3 exam preparation: 17/12 ; exam: 14/01

Calendar

	Tuesday			Friday		
09/09 - 13/09	(10/9) INTRO **CPDS**			(13/9) INTRO **M1**		
16/09 - 20/09	(17/9) INTRO **M2**			(20/9) INTRO **M3**		
23/09 - 27/09	HOLIDAY			(27/09) **M1** (1st IT)	(27/09) **M2** (1st IT)	(27/09) **M3** (1st IT)
30/09 - 04/10	(01/10) **M1** (1st IT)	(01/10) **M2** (1st IT)	(01/10) **M3** (1st IT)	(04/10) **M1** (1st IT)	(04/10) **M2** (1st IT)	(04/10) **M3** (1st IT)
07/10 - 11/10	(08/10) **M1** (1st IT)	(08/10) **M2** (1st IT)	(08/10) **M3** (1st IT)	(11/10) **M1** (1st IT)	(11/10) **M2** (1st IT)	(11/10) **M3** (1st IT)
14/10 - 18/10	(15/10) **M1** (1st IT)	(15/10) **M2** (1st IT)	(15/10) **M3** (1st IT)	(18/10) **M1** (1st IT)	(18/10) **M2** (1st IT)	(18/10) **M3** (1st IT)
21/10 - 25/10	(22/10) **M1** (1st IT)	(22/10) **M2** (1st IT)	(22/10) **M3** (1st IT)	(25/10) **M1** (1st IT)	(25/10) **M2** (1st IT)	(25/10) **M3** (1st IT)
28/10 - 01/11	(29/10) **M1** (1st IT)	(29/10) **M2** (1st IT)	(29/10) **M3** (1st IT)		(31/10) **M2** (2n IT)	(31/10) **M3** (2n IT)
04/11 - 08/11		(05/11) **M2** (2n IT)	(05/11) **M3** (2n IT)		(08/11) **M2** (2n IT)	(08/11) **M3** (2n IT)
11/11 - 15/11		(12/11) **M2** (2n IT)	(12/11) **M3** (2n IT)		(15/11) **M2** (2n IT)	(15/11) **M3** (2n IT)
18/11 - 22/11		(19/11) **M2** (2n IT)	(19/11) **M3** (2n IT)		(22/11) **M2** (2n IT)	(22/11) **M3** (2n IT)
25/11 - 29/11		(26/11) **M2** (2n IT)	(26/11) **M3** (2n IT)		(29/11) **M2** (2n IT)	(29/11) **M3** (2n IT)
02/12 - 06/12		(03/12) **M2** (2n IT)	(03/12) **M3** (2n IT)	HOLIDAY		
09/12 - 13/12	(10/12) EXAM PREPARATION **M1**			(13/12) EXAM PREPARATION **M2**		
16/12 - 20/12	(17/12) EXAM PREPARATION **M3**					

06/01 - 10/01		(10/01) EXAM **M2**
13/01 - 17/01	(14/01) EXAM **M3**	(17/01) EXAM **M1**

Course material

- **https://mwiki.fib.upc.edu/cpds-miri**
  - Lecture slides
  - Practical assignments
  - Supporting documentation and references

- You have to log in using the same credentials as when you log into 'Racó'
  - Use VPN to connect from outside the UPC network
    - https://www.fib.upc.edu/en/fib/it-services/vpn-upclink

Grading

- Final Grade for CPDS:
  - 1st module in itinerary: 50%
  - 2nd module in itinerary: 50%

- On each module:
  - Practical assignments: 40%
  - Exam: 60%

Module 1: Concurrency

- Basics on concurrency
  - Modeling concurrent interaction with finite state processes (FSP)
  - Deadlock, mutual exclusion, safety and liveness analysis
- Programming paradigms
  - Shared memory: Threads and monitors (Java)
  - No shared memory: Asynchronous message passing. Massive parallelism (Introduction to Erlang)

Instructors

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- Name: Jorge Castro
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Module 2: Parallelism

- Introductory course on parallel programming covering 3 different programming models:
  1. Shared-memory programming using **OpenMP**
  2. Distributed-memory programming using **MPI**
  3. Programming GPU devices for computation acceleration using **CUDA**
- Lab assignments for each model
  - Using C programming language
  - Performed in a Linux-based environment
  - Students have access to a shared memory parallel architecture, including several GPUs in the system

Instructor

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Module 3: Distributed Systems

1. Distributed algorithms
   A. Time and global states: clock synchronization, logical clocks, distributed snapshot, predicates
   B. Coordination and agreement: leader election, (ordered) reliable multicast, consensus (Paxos)
2. Distributed shared data
   A. Distributed transactions: concurrency control and commit protocols
   B. Replication and consistency (models & protocols)

- Practical assignments in Erlang

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Bibliography

- Basic textbooks
  - A. S. Tanenbaum, M. van Steen. *Distributed Systems: Principles and Paradigms*, 2nd edition, Prentice Hall, 2007
  - G. Coulouris, J. Dollimore, T. Kindberg, G. Blair. *Distributed Systems: Concepts & Design*, 5th ed., Addison-Wesley, 2011
  - J. Magee, J. Kramer, *Concurrency : State Models & Java Programming* , 2nd edition, John Wiley & Sons, 2006
  - B. Goetz, T. Peierls, J. Bloch, J. Bowbeer, D. Holmes, D. Lea, *Java Concurrency In Practice*, Addison-Wesley, 2006
  - A. Grama, G. Karypis, V. Kumar, A. Gupta, *Introduction to Parallel Computing*, Pearson Education, 2003
  - J. Armstrong. *Programming Erlang: Software for a Concurrent World*, 2nd edition, Pragmatic Programmers, 2013

Bibliography

- Additional books
  - S. Ghost. *Distributed Systems: An Algorithmic Approach*, Second Edition, Chapman and Hall/CRC, 2014
  - F. Cesarini, S. Thompson. *Erlang Programming: A Concurrent Approach to Software Development*, O'Reilly, 2009
  - F. Hebert. *Learn You Some Erlang for Great Good!*, No Starch Press, 2013
  - M. Herlihy, N. Shavit, *The Art of Multiprocessor Programming* , O'Reilly, 2006