CPDS

Concurrency
Parallelism
Distributed Systems

Course Presentation

Facultat d'Informàtica de Barcelona (FIB)
Universitat Politècnica de Catalunya (UPC)
2020/2021 Q1

FIB

Course coordinator

- Name: Jordi Guitart
- E-mail: jguitart@ac.upc.edu
- Office: C6-205
- Office Hours: Arrange an appointment by mail to meet physically or virtually (e.g. Google Meet)

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 (4h)
   - 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 18th

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: 27/10 ; exam: 07/01
  - M2 exam preparation: 17/12 ; exam: 12/01
  - M3 exam preparation: 22/12 ; exam: 14/01

Calendar

	Tuesday			Thursday		
14/09 - 18/09	(15/09) INTRO **CPDS** + INTRO **M1**			(17/09) INTRO **M2** + INTRO **M3**		
21/09 - 25/09	(22/09) **M1** (1st IT)	(22/09) **M2** (1st IT)	(22/09) **M3** (1st IT)	HOLIDAY		
28/09 - 02/10	(29/09) **M1** (1st IT)	(29/09) **M2** (1st IT)	(29/09) **M3** (1st IT)	(01/10) **M1** (1st IT)	(01/10) **M2** (1st IT)	(01/10) **M3** (1st IT)
05/10 - 09/10	(06/10) **M1** (1st IT)	(06/10) **M2** (1st IT)	(06/10) **M3** (1st IT)	(08/10) **M1** (1st IT)	(08/10) **M2** (1st IT)	(08/10) **M3** (1st IT)
12/10 - 16/10	(13/10) **M1** (1st IT)	(13/10) **M2** (1st IT)	(13/10) **M3** (1st IT)	(15/10) **M1** (1st IT)	(15/10) **M2** (1st IT)	(15/10) **M3** (1st IT)
19/10 - 23/10	(20/10) **M1** (1st IT)	(20/10) **M2** (1st IT)	(20/10) **M3** (1st IT)	(22/10) **M1** (1st IT)	(22/10) **M2** (1st IT)	(22/10) **M3** (1st IT)
26/10 - 30/10	(27/10) EXAM PREPARATION **M1**			(29/10) **M1** (1st IT)	(29/10) **M2** (1st IT)	(29/10) **M3** (1st IT)
02/11 - 06/11		(03/11) **M2** (2n IT)	(03/11) **M3** (2n IT)	MIDTERM PERIOD		
09/11 - 13/11	MIDTERM PERIOD				(12/11) **M2** (2n IT)	(12/11) **M3** (2n IT)
16/11 - 20/11		(17/11) **M2** (2n IT)	(17/11) **M3** (2n IT)		(19/11) **M2** (2n IT)	(19/11) **M3** (2n IT)
23/11 - 27/11		(24/11) **M2** (2n IT)	(24/11) **M3** (2n IT)		(26/11) **M2** (2n IT)	(26/11) **M3** (2n IT)
30/11 - 04/12		(01/12) **M2** (2n IT)	(01/12) **M3** (2n IT)		(03/12) **M2** (2n IT)	(03/12) **M3** (2n IT)
07/12 - 11/12	HOLIDAY				(10/12) **M2** (2n IT)	(10/12) **M3** (2n IT)
14/12 - 18/12		(15/12) **M2** (2n IT)	(15/12) **M3** (2n IT)	(17/12) EXAM PREPARATION **M2**		
21/12 - 25/12	(22/12) EXAM PREPARATION **M3**					

04/01 - 08/01		(07/01) EXAM **M1**
11/01 - 15/01	(12/01) EXAM **M2**	(14/01) EXAM **M3**

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

- Name: Joaquin Gabarro, Jorge Castro
- E-mail: {gabarro,castro}@cs.upc.edu
- Office: Omega-216 / Omega-S121
- Office Hours: Arrange an appointment by mail to meet physically or virtually (e.g. Google Meet)

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

- Name: Marc Gonzalez
- E-mail: marc@ac.upc.edu
- Office: C6-E207
- Office Hours: Arrange an appointment by mail to meet physically or virtually (e.g. Google Meet)

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