

# Distributed Calculus and Coordination (DCC)

Emanuela Merelli

Introduction to the DCC  
2011-2012

## 1 Organization of the Course

- Overview
- Lectures and Exercises/Project Sessions
- Exams and Literature

## 2 Introduction

- Aims of the Course
- Project
- Schedules

## Focus of the Course

- Study of formal **models** for the description of the dynamic of **complex systems**: emerging behaviours from a set interactive autonomous components (agents)
- Study of **languages** for the specification of coordination of autonomous interactive components
- Focus on **agent oriented modelling and simulation**
- Glance into **multi-level** modelling and analysis of **complex systems**
- Practice with simulation and verification **tools** and coordination **middlewares** and
- This year, quick learn of CUDA and programming on GPUs **offered by NVIDIA**

# COMPLEX SYSTEMS

## From Wikipedia

A **complex system** is a system composed of interconnected parts that as a whole exhibits one or more properties (behavior among the possible properties) not obvious from the properties of the individual parts.

A **system complexity** may be of one of two forms: disorganized complexity and organized complexity. In essence, disorganized complexity is a matter of a very large number of parts, and organized complexity is a matter of the subject system (quite possibly with only a limited number of parts) exhibiting emergent properties.

## EXAMPLES of Complex Systems

- Natural phenomena such as biological systems – Bone Remodelling
- Artifacts such as smart systems – Self-adaptive ambients for assisting elderly at home

## Overview of the Course

- Reactive, adaptive and proactive (self-adaptive) **agents**
- Multi-agent systems (**MAS**)
- Linda, distributed and coordination **model**
- Klaim, distributed and coordination **language**
- Shape, multilevel **spatial calculus**
- Hermes, **middleware** for mobile computing
- Repast, Swarm and BioShape **simulation environment**
- **Integrative project**

## Project

Putting the theory and tools into practice!

### Three steps project.

- 1 Specification of a dynamic complex system, possibly multilevel
- 2 Analysis and verification of the complex system
- 3 Simulation and validation of the complex system



## Lectures

- There will be lectures for about 15 weeks for semester,  
**Tuesday, Wednesday\* 11:00-13:00**
- Ask/answer question. Be active!
- Take your own notes. Slide will be available before each lecture
- Read the recommended literature as soon as possible after the lecture

**(\*) Start at 24th October** because the lesson overlaps to Advanced English

## Project Sessions

- Three hours per week: **Thursday 10:00-13:00**
  - **Learning by doing**
  - Work in group of 2 or 3 people
  - **Print out the exercise list**, bring literature and your notes.
  - Be responsible for your own learning!
- 
- Collaborators: **Luca Tesei, Diletta Cacciagrano, Rosario Culmone, Leonardo Vito, Federico Buti, Nicola Paoletti**

# Lectures

I semester 42 hours of lesson and 48 hours of projecting

|           |       |       |     |
|-----------|-------|-------|-----|
| Tuesday   | 11:00 | 13:00 | AB3 |
| Wednesday | 11:00 | 13:00 | AB3 |
| Thursday  | 10:00 | 13:00 | LA2 |

## Materials of the Course

<http://www.cs.unicam.it/merelli/calcolo11/DCC11.htm>

## Exam.

Distribution of work for the final grade:

- CUDA project, two options: Mini course or Flaim Agent-based CUDA (20% )
- Take-home exercises and written exam (30%)
- Individual and oral presentation of the project results. (50%)

**Note:** Slides must be prepared with Latex



## Literature.

- on-line literature, check the course web site
- Michael Wooldridge, An Introduction to Multiagent Systems, Wiley, 2nd Edition, 2009 (Cap. 1,2,6,7,8,9,11)
- M. Huth, Logic in Computer Science: Modelling and Reasoning about Systems, Cambridge, 2004 (Cap. 3,5)
- Edward A. Lee, Sanjit A. Seshia, Introduction to Embedded Systems, A cyber physical approach, UC Berkely, 2011(Cap. 1,2,3)
- Alessandro Aldini, Marco Bernardo, and Flavio Corradini, A Process Algebraic Approach to Software Architecture Design, Springer, ISBN: 978-1-84800-222-7, 2009 (Cap. 1,2,3)
- L. Aceto, A. Ingolfssdottir, K. Larsen, J. Srba, Reactive systems: modelling, specification and verification, Cambridge, 2008



## Examination days

### **I Term/Semester**

6 February 2012

20 February 2012

### **II Term/Semester**

18 June 2012

16 July 2012

### **Autumn Term**

10 September 2012

24 September 2012

**Note:** subscribe to ESSE3 at <http://didattica.unicam.it/>

## Hints

- Check regularly the course web-page
- Offer feedback to the lecturer
- Attend and actively participate during Exercise/Project
- Take your own notes

## Aims of the Course

Present a general framework for distributed and coordinated computing, consisting of

- modelling a pool of **interactive autonomous components**
- analysis and simulation of the **dynamics of complex systems**

### Aims.

- 1 Give the students **practice in modelling** agent-based systems in a formal framework
- 2 Give the students **skills in analysing** the individual and collective behavior of multi-agent systems
- 3 Give the students **ability to use simulation tools** for analysing the dynamics of complex systems



# Project main steps

## *Part I - DCC*

- 1 Choose the topic and the open issue to be faced in your project
- 2 Define of the state of the art of your topic by using a targeted bibliographic research
- 3 Describe the problem by writing a LaTeX article
- 4 Design and specify the model in terms of multiagent system in (REO, Tropos, PASSI, ...)

## *Part II - DCC+CSD*

- 5 Specify the model by formal language (CCS, Pi, SHAPE, ...)
- 6 Specify the properties of the model by a modal logic (LTL, ...)
- 7 Verify the model properties by model checking (CWB, PRISM, DIVINE, ...)
- 8 Simulate the model (REePast, SPIM, NetLogo, BioSHAPE, SWARM...)

# Modelling and Simulation Laboratory

Modelling and Simulation Laboratory

[http://www.cs.unicam.it/home/component/content/  
article/22-modeling-a-simulation](http://www.cs.unicam.it/home/component/content/article/22-modeling-a-simulation)

# Lesson Schedule, October-November 2011

| lesson n.  | date                                   | topic  |
|--|--|--|
| <b>Introduction to DCC course</b>                    |  |  |
| 1  | Tuesday 18 October 2011<br>11:00-12:00 | Introduction to the course                         |
| 2  | Wednesday 19 October<br>11:00-12:00    | Concurrent and Distributed Systems - main features |
| <b>Reactive, Adaptive and Proactive Agents</b>       |  |  |
| 3  | Wednesday 2 November<br>10:00-11:00    | Agent, environment and task - 1 part               |
| 4  | Tuesday 8 November 2011<br>11:00-12:00 | Agent, environment and task - 2 part               |
| 5  | Wednesday 9 November<br>11:00-12:00    | Agent, environment and task - 3 part               |
| 6  | Thursday 10 November<br>10:00-13:00    | Agent, environment and task - Exercises            |
| <b>MultiAgent System Modeling</b>                    |  |  |
| 7  | Tuesday 15 November<br>11:00-13:00     | Multiagent Decision Making - part 1                |
| 8  | Wednesday 16 November<br>11:00-12:00   | Multiagent Decision Making - part 2                |
| 9  | Tuesday 22 November<br>11:00-13:00     | Multiagent Decision Making - part 3                |
| 10   | Wednesday 23 November<br>11:00-13:00   | Multiagent Decision Making - Exercises             |
| <b>Cooperative &amp; Distributed Problem solving</b> |  |  |
| 11   | Tuesday 29 November<br>11:00-13:00     | Distributed Problem solving                        |
| 12   | Wednesday 30 November<br>11:00-13:00   | Cooperative Problem solving                        |

# Lesson Schedule, December 2011 - January 2012

| lesson n.                                   | date                                 | topic                                   |
|---|--------------------------------------|---|
| <b>Agent based modelling and simulation</b> |                                      |   |
| 13  | Tuesday 6 December<br>10:00-13:00    | Agent Based Modelling - part 1          |
| 14  | Wednesday 7 December<br>10:00-13:00  | Agent Based Modelling - part 2          |
| 15  | Tuesday 14 December<br>10:00-13:00   | Agent Based Modelling - part 3          |
| 16  | Wednesday 15 December<br>10:00-13:00 | Agent Based Modelling - Exercises       |
| <b>Multi-level modelling and simulation</b> |                                      |   |
| 17  | Tuesday 10 January<br>10:00-13:00    | Multi-level Modelling                   |
| 18  | Wednesday 11 January<br>10:00-13:00  | Multiscale Modelling and Analysis       |
| 19  | Tuesday 17 January<br>10:00-13:00    | Multi-level Simulation                  |
| 20  | Wednesday 18 January<br>10:00-13:00  | ODE simulation                          |
| 21  | Tuesday 24 January<br>10:00-13:00    | Agent Based-CUDA Simulation             |
| 21  | Wednesday 25 January<br>10:00-13:00  | Agent Based-CUDA Simulation - Exercises |

# Laboratory Schedule, October-November 2011

| lesson n.   | date                                   | topic                         |
|---|--|-------------------------------|
| <b>A Powerful Computational Environment for Complex Systems</b>       |  |                               |
| Mini-course of CUDA in collaboration with Gunnar Kristinn Vilbergsson |  |                               |
| 1   | Tuesday 18 October 2011<br>12:00-13:00 | Introduction to CUDA          |
| 2   | Wednesday 19 October<br>12:00-13:00    | CUDA                          |
| 3   | Thursday 20 October<br>10:00-13:00     | CUDA                          |
| 4   | Tuesday 25 October 2011<br>11:00-13:00 | CUDA                          |
| 5   | Thursday 27 October<br>10:00-13:00     | CUDA                          |
| <b>Running Projects</b>   |  |                               |
| Ambient Assisted Living   |  |                               |
| 6   | Thursday 3 November<br>10:00-13:00     | Introduction to AAL project   |
| Adaptive e-Learning   |  |                               |
| 7   | Thursday 17 November<br>10:00-13:00    | Introduction to AeL project   |
| LuLab   |  |                               |
| 8   | Thursday 24 November<br>10:00-13:00    | Introduction to LuLAB project |

# Laboratory Schedule, December 2011 and January 2012

| lesson n.                            | date  | topic                          |
|--------------------------------------|---|--------------------------------|
| <b>Useful Tools</b>                  |   |                                |
| Mini-course of FLAME-CUDA for Agents |   |                                |
| 9                                    | Thursday 1 December<br>10:00-13:00            | FLAME and CUDA for Agents e BR |
| Mini-course of REPAST                |   |                                |
| 10                                   | Thursday 8 December<br>10:00-13:00            | Introduction to REPAST         |
| Mini-course of PRISM                 |   |                                |
| 11                                   | Thursday 15 December<br>10:00-13:00           | Introduction to PRISM          |
| Project Development                  |   |                                |
| 12-13-14-15-16                       | Thursday 12, 19 and 26 January<br>10:00-13:00 | Project                        |