Introduction to the Course

Advanced Topics in Agent-Oriented Computing

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ICT International Doctorate School, Trento, Italy, 2007

Outline

Computational Systems

What is a computational system?

- any system with computational capabilities
- how many computational systems today in this room?
  - how many a few years ago?

Interactivity & Interoperability

- Almost any computational system of today comes equipped with TLC technologies for interacting with other computational systems
- We live immersed in a sort of *computational cloud*, where an incredible (and always increasing) number of computations are performed at every instant
  - distributed, concurrent computations
  - either controlled / triggered, or autonomous computations

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Pervasiveness of Computational Systems

Nowadays, computational systems...

- ...have become *pervasive*
- ...are at the core of *most* artificial systems

The physical nature of artificial systems...

...adds complexity to computational components / systems

- in terms of physical distribution
- in terms of temporal distribution
- in terms of unpredictability of the scenarios

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On the Notion of System

No more distinctions between SW & HW systems

- no more *easy* distinctions
- at a given level of abstraction

We consider *artificial systems* in general

either human-made or human-affected natural systems

Abstraction of *system*

to explain complex behaviour in terms of

- components' *behaviour & interaction*
- interaction with the *environment*

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On the Notion of Distribution

What is distributed?

- computational units, communication channels. . .
- data, information, knowledge
  - as well as their representations
- sensors, actuators, . . .

Spatio-temporal unity of systems is lost

- there is no longer a notion of *system time*, nor a *location*
- system components, at different level of abstraction, are only partially related
  - temporally & topologically

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What is Changed?

A number of assumptions over systems no longer hold

- system events constitute a partially-ordered set
  - generally speaking
- admissible interactions among system components depends on compresence
  - in space / time
  - within a physical / virtual topology

What is Needed?

- New *meta-models* for computational systems
- New *methodologies* for system analysis, design & development
- New *technologies* for system development, implementation & deployment

New abstractions

- to straightforwardly deal with the nature of artificial / computational systems of today
- to capture
  - distribution in space & time
  - the new nature of components and of their interaction
  - complexity & unpredictability of environment

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Outline

Why Multiagent Systems (MAS)?

MAS first of all address the problem of *distribution*

bringing the principles of encapsulation & locality up to the required level of abstraction

MAS are a suitable source of

- new abstractions
- new meta-models
- new technologies
- new methodologies

for today complex artificial / computational systems
[Zambonelli and Omicini, 2004]

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Convergence of Areas on Computational Systems

A number of heterogeneous areas contribute(d) to the MAS field

- Artificial Intelligence, Programming Languages, Distributed Computing, Mobile Computing, Robotics, Software Engineering, Operation Research...

The field of MAS is an independent research area, today

even though some of the contributing fields claim to contain it from its very beginnings

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Convergence of Areas from outside Informatics

From either technological areas. . .

such as Telecommunications, Electronics, Automation, Bioengineering, . . .

. . . and non-technological ones

such as Cognitive sciences, Psychology, Social sciences, Organisational sciences, Biology, Ethology, System sciences, . . .

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Convergence is not just a Tool for Researchers

- It comes from the pervasiveness of computational devices and technologies...
- ...as well as from the increasing complexity of computational systems

Convergence of heterogeneous research areas is just a matter of fact

the time of specialisation (and specialists) is going to end soon

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Goals of the Course

Students of this course should become

- aware of the basics of agent-oriented computing
- able to re-interpret the main issues of agent-oriented computing
- face advanced topics of agent-oriented computing in a new perspective

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Some of the topics of the course

- Foundations of agent-oriented computing
- Agents and artifacts (A&A): the meta-model
- Programming languages for agents and MAS
- Interaction, communication, coordination, organisation, security
- Agent-oriented Software Engineering (AOSE)
- Agent-oriented simulation of complex systems
- Self-* systems, autonomic computing and MAS

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Bibliography


Zambonelli, F. and Omicini, A. (2004).
Challenges and research directions in agent-oriented software engineering.
Autonomous Agents and Multi-Agent Systems, 9(3):253–283.
Special Issue: Challenges for Agent-Based Computing.

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