UNIBO: Multi-Agent System Infrastructures

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Infrastructures

- MAS infrastructures play a fundamental role in the engineering of complex software systems
- Their role is at least as fundamental as the one of methodologies
- Infrastructure is a fundamental notion for complex systems in general:
  - computer science and engineering
  - organisational and social sciences
  - political and economical sciences

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In its most general acceptation...

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Infrastructures: some definitions

Gasser 2001:

a technical and social substrate that stabilises and rapidly enables in-strumental (domain-centric, intentional) activity in a given domain... (solving) typical, costly, commonly accepted community (technical) problems in a systematic and appropriate ways.

Infrastructures: some definitions

Sycara et al. 2003:

Agents in a MAS are expected to coordinate by exchanging services and information, to be able to follow complex negotiation protocols, to agree on commitments and to perform other socially complex operations. We define the infrastructure of a MAS as the set of services, conventions, and knowledge that support such complex interactions.

Infrastructures: the main role

- The main role is to model and shape the *agent environment*, from the two points of view:
  - *the agents living in the MAS* – infrastructure provides the means to deal with the agent environment
  - *MAS designers* – infrastructures are the suitable places for embedding elements of control

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- The increasing complexity and articulation of MAS calls for a most effective engineering support from infrastructure, beyond the mere enabling of agent interaction:
- Some examples:
  - Electronic Institutions
  - TEAMCORE
  - RETSINA
- Current MAS infrastructures typically lack suitably abstractions to *govern* agent interaction.
- This seems instead a *fundamental feature* for enabling the specification and enactment of social norms, and for defining and executing social activities (coordination)

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Infrastructures

- Infrastructures play a key role in the engineering of MAS, too
- The abstractions provided by the infrastructure are the *most natural candidates* to be adopted and exploited in the design of MAS structures
- Runtime abstractions should be:
  - flexible enough to support the engineering of heterogeneous systems
  - effective in minimising the gap between the design and development/deployment/runtime of systems.
- In this context, the tools provided by an infrastructure are fundamental to enable the manipulation of the abstractions through all the engineering stages, in particular at runtime.

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Infrastructures

- MAS infrastructures and tools play an essential engineering role by
  - keeping abstractions alive through the whole engineering process
  - enabling software engineers to first design and then observe and act on MAS structures and processes at runtime,
  - working upon abstractions adopted and exploited for the design of a MAS.
- This feature is important to support forms of *on-line engineering* a relevant feature in the context of MAS, given their intrinsic complexity and openness.

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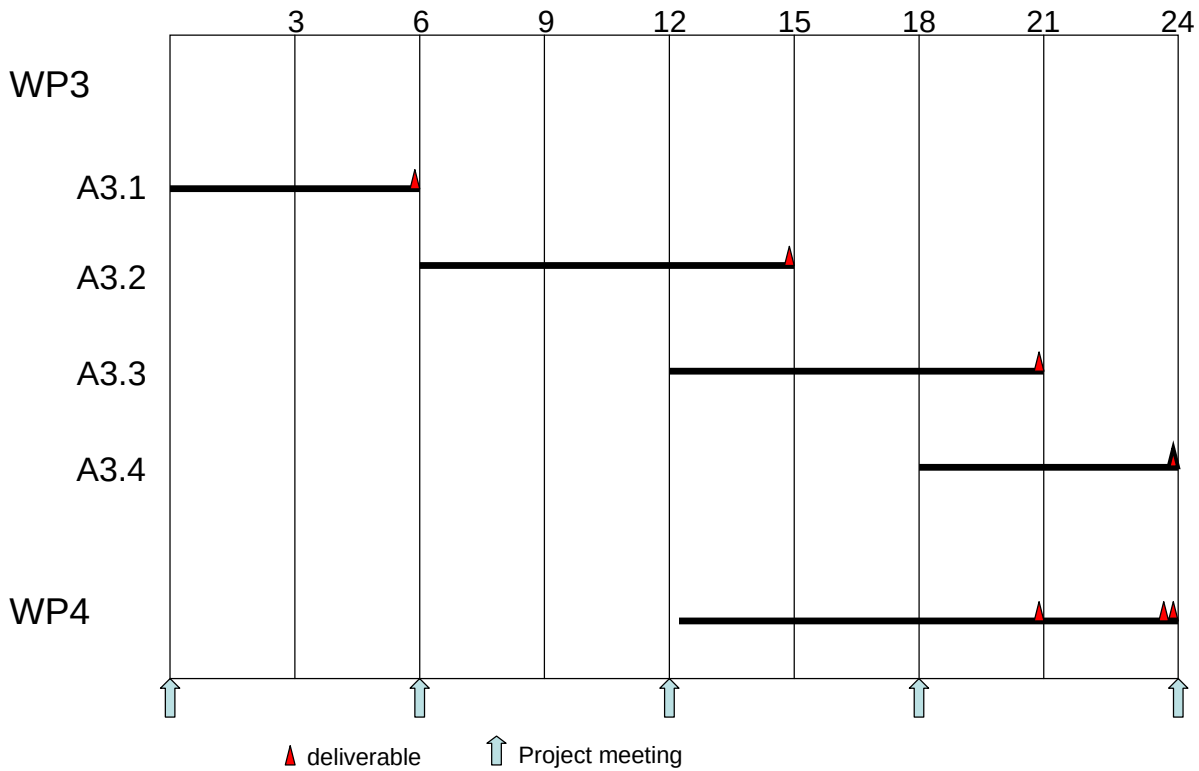
Responsibilities

- UNIBO is responsible for the achievement of
  - Workpackage WP3: *Agent Infrastructures Development*
  - Workpackage WP4: *Case Study*
- The Gantt diagram shows the timetable of the workpackages:



People involved

- Prof. Andrea Omicini (National Coordinator)
- Ing. Ambra Molesini (Ph.D Student)
- Ing. Elena Nardini (Research Grant)
- Ing. Giulio Piancastelli (Ph.D Student)
- Ing. Matteo Casadei (Ph.D Student)

- External Partners:
  - Prof. Massimo Cossentino (ICAR-CNR Palermo)

Other people involved

- Working on SODA:
  - Prof. Enrico Denti
  - Prof. Alessandro Ricci
- Working on Pattern in AOSE-SO
  - Prof. Mirko Viroli
  - Ing. Luca Gardelli (Ph.D Student)

Outline

Agent Infrastructures Development

- Most of the available MAS infrastructures has been conceived and designed in academic contexts, and can be still considered in their infancy, in particular with respect to mainstream middlewares.
- Such an immaturity affects three different aspects:
  - abstractions and services provided
  - available tools and technologies
  - integration with agent-oriented methodologies.
- Then, we consider the research on MAS infrastructure models and supporting tools essential for advancing the state of the art on software engineering.

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Agent Infrastructures Development

- The objective of this workpackage is the *identification of suitable infrastructure* supports for agent-based systems and MAS, for the engineering of complex software systems, in particular for their runtime and on-line management.
- We will
  - consider existing infrastructure models, approaches, and their extension and integration
  - develop a framework that will cover the main infrastructure issues of interest and support the methodological framework developed in WP1 and WP2

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Agent Infrastructures Development

- The workpackage will be articulated in four different activities:
  - A3.1 Study of the state of the art
  - A3.2 Definition of an infrastructural model
  - A3.3 Design and Development of Prototypes
  - A3.4 Infrastructures evaluation

A3.1 Study of the state of the art

- In this stage, we will consider the main abstractions at the base of current MAS infrastructures and which play a key role in the engineering of systems on top of such infrastructures.
- We will consider the main infrastructure approaches: JADE, TuCSoN, RETSINA, TOTA and CArtAgO.
- Also, standard and mainstream infrastructures will be briefly considered: Web Services, OSGi, CORBA, PKI, ...
- The main aspects that will be focussed will concern:
  - infrastructure support for systemic dimensions
  - organisation
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Expected Results

- Technical reports will be produced as an outcome of the stage, to be distributed to the other research units involved in the projects and to the scientific community.
- The reports will discuss the result of the survey, focusing in particular on the weakness and strength in existing approaches with respect to the objective of this project.
- Deliverables:
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A3.2 Definition of an infrastructural model

- An infrastructural model will be developed in order to provide some basic *unifying abstractions* to integrate the two worlds:
  - the methodological framework outcome of the WP2
  - in harmony with the meta-model identified in WP1
- The key point of such a framework will be the identification of first class abstractions which:
  - could be easily mapped on primary concepts of the methodological framework devised in WP2
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- Such abstractions are meant to be expressive to cope with the heterogeneity of existing agents and MAS meta-models,
  - dealing both with strong and weak notion of agency
  - and related conceptual domains
- This activity will be devoted to identify a suitable infrastructure model, starting from existing approaches considered in A3.1.
- We focus on the infrastructures which are part of the research work of the groups involved in the project:
  - TuCSoN, that provides services for coordination, organisation and security
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- The research unit aims at adopting languages and tools to support the engineering of system for heterogeneous application domains.
- This leads to the adoption of the Java language and Java platform, as the base on which possibly stacking other languages and virtual machines.
- All the technologies developed in this stage are meant to be open-source.

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- Moreover the unit will evaluate the possibility to distribute infrastructure tools in the form of plug-ins for well known extensible open-source IDE.
- Interaction and cooperation between UNIBO unit and UNIMORE unit will be strong:
  - for what concerns the development of infrastructure tools supporting the methodological framework
  - for the engineering of systems on top of the infrastructure

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Expected Results

- As a result of the stage, infrastructure prototypes will be realised, with related technical documentation. The design and development of the prototypes could eventually generate some technical reports and papers concerning significant aspects of the architecture and the implementation.
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  - *D3.3* Infrastructure prototypes and related documentation
- Begin/End: month 12 - month 21

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A3.4 Infrastructures evaluation

- This activity will be dedicated to the evaluation of the proposed infrastructure. We will evaluate the usability of the infrastructure through a case-study application (WP4).
- *Expected Results*: scientific papers will be produced to spread the results of the research activity.
- Deliverables
  - *D3.4* Document describing the evaluation results
- Begin/End: month 18 - month 24

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Outline

Case Study

- This stage will investigate the adoption of the infrastructure for the engineering of some case studies, both theoretical and real-world.
- Among the possible application domains:
  - logistics
  - e-learning
  - intelligent environments
  - virtual enterprises
  - distributed workflow management
- The engineering of the case studies will stress the synergy between the methodological framework and the developed infrastructure.

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Expected Results

- As a result of this activity, technical reports will be produced describing the engineering of the case studies, along with simple prototypes developed on top of the infrastructure(s).
- Deliverables:
  - *D4.1* Document describing the case study
  - *D4.2* Document(s) describing the analysis and design according to the methodological framework resulted from WP2
  - *D4.3* Experimental prototypes on top of the infrastructure(s) and tools resulted from WP3
- Begin/End: month 12- month 24

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