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Kick-off meeting
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Bologna Involvement

Direct involvement in three subprojects:

- SP4 (CTI): Game Theoretic and Organisation Economics Inspired Approaches
- SP5 (UniBO): Biologically-Inspired Techniques for “Organic IT”
- SP6 (MPII): Data Man., Search and Mining on Internet-scale Dynamically Evolving P2P Nets.

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Talk Overview

- Overview of SP5 (lead by UniBo)
- Outline of SP4 and SP6 WP's we are directly involved in
- Summary
- An Example (time permitting)

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Subproject 5
Biologically-Inspired Techniques for “Organic IT”

Participants:

Universita di Bologna, Italy (UniBO)

Telenor Communication AS, Norway (Telenor)

Universitat Pompeu Fabra Barcelona, Spain (UPF)

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The Problem

How nodes (agents) perform tasks involving:

- Coordination & Cooperation
- Specialisation & Self-Repair
- Scalability & Adapting to Change

WITHOUT centralised supervision and in a scalable way

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The Bigger Problem

- Often systems composed of agents with limited or faulty knowledge
- Agents may be malicious, deceptive, selfish or crazy (open systems and / or adaptive agents)
- Agents have limited resources
- How to design algorithms that allow agents to collectively emerge the desired properties under these difficult conditions?

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A Solution

- Required properties bear a strong resemblance to those of “living” systems (organisms, groups, societies etc.)
- Historically studied within in the broad fields of Life and Social Sciences (L&SS).
- Theories exist in various forms

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A Solution

- We want to engineer systems to solve problems
- L&SS want to understand existing animal and human systems
- But the fundamental mechanisms of interest are the same
- Applying, hitherto unapplied, ideas from L&SS to engineer required properties

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SP5 Workpackages

Four Workpackages:

- WP5.0: Management (UniBo)
- WP5.1: Novel biological metaphores for information systems (Telenor)
- WP5.2: Evolving tinkering and degeneracy as engineering concepts (UPF)
- WP5.3: Biology-inspired design for dynamic solution spaces (UniBo)

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SP5 Activities

- Identify desirable life-like properties of large-scale info. systems (WP5.1)
- Investigate results from Biology. Identify engineering applications (WP5.1, WP5.2, WP5.3)
- Design algorithms for specific functions e.g. network design, self-repair, routing, etc. (WP5.2, WP5.3)

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SP5 Activities

- Test algorithms in simple simulated environments - proof of concept (WP5.2, WP5.3)
- Test algorithms in larger scale simulation environments - more realistic (WP5.2, WP5.3)
- Investigate strategies for collaboration between engineers and artificial systems during the design process (WP5.2)

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SP5 Cooperation

Possible cooperation with other SP's:

- SP1 monitoring and debugging – we can provide tested bio-inspired algorithms
- SP2 we can benefit from results that may help us in the analysis of our results.
- SP4 methods in game theory particularly evo. game theory overlap with parts of SP5 (e.g. dealing with self-interest).
- SP6 P2P applications – we can test and provide bio-inspired algorithms.

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WP5.1 Novel biological metaphors for information systems

- Resp: Telenor, Part: UniBo, UPF
- Build on BISON (running FET FP5 IP), results using “ant” algorithms and “gossip” protocols
- Identification of mechanisms for life-like properties in dynamic networking environments
- Broad survey of relevant theoretical and experimental biological (and social) research
- Provide input to other SP5 WP’s
- Period 12-18, D5.1.1 (@18)

WP5.2 Evolved tinkering and degeneracy as engineering

- Resp: UPF, Part: UniBo, Telenor
- Biological “tinkers” rather than designs
- Solutions are often “degenerate” (much redundancy) but consequently robust
- Complex engineered systems have similar properties (electronics, software, networks)
- Improve existing systems and design new ones. Provide tools to help designer
- Period 0-18, Deliverables D5.2.1 (@10), D5.2.2 (@18), D5.2.3 (@18)

WP5.3 Biology-inspired design for dynamic solution spaces

- Resp: UniBo, Part: Telenor, UPF
- Ideas from biology will need to be adapted for application to DELIS environments
- Apply evolutionary and machine learning to search solution spaces (from WP5.1 and 5.2) to find desirable algorithms
- Find algorithms (at node level) that produce desirable properties at aggregate level
- Possible novel (non-bio inspired) mechanisms
- Period: +18, Deliverables: to be defined

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SP4 and SP6 Involvement

Direct involvement in:

- WP4.3 – Models and methods for dynamics, evolution, and self-organisation
- WP6.3 – Strategies for self-organising Information dissemination and load sharing

With the following partners:

- Comp. Sci. Institute, Patras, Greece (CTI)
- Uni. of Cyprus, Cyprus (UCY)
- Wroclaw Uni. of Tech., Poland (TU Wroclaw)

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WP4.3 Dynamics, evolution and self-organisation of complex nets

- Resp: UniBo, Part: CTI, UCY
- Economies are networks
- Examine boundedly rational agents embedded within networks
- Relax assumptions of: complete knowledge, utility maximisation (e.g. satisfying)
- Evolutionary Game Theory
- Out of equilibrium, trajectories, noise, limited computation

WP4.3 Dynamics, evolution and self-organisation of complex nets

- Draw on existing theory (e.g. Robert Burgelman intra-organizational ecology theory)
- Existing models (Social Simulation, Artificial Societies)
- Develop, test and apply using agent-based simulations (ABS)
- Develop organisation theories to a point where results can be applied to DELIS objectives
- Period: 0-18, Deliverables: D4.3.1 (@6), D4.3.2 (@18)

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Self-organisation and Hierarchy in organisational adaptation

- A fundamental issue in organisational theory concerns the mechanisms that underpin organisational change and the role managers play in governing a firm's adaptation behaviour.
- Selection vs. adaptation debate:
  - Observed organisational change is the product of firms' adaptation
  - Observed organisational change is the product of adverse selection of unfit organisations.

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The Intra-organisational Ecology Model (Burgelman, 1983, 1991)

- Adapting behaviour of organisations blends elements of hierarchical control and elements of self-organisation.
- A firm is an ecology of strategic initiatives, organisational adaptation proceeds through competition among these strategic initiatives.
- Organisational morphology crystallises a selected balance between hierarchy and self-organisation …

- …thus influences adaptation performances.

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Computer simulation to study organisational behaviour

- To better understand the behavioural, non-trivial, implications of IOE theory:
- we translate the theory in a mathematical model and we simulate the model to …
- create a laboratory where organizational behaviour is reproduced…
- and the link between a firm's organisational morphology and adaptation performance can be closely scrutinized.

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WP6.3 Strategies for self-organising info. dissemination & load sharing

- Resp: CTI, Part: Telenor, UniBO, TU Wroclaw
- Self-organising dynamic P2P
- Share information and computational resources fairly to meet demands of users
- Suppression of node-level self-interest
- Mechanisms from SP5
- Period 0-18, Deliverables: D6.3.1 (@12), D6.3.2 (@18), D6.3.3 (@18)

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Summary of Deliverables in the first 12 months

- D4.3.1 @6 (UniBO, CTI, UCY)
  - Report: “Evaluation of evolutionary game theory approaches”
- D5.2.1 @10 (UPF, UniBo, Telenor)
  - Report: “Algorithms to identify locally efficient sub-graphs in information transfer networks”
- D6.3.1 @12 (CTI,Telenor,UniBO,TU Wroclaw)
  - Intermediate report: “Requirements and restrictions of desired P2P infrastructure and survey of existing and proposed architectures”

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Summary of Deliverables at 18 months

- D4.3.2 (UniBO, CTI, UCY)
  - Report: “Tools that can be applied to net evolution, characterisation and design”
- D5.1.1 (Telenor, UniBO, UPF)
  - Report: “Desirable lifelike properties in large-scale information systems”
- D5.2.2 & 3 (UPF, UniBo, Telenor)
  - Report: “Strategies for collective construction of efficient information-processing webs”
  - Report: “Degeneracy for redundancy in human-constructed information systems”

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Summary of Deliverables at 18 months

- D6.3.2 & 3 (CTI, Telenor, UniBO, TU Wroclaw)
  - Final report: “Requirements and restrictions of desired P2P infrastructure and survey of existing and proposed architectures”
  - Software: Proof-of-concept implementation of the P2P network

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SP5 thoughts - good news

- We don't need theories that are correct, just algorithms that work (obviously need to have theories of *why* they work!)
- Discarded / overly simple ideas may be fine for our task (e.g. Lamarckian evolution in optimisation tasks)

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More good news

- A increasing number of Biologists and Social Scientists are producing computer simulations of their ideas
- This gives us an algorithmic understanding of their ideas (though that is not their reason for doing it)
- Wealth of published material (mainstream journals: Nature, Science)

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Some Sources

- Artificial Life (Journal, U.S. and E.U. Conferences etc.) pitched at the biological and ecological level
- Artificial Societies, Social Simulation, Evolutionary Game Theory (Journal JASSS, CMOT, various international conferences) social and Institutional level
- Some relevant work within Multi-Agent Systems (AAMAS conference and associated workshops) more engineering related

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Summary

- We will apply ideas from Biology and other life sciences to engineer self-organising systems
- In order to do this we will search for relevant ideas, theories and mechanisms in the research
- We will test and develop these mechanisms using (agent-based) simulation
- Build on existing work coming from the BISON project

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