SP 5: Biologically Inspired Techniques for "Organic IT"

Plan for months 13 - 30

Participants

UniBO, UPF, Telenor, TILS

presented by David Hales (UniBO)
www.davidhales.com

New Faces – SP5

- Javier Macía (Barcelona – UPF)
- Federico Morabito (Telecom Italia – TILS)
- Stefano Arteconi (Bologna – UniBO)
- Isaac Chao (Barcelona – UPC, not part of DELIS or UPF group, working on another project “CATSNETS” but playing with Tags on DIET agent platform, so might drop in later)

Goals of SP5 “Biologically Inspired Techniques for Organic IT”

Long term

Identify, understand and reverse engineer techniques inspired by biological and social systems that display “self-*” properties. Deploy these in networked information systems

Short term

Consolidate and import BISON findings. Identify “nice” properties of biological and social systems. Relate found natural network “forms” to engineering “functions”

Identify desirable life-like properties - “Self-*”

Algorithms | Simulations / Tools | Implementations

Industrial Applications

Structure of SP5 "Biologically Inspired Techniques for Organic IT"

WP	Months 1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30
5.1					Bio-inspired metaphors			●		
5.2	Evolved tinkering and degeneracy as engineering concepts			●				● ●		
5.3							Bio-inspired design for dynamic solution spaces			●
5.4					Multi-scale topology evolution in natural and artificial networks			●		
5.5					Identifying and promoting industrial applications and knowledge transfer					●
5.6						The structure of tinkered landscapes		●		

● = deliverable

We are here

BISON input

BISON project overview

Main focus of BISON: **functions** implemented over distributed systems

- living systems
- nonliving (overlay and ad-hoc networks)

We have sought to *learn* from biology:

- Routing, finding paths: ants
- Load balancing: diffusion, chemotaxis
- Content search: immune system, proliferation
- Topology management: adhesion

We have the beginnings of a systematic synthetic approach, using a set of “microscopic mechanisms”

Goals

Long term

Preliminary designs for algorithms and models with direct application to network engineering and design

Short term

Identify a set of desirable, life-like properties in large-scale engineering systems. Review existing biologically inspired work.

Partners

Telenor, UniBO, UPF

Plan

- Identify and characterize “nice” properties from Biology
- Will use some inputs from BISON project
- Knowledge from biology and related disciplines => how are properties achieved in nature?

Deliverables

D5.1.1: Desirable lifelike properties in large-scale information systems (due date: month 24)

Goals

Long term

Explore ways of applying evolutionary computational streatgies to the optimisation of pre-existing information systems. Facilitate the interaction between engineers and automatic systems in the construction of efficient information processing networks

Short term

Investiage the topological evolution of found natural networks over time. Characterise these patterns algorithmically. Relate them to desirable functional properties for artificial engineered networks.

Partners

UPF, UniBO

Results (from D5.2.1, month 10)

Software Architectures as networks

- "Motif" analysis of the evolution of found natural networks
- Applied to the evolution of software graphs
- Identification of "duplicate and re-wire" rules in such networks

Self-Organising Cooperation in peer-to-peer networks

- Socially inspired "duplicate and re-wire" algorithm for cooperation in P2P networks
- Tested with simulation over a number of domains (e.g. file sharing)

Plan

- Explore ways of applying evolutionary computational strategies to the optimization of pre-existing information systems (evolutionary tinkering)
- Investigate new techniques to design and exploit systems characterized by degeneracy

Deliverables

D5.2.2: Optimal Strategies for collective construction of efficient information-processing webs (due date: month 24)
D5.2.3: Degeneracy for redundancy in human-constructed information systems (due date: month 24)

Goals

Long term

Develop tools and methods to translate / modify biologically and socially inspired algorithms for application in realistic information systems environments

Short term

Select a set of candidate algorithms and application domains. Use simulation and apply necessary tuning using

Partners

UniBO, UPF, Telenor, TILS

Plan

- Select ideas from WP 5.1 and WP 5.2 applicable to distributed engineering problems
- Identify the engineering constraints / requirements that differ from the existing algorithms
- Develop tools and methods to translate / modify the algorithms
- Apply and test in simulation / implementation

Deliverables

D5.3.1: From Biological and social algorithms to engineering solutions (due date: month 30)

Goals

Long term

Explore processes of general network evolution in both natural and artificial systems - determine and harness both the form and function of multi-level evolution for engineering

Short term

Apply “motif analysis” to artificial networks developed for functional properties and compare with natural systems with similar or desired properties. Relate network forms to functions.

Partners

UPF, UniBO, Telenor

Plan

- Apply / develop dynamical analysis techniques for evolving networks
- Identify natural and artificial network (algorithms) with selection / topology evolution at different levels
- Relate these network “forms” to desirable network “functions” in engineered networks

Deliverables

D5.4.1: Application of “motif analysis” to artificial evolving networks (due date: month 24)

D5.4.2: Understanding and engineering “multi-scale” selection in evolving dynamic networks (due date: month 30)

Goals

Long term

Bridge between academic research (in DELIS SP5) and realities of industry (telecom). Patents, spin-offs, industrial projects

Short term

Identify SP5 activities and mechanisms with possible commercial and industrial applications

Partners

Telenor, UniBO, UPF

Plan

- Proposed and lead by Telenor
- Can play a valuable role in bridging between the academic sides of DELIS SP5, and the realities of industry (telecom)
- Telenor already have some experience doing this (patents pending, internal projects, and commercialization)
- It is too early to say which SP5 activities will be taken further in WP5.5

Deliverables

D5.5.1: Promising industrial applications in dynamically evolving networks (due date: month 30)

Goals

Long term

Comparison of biological networks and engineered designs
Understand evolutionary mechanisms that make natural networks robust and have other differing properties. Produce simulator package.

Short term

Characterize topologies, functional constraints, fitness landscapes of existing networks. Relate knowledge to optimizing evolutionary rules / algorithms.

Partners

UPF, UniBO

Plan

- Characterization of fitness landscapes of evolved computational graphs
- Exploration of the impact of landscape structure on optimal information networks

Deliverables

D5.6.1: Classification of info. Networks based on topology and functional structures related to fitness landscape (due date: month 24)

Cooperation with other SP's

SP4-SP5	Game theory and evolutionary economics models
SP5-SP6	Possible application of existing SP5 work to distributed information sharing (cooperation). Also, other specific application domains

Cooperation with other projects

- BISON — As described, extensive cooperation with BISON
- NANIA — A new EPSRC (UK) 5 year project - collaborative meetings planned / already made, with Manchester group
- CATSNETS — Potential new collaboration (new FP6 STREP)

Dissemination

As well as scientific publications and presentations in a wide range of academic journals and conferences we aim to produce a number of popular overviews publication within popular science outlets

From theory to application?

- Theory and simulations create a set of possibly useful techniques
- Can we identify well defined engineering problems?
- Modify / apply these techniques within the engineering constraints?
- Identify a methodology / procedure that has general application
- Current direction and thinking (stages):
  - Start with theory / ideas (biological, social or whatever)
  - High-level abstract simulations / analysis
  - Less abstract simulations – nearer to application domain (align)
  - Prototype implementation, proof of concept (align)
  - Refined implementation (align)

Example from BISON project:

- Task: maintain an open, scalable, robust random connected P2P overlay network
- Gossip / epidemic spreading => Newscast protocol
- Newscast => Peersim (open source P2P simulator)
- Peersim Newscast protocol => PlanetLab prototype implementation
- Can we at each stage identify steps taken
- Produce generalized / reusable tools, methods

Example from DELIS (on-going):

- Task: maintain an open, scalable, robust cooperative P2P overlay under assumptions of possible selfish node behavior
- Tag systems => SLAC protocol
- SLAC protocol => Peersim
- Since SLAC requires a random sampling service over the network it is implemented on top of Newscast in Peersim
- SLAC / Newscast => Planetlab (not done, possible)
- Tools to take a Peersim protocol and translate to an implementation (possible BISON on-going)

- But these previous tasks are really generic kinds of P2P services
- What about “real applications”
- SLAC => File-sharing (but not in Peersim yet / abstract)
- SLAC(ER) => Artificial trusted dynamic social networks
- Automatic collaborative Spam filters? (possibly)
- SP6 collaboration => distributed trusted search engine
- Load balancing (GRID, instead of using “markets”)
- Others?

Key idea:

- Not to produce fully usable applications as such
- But to identify a viable methodology / process
- Where possible produce reusable tools and knowledge
- Note what doesn't work as well as what does

Thank you!