Ecologically inspired agent networks

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Outline

- EcoBusiness project
- complex systems - ecological networks
- mutualistic networks
  - patterns (e.g. frequency distributions, nestedness, asymmetry)
  - mechanisms
- agents interactions inspired by ecological relations
- LCC and OpenKnowledge
- complex agent networks
- future work

EcoBusiness

Goal: Create an ecologically inspired Multi-Agent Digital Business Ecosystem for SMEs cooperation

Project Facts

- Project Duration: 36 Months
- Schema: Industry - Academia Partnership and Pathways
- Partners: MicroArt (SME), School of Informatics, Business School
- People: 2 MicroArt fellows, 3 UEDIN fellows, 2 UEDIN supervisors, 1 MicroArt coordinator
- Website: http://www.ecobusiness.cat

Complex Systems - Ecological Networks

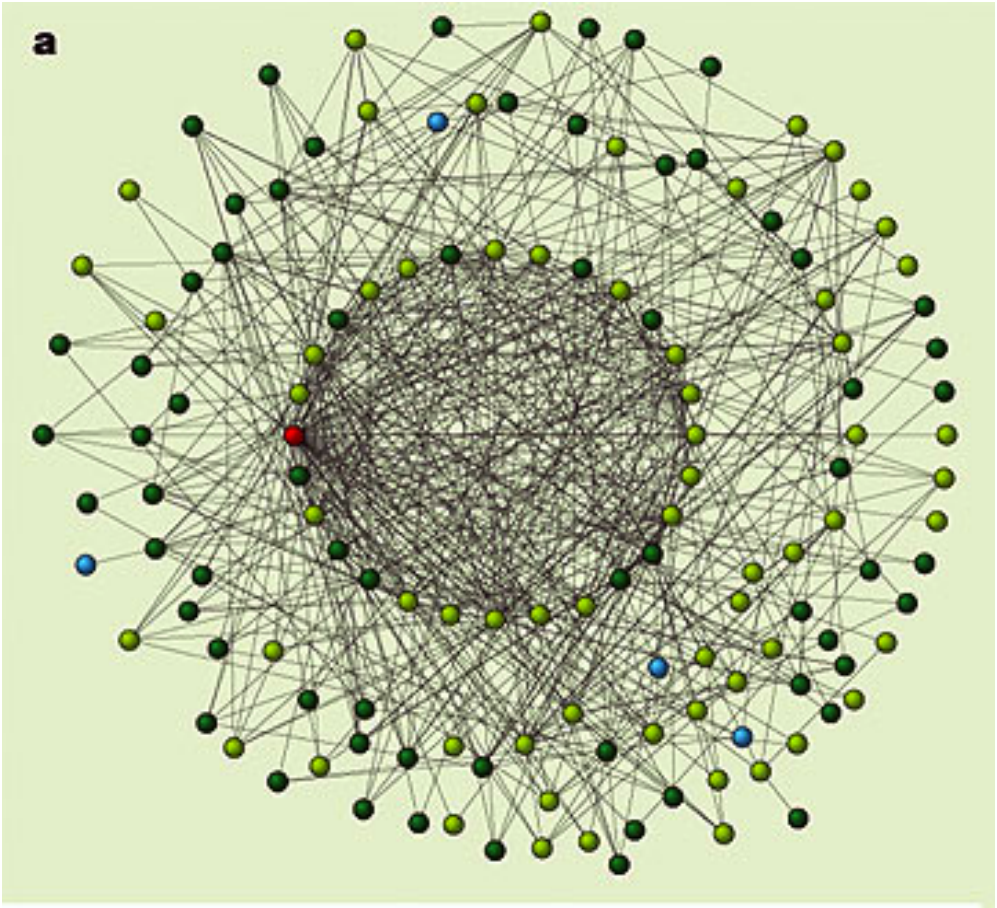
`complex systems`:

- emergent behaviour from individual interactions
- studied using network/graph theory
- patterns that provide them with stability

Ecological Networks

- interactions among species in real ecosystems (e.g. trophic, parasitic, mutualistic)
- patterns: truncated power-law, small world, connectance
- these features help study keystone species, stability, resilience...

Ecological Networks



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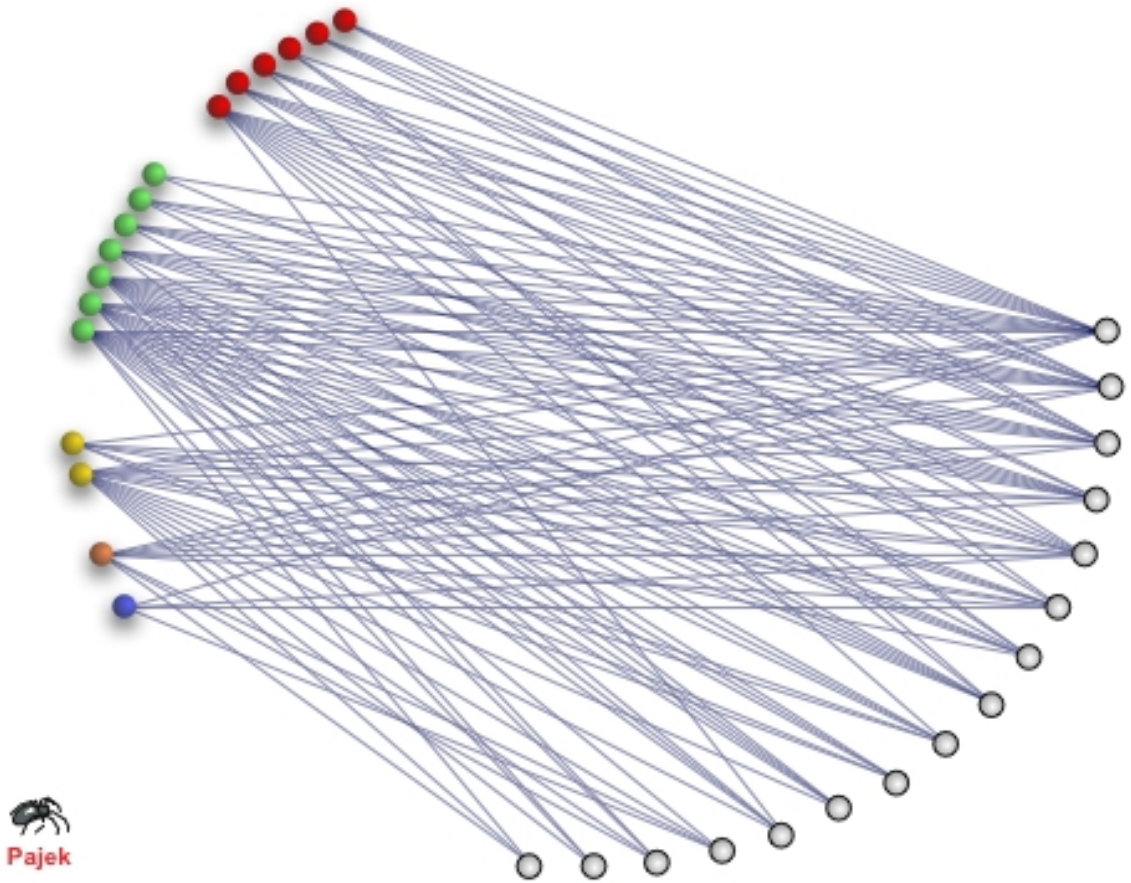
[1] figure provided by José Montoya (from J. M. Montoya, S. L. Pimm, and R. V. Solé, "Ecological networks and their fragility", *Nature*, vol. 442, July 2006.)

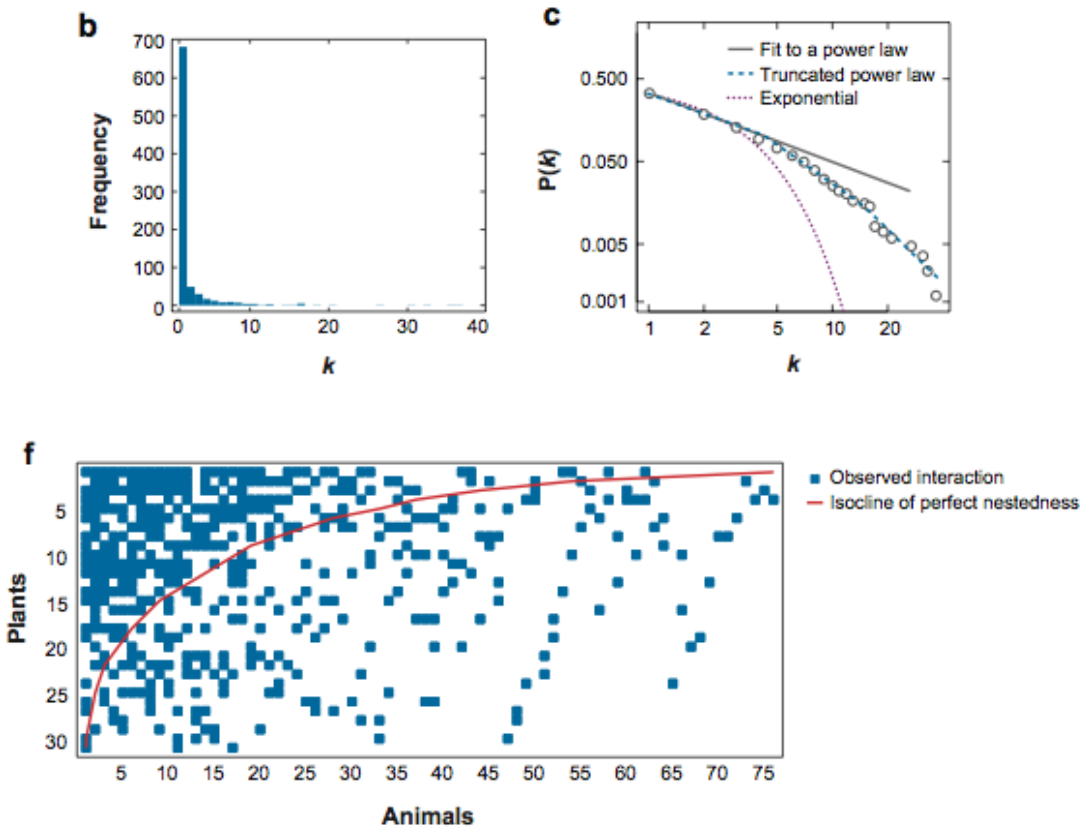
Mutualistic Networks



[2]

[2] figure provided by Pedro Jordano, Estación Biológica de Doñana, CSIC, Spain.

Mutualistic Networks - Patterns



[3]figures taken from: J. Bascompte and P. Jordano, "Plant-animal mutualistic networks: the architecture of biodiversity", *Annu. Rev. Ecol. Evol. Syst.*, vol. 38, pp. 567 - 593, December 2007.

Mutualistic Networks - Patterns

These and other characteristics are believed to be responsible for the stability, increased biodiversity, and minimised competition displayed by these kind of natural systems

Mutualistic Networks - Mechanisms

For explaining the emergence of the system level patterns that emerge in these kind of interaction networks, different mechanisms have been proposed

we are interested in:

- trait matching
- spatial distribution
- meta-communities

Agents interactions inspired by ecological relations

Goal: obtain a collection of autonomous digital entities interacting in a digital environment, closely resembling natural ecosystems:

- complexity
- self-organisation
- emergence
- coevolution
- adaptation

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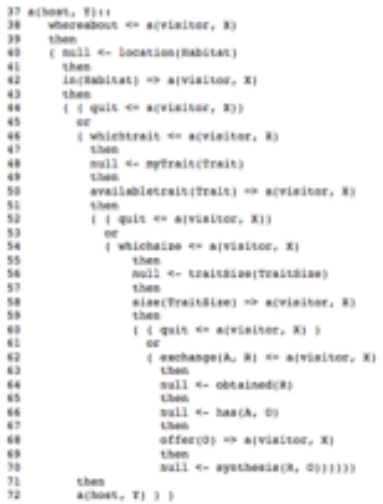
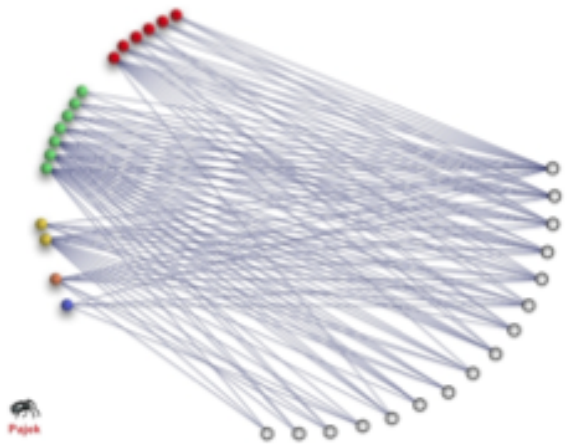
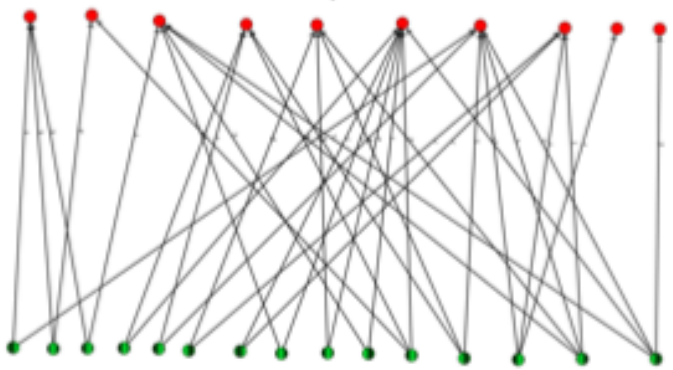
in order to facilitate collaboration (mutualism) among agents in intelligent systems, truly realising in this way the ecosystem metaphor in a digital ecosystem

Agents interactions inspired by ecological relations







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LCC and OpenKnowledge

`multi-agent based approach`:

- an interaction-centred approach for knowledge sharing

[4] David Robertson, “A lightweight coordination calculus for agent systems”, in DALT 2004

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this provides a very intuitive way of translating the descriptions of the interactions between entities in natural ecosystems, into the artificial ones

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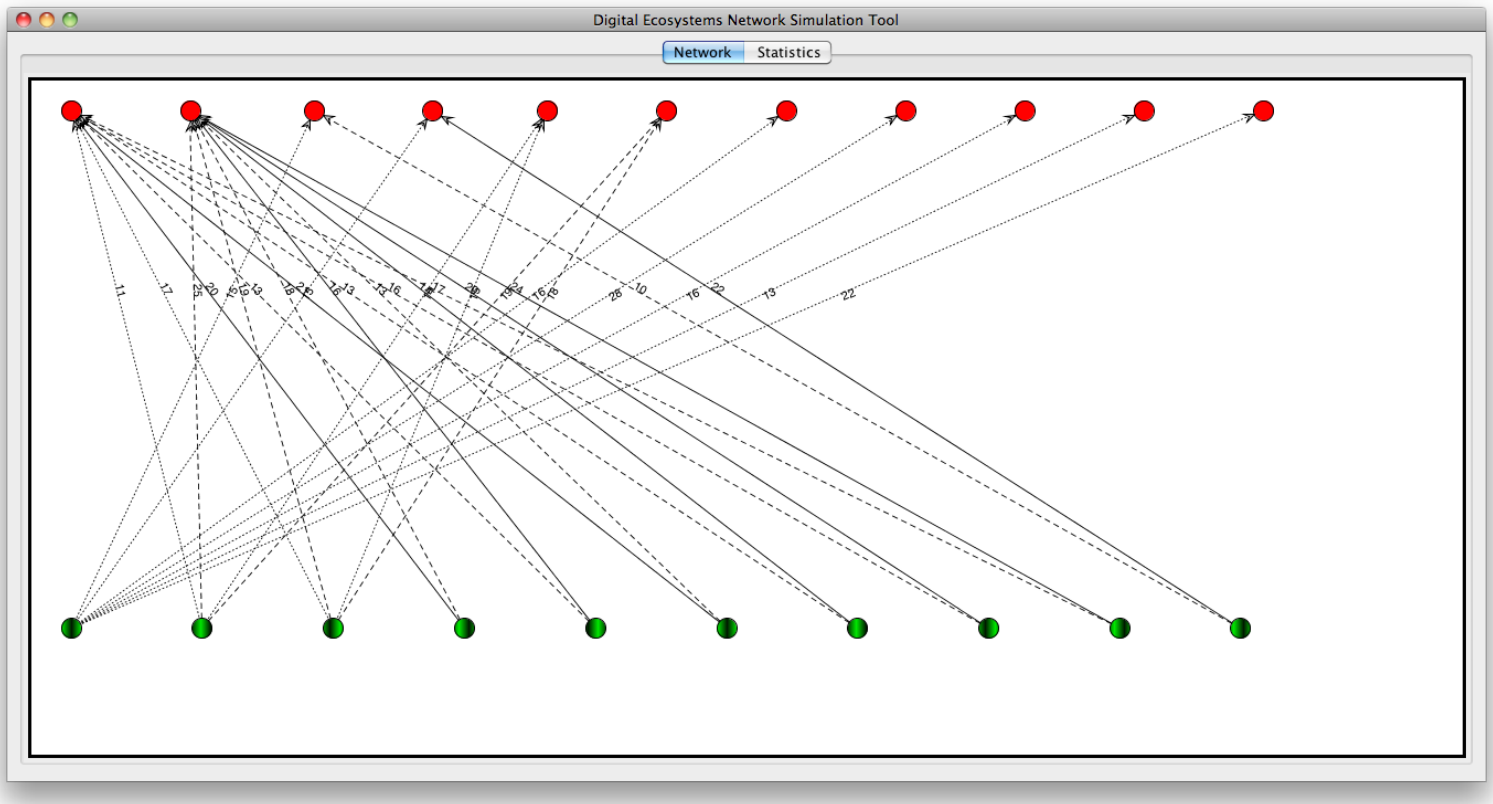
LCC and OpenKnowledge

ecological interaction protocol in LCC

```
37 a(host, Y)::
38    whereabout <= a(visitor, X)
39    then
40    ( null <- location(Habitat)
41      then
42      in(Habitat) => a(visitor, X)
43      then
44      ( ( quit <= a(visitor, X))
45        or
46        ( whichtrait <= a(visitor, X)
47          then
48          null <- myTrait(Trait)
49          then
50          availabletrait(Trait) => a(visitor, X)
51          then
52          ( ( quit <= a(visitor, X))
53            or
54            ( whichsize <= a(visitor, X)
55                then
56                null <- traitSize(TraitSize)
57                then
58                size(TraitSize) => a(visitor, X)
59                then
60                ( ( quit <= a(visitor, X) )
61                  or
62                  ( exchange(A, R) <= a(visitor, X)
63                    then
64                    null <- obtained(R)
65                    then
66                    null <- has(A, O)
67                    then
68                    offer(O) => a(visitor, X)
69                    then
70                    null <- synthesis(R, O))))))
71        then
72        a(host, Y) ) )
```

complex agent networks

network features similar to those found in mutualistic networks in real communities:



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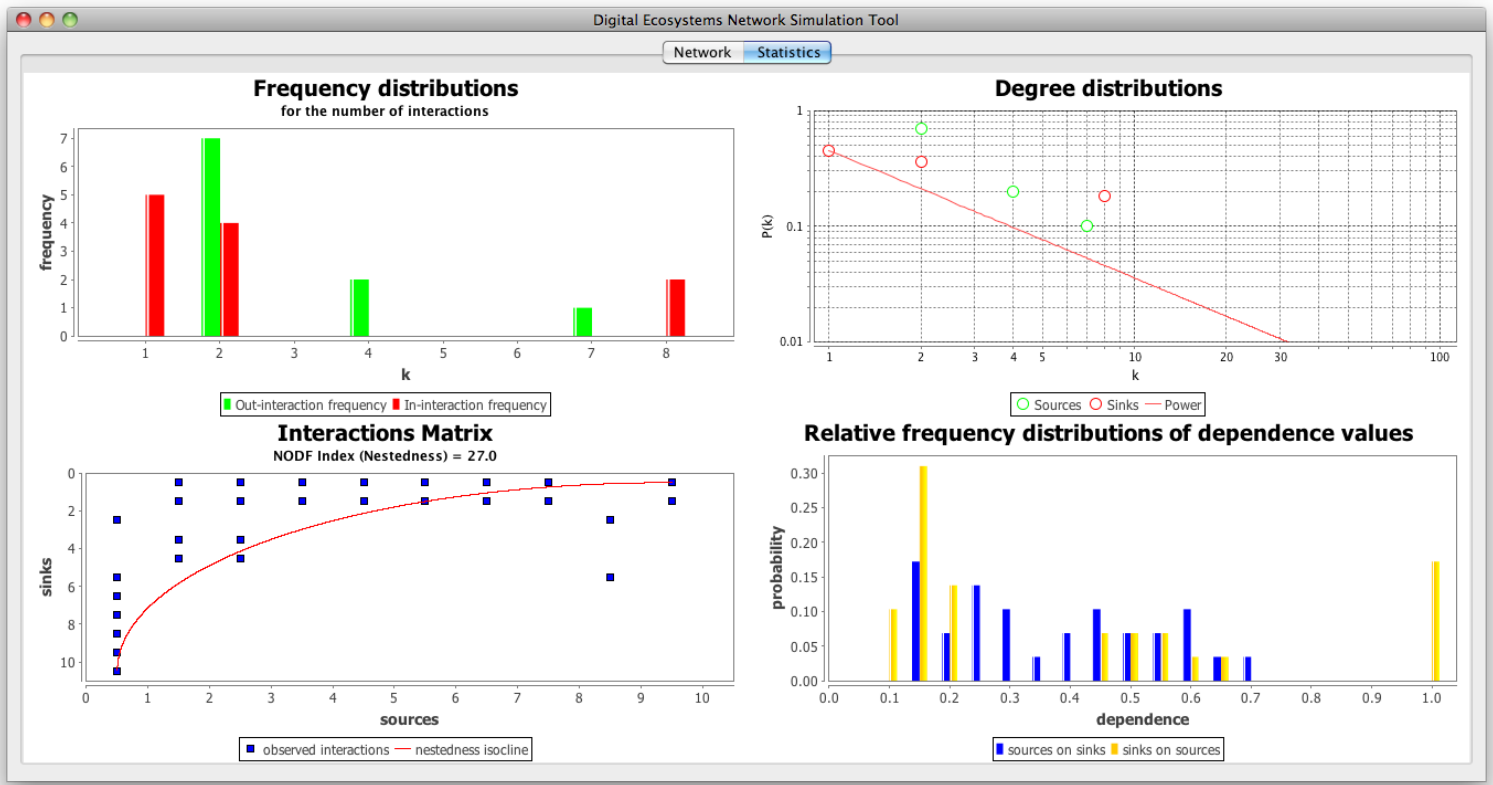

complex agent networks

We obtained networks with:

- scale-free structure: the majority of nodes have small degree ($\leq$2), while a low fraction of them are highly connected
- small-world properties: with short paths between any two nodes
- asymmetric interactions

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These patterns are important in practice because they can give us information about functional properties of the system such as: information propagation speed and resistance to node failures, which can provide us with a better understanding of the relationship between the complexity and stability of agents systems.

future work

Ecology/Intelligent Systems

- explore the usage of protocols based on other kinds of species' relationships (e.g. predatory, antagonistic, parasitism)
- further refine the interactions to include more details

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Digital Business Ecosystem

- translate the ecological concepts used for specifying the interaction protocols into the business domain
- investigate the extent to which the interactions thus specified create network of mutualistic entities in these digital environments
- evaluate the interaction networks from the business perspective