



# The BISON Project

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- Current networked information systems are fragile (not robust), rigid (not adaptive) and are notoriously difficult to configure and maintain (not self-organizing)
- Many natural (biological, social) systems are exactly the opposite — they are *robust*, *adaptive* and *self-organizing* despite being highly *decentralized*
- Can we build information systems that are more “organic” or “life-like”?
- Do this by drawing inspiration from biology



- The problem is further aggravated in modern network structures
  - Mobile ad-hoc networks (MANET)
  - Overlay Networks
    - **Peer-to-Peer systems**
    - Grid computing
- Due to their extreme size and extreme dynamism

- Funded by IST-FET under FP5
- Partners
  - University of Bologna, Italy (Coordinator)
  - Telenor Communication AS, Norway
  - Technical University of Dresden, Germany
  - IDSIA, Lugano, Switzerland
- 1 January 2003 start date, duration 36 months
- Total cost €2,251,594
- EU funding €1,128,000
- URL: <http://www.cs.unibo.it/bison>



- Complex adaptive system CAS are collections (swarm) of “agents”, acting in a decentralized and distributed fashion found in
  - Nature and biological processes
  - Social structures
  - Economies, financial markets
- Behavior of CAS is often self-organizing, adaptive and robust (“nice properties”)
- We want to implement a number of functions on a variety of network structures using ideas from CAS
- Note that we are *not* interested in modeling or developing theories for explaining particular CAS



# BISON expected results

- Decentralized, self-organizing, adaptive and robust solutions to important technological problems that arise in dynamic networks
- Systematic framework and a coherent set of heuristics to guide the synthesis of complex systems that solve interesting technological problems



# BISON biological inspirations

- Social insects, ants
- Amoebae
- Chemotaxis
- Immune system
- **Epidemics (gossip)**
- **Aggregation**
- Neurons
- Regeneration



- Routing (MANET)
- Power management (MANET)
- Load balancing
- Searching
- **Collective computation**
- Monitoring
- **Topology management**





- The set of local agents that are equals (peers) forms the “swarm”
- The agents interact (locally)
- Each individual agent has very limited intelligence (i.e., simple rules)
- But the *swarm* has a collective intelligence that can handle difficult challenges
- The intelligent behavior that the swarm exhibits (built from simple agents following simple rules) is called “emergence”



- Emergence is all around us
  - A city
  - Car traffic
  - The brain
  - The immune system
  - An ant colony
- *Emergent behavior* is collective behavior arising from the interaction of many autonomous units, where the units obey simple rules, and yet it is:
  - *Complex and interesting* (maybe even *adaptive*)
  - *Difficult to predict* from knowledge of the agents' rules



- BISON applies these ideas to large-scale, dynamic networks of computers, PDAs, phones, etc. to solve important problems such as efficient routing of traffic; load balancing; search over distributed content; distributed computation



- Biology is a rich source of inspiration for developing solutions with “nice properties” to technological problems
- To date, we have looked at five biological systems with interesting behavior:
  - Ants: path finding using pheromone, gathering
  - Slime mold amoebae: physical aggregation as a response to collective hunger, using chemotaxis
  - Immune cells: search, recognition, and response to antigens
  - **Viruses: epidemic spreading, collective computation**