COMPLEX SYSTEMS NETWORK OF EXCELLENCE

The Complex Systems Network of Excellence, EXYSTENCE, is funded by the European Commission within the Future Emerging Technologies (FET) programme of the Information Society Technologies Programme (IST) of the Fifth Framework (IST-2001-32802) to develop collaboration among European researchers interested in Complex Systems, from fundamental concepts to applications, and involving academia, business and industry. The Network started in March 2002 and is funded until September 2005.

Steering committee and administration staff: (left to right)
Enza (admin), Eve, Frank, Mario, Erik, Tiziana (admin) and Gérard.

The EXYSTENCE Steering Committee

The EXYSTENCE project is led by a Steering Committee, who are advised by the Science Board. The members and their respective areas of the project are:

▪ Erik Aurell	Project management
▪ John Casti	Focus Document
▪ Nigel Gilbert	Electronic information infrastructure
▪ Eve Mitleton-Kelly	Links with business, industry and government
▪ Mario Rasetti	Project management
▪ Frank Schweitzer	Topical Workshops
▪ Gérard Weisbuch	Thematic Institutes

Membership

There are three levels of membership in EXYSTENCE - associate and full personal memberships and institutional membership.

Associate Membership

To maintain a link with the network, you should register on the Network web site, **www.complexityscience.org**.

Full Membership

Individuals having an interest in the activities of the Network are encouraged to join as full members. Participation in any specific activity such as Thematic Institutes, Topical Workshops, Business activities, and the development of a 'Road map' of future research directions will either be by invitation or by application in response to calls for participation. Potential applicants for membership should bear in mind that a proven track record of excellence in research and/or an interest in the application of complexity principles to practice, and a proven interest in complex systems are necessary to qualify.

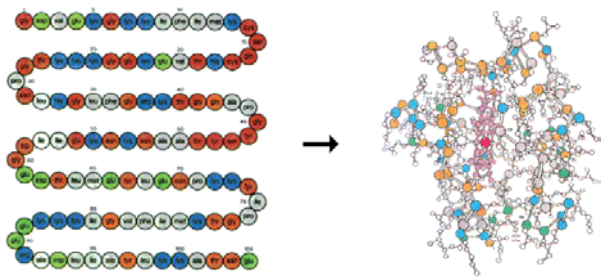
Institutional Membership

The Network also has Institutional members (academic or industrial partners). Only institutional members can enter into a contract with the Commission. The person indicated as the reference person of the institution could be selected to join the Science Board and the Institution will be eligible for being a site of EXYSTENCE activities such as workshops, seminars, etc. If your Institution is interested in joining the network, please submit an application on the form that can be found on the web site. The application will be evaluated by the Steering Committee.

Complexity: an introduction by John L Casti

Complexity as a Systems Concept

In everyday parlance the term "complex" is generally taken to mean a person or thing composed of many interacting components whose behaviour and/or structure is difficult to understand. The behaviour of national economies, the human brain and a rain forest ecosystem are all good illustrations of complex systems. These examples underscore the point that sometimes a system may be structurally complex, like a mechanical clock, but behave very simply. In fact, it's the simple, regular behaviour of a clock that allows it to serve as a timekeeping device. On the other hand, there are systems whose structure is very easy to understand but whose behaviour is impossible to predict. And, of course, some systems like the brain are complex in both structure and behaviour.



The primary and tertiary sequence of the protein cytochrome-c. The diagram illustrates the notion of a complex system, in which the local interactions among the parts gives rise to a global structure that cannot be predicted just from knowing what each part is doing.

The examples just cited show that there's nothing new about complex systems; they've been with us from the time our ancestors crawled up out of the sea. But what is new is that for perhaps the first time in history, we have the knowledge and the tools to study such systems in a controlled, repeatable, scientific fashion. So there is reason to believe that this newfound capability will eventually lead to a viable theory of such systems.

Prior to the recent arrival of cheap and powerful computing capabilities, we were hampered in our ability to study a complex system like a road-traffic network, a national economy or a supermarket chain because it was simply too expensive, impractical, too time-consuming or too dangerous to tinker with the system as a whole. Instead, we were limited to biting off bits and pieces of such processes that could be looked at in a laboratory or in some other controlled setting. But with today's computers we can build complete silicon surrogates of these systems, and use these would-be worlds as laboratories within which to look at the workings and behaviors of the complex systems of everyday life.

In coming to terms with complexity as a systems concept, we first have to realize that complexity is an inherently subjective concept; what's complex depends upon how you look. When we speak of something being complex, what we're really doing is making use of everyday language to express a feeling or impression that we dignify with the label Complex. But the meaning of something depends not only on the language in which it is expressed (i.e., the code), the medium of transmission and the message, but also on the context. In short, meaning is bound up with the whole process of communication and doesn't reside in just one or another aspect of it. As a result, the complexity of a political structure, an ecosystem or an immune system cannot be regarded as simply a property of that system taken in isolation. Rather, whatever complexity such systems have is a joint property of the system and its interaction with another system, most often an observer and/or controller...

The full version of this paper is available at **www.complexityscience.org** in the 'Focus Document' section.

EXYSTENCE activities

Links with Business, Industry, Government

EXYSTENCE will bring complex systems expertise to the world of business and policy making. Dissemination will be promoted by focussed "tutorials" and seminars (about three per year), user groups and focussed symposia (about four per year), and by collaboration with the other publishing and dissemination activities of EXYSTENCE, to which all businesses will be strongly encouraged to participate. The exchange is expected to be bi-directional: scientists will learn about concrete business and government challenges while decision makers will learn the basic methods of complexity. During the symposia, time will be devoted to case studies presented by business, industry and government.

Electronic Information Infrastructure and Information Exchange

Many of the Network's functions will be achieved through the distribution, exchange and presentation of information electronically. Some of the services offered by the website are an electronic archive of complexity related material, a members list, a jobs page, complexity related news items, papers from related projects, partner search, discussion boards, complexity links and a calendar of complexity related events.

Focus Document and Roadmap

Over its lifetime EXYSTENCE will produce and maintain a "Complexity Focus Document", primarily to serve in planning for the future. The document will contain an introduction to the science of complex systems, a summary of current complexity research activity and a discussion of the ways forward. The latter section will identify key objectives, milestones and challenges for the future across the spectrum of activities concerned with complexity, from open fundamental problems through to societal and technological goals.

Thematic Institutes

Thematic Institutes are an important part of the activities of the EXYSTENCE Network. The objective of Thematic Institutes is to get scientists of diverse background, e.g. physicists and economists, to engage in active collaboration for extended periods (from one to three months) at Thematic Institutes. These will be organised by inviting the participants to a specific location -- the host institution, not always the same, but rotating among a number of candidate places -- to work together on a specific theme in complexity. This will give the opportunity not only for intense, real, day to day collaboration between scientists from diverse disciplines (fostering interdisciplinarity), but also to start collaborations that would not have otherwise been conceivable and to exchange technical skills effectively. Co-operative interactions started at the Institute should generate long lasting collaborations to be maintained by other means, such as electronic interchange and mutual visits.

Topical Workshops

The activities of the Network also include 9-12 Topical Workshops. These workshops will cover transdisciplinary aspects of Complex Systems, in order to develop commonality of concepts and methods applicable to different fields. Topics will be proposed by the local workshop organizers, but should be not too specialized, in order to allow participation from different fields. Further, there should be some relation to the issues of information societies technology program (IST) of the EC within which the Network has been funded.

Introduction from Ralph Dum, of Future and Emerging Technologies

"Exystence has been launched by the Future and Emerging Technologies unit of the European Commission in order to help the young research area of 'complex systems' to grow into a discipline of its own merit. To achieve this goal a couple of activities are foreseen which should on the one hand enable the necessary multidisciplinary contacts between researchers in workshops and thematic institutes, and on the other hand help the discipline create its own identity via creation of a focus document outlining the main directions of research and by organising seminars for 'stakeholders' which should help the research community address a large audience interested in applying complex system thinking in areas as diverse as socio-economic systems, engineering and in particular science."

Swarm-Bots

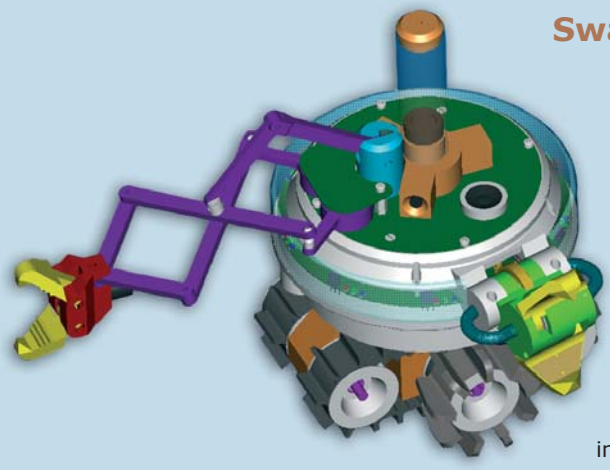
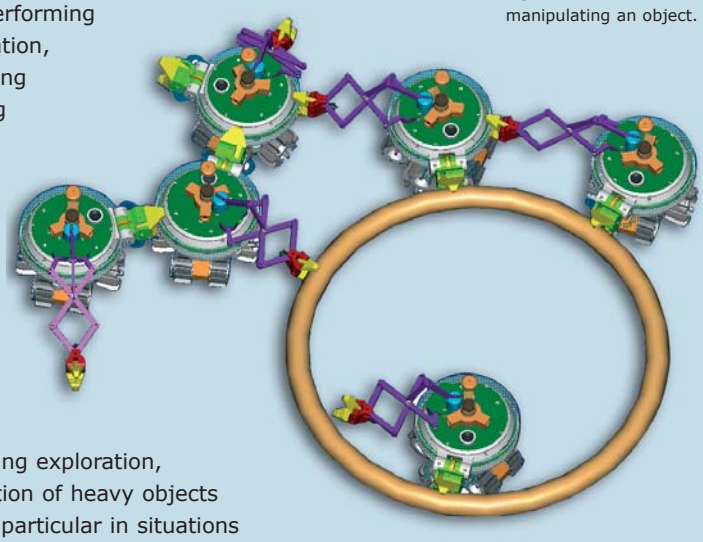


Figure 1 The S-bot concept.

SWARM-BOTS, a project funded by the Future and Emerging Technologies program of the European Community (project IST-2000-31010), focuses on the design and the implementation of self-organising and self-assembling biologically-inspired robots. The project benefits from the joint activity of four leading European research institutes: IRIDIA, the artificial intelligence lab of the University Libre de Bruxelles; IDSIA (Dalle Molle Institute of Artificial Intelligence Studies), a non-profit research institute affiliated with the University of Lugano and SUPSI; ASL, the autonomous systems lab of the Swiss Federal Institute of concept Technology in Lausanne, and ISTC-IP, the institute of cognitive sciences and technology of the Italian National Research Council.

The main scientific objective of SWARM-BOTS is the design and the realisation of robots capable of self-organisation and self-assemby. At the core of the SWARM-BOTS project is one bold idea: that one can design small mobile robots, called s-bots, that will aggregate to perform specific functions commonly shown by social insects (e.g., ants) and other animal societies. An s-bot (the concept is shown in figure 1) is a fully autonomous mobile robot capable of performing basic tasks such as navigation, perception of its surrounding environment, and grasping of objects. An s-bot can also communicate with other peer units and physically join either rigidly or flexibly to them, thus forming a swarm-bot.

Figure 2 A swarm-bot manipulating an object.



A swarm-bot is an aggregate of s-bots that is capable of performing exploration, navigation and transportation of heavy objects on very rough terrains, in particular in situations where a single s-bot has major problems in achieving the task alone (figure 2). The aggregate itself is expected to move as a whole and reconfigure along the way when needed. For example, the swarm-bot might have to adopt a different shape in order to go through a tunnel or overcome an obstacle.

Figure 3 Sketch of swarm-bot moving on a very rough terrain.

The hardware structure is combined with a distributed adaptive control architecture inspired by ant colony behaviours. Reinforcement learning and evolutionary robotics techniques will be tested in a 3D simulation environment before being transferred to the real robots.

Potential applications of this novel type of robot are, for instance, semi-automatic space exploration, search for rescue and underwater exploration (figure 3).

The first s-bot hardware prototype will be released in early 2003. Further and more detailed information on the current research activities of the project can be found at **www.swarm-bots.org.**