1. A Specialized Support Centre for the research on Complexity Science (CS-SSC)

1.1. Objective of the proposal

Interdisciplinary science has drawn an increasing amount of attention over the last two decades. Particularly with the changes in the rate and nature of data production of economic, social and biological sciences, new kinds of systems emerged. Studies on such systems evolved from early on around their common properties, their complex structure and the underlying dynamics. From such perspectives, in different research contexts complex systems are defined on the basis of their different attributes.

The aim of this proposal is the establishment of a Specialized Support Centre focusing on the ICT needs of the European research community dealing with Complexity Science, an emerging field of interdisciplinary scientific interest.

1.2. Scientific Scope

Complexity science is trying to reveal the function and behavior of complex systems in the real world. Such systems include information-technology networks, power grids, transport networks, financial markets, social systems, nervous systems etc. By using an interdisciplinary approach we try to understand the variety of different problems.

As an example consider, the spread of information and rumors across human interaction networks. Such rumors enhanced by mobile communications can escalate out of control. Knowledge of this phenomenon will prevent further incidents like the one in Hungary in June 2003, which caused nationwide panic about a nuclear explosion, which turned out to be a hoax. Understanding the relay of information through a crowd in panic will help develop more efficient evacuation methods, for instance from football crowds, earthquakes or terrorist attacks. Understanding the way epidemic spreads will yield a more effective approach into immunizing it.

In many systems complexity arises as the result of interactions between numerous individual elements, inducing collective phenomena that can spread with fortuitous or disastrous consequences, creating the so-called “extreme events”. Such events can be of human origin i.e. stock-market crashes, bridge collapses, crime waves and terrorist attacks. Even though the above events seem to be unrelated, they share many of the same characteristics and we need to understand their causes in order to be prepared for them in the design of buildings, control of land use and emergency planning. In each case, we need to know how often, where and of what magnitude any such events are likely to occur.

The behavior of networks in general, and our understanding of their topology and properties can contribute to organized search strategies, e.g. in the search for missing persons. In a random search, a new direction and distance are selected by the searcher every time the target is not found; better understanding

of the network properties will help us design more effective collective search methods.

Traffic flow is yet another example of crowd behavior where enhancing flow is important. If a large number of drivers are heading in the same direction, their choice of route will be influenced by the same information originating from their observations and traffic reports. If in such a system collective behavior emerges, it will make the bottlenecks even worse. Controlling such phenomena will contribute to more effective distribution of resources, such as of food supplies and medical aid, in crisis situations.

One area where there is a necessity to minimize specific flow paths, is the area of epidemics. The epidemic spread of disease is almost inevitable if individuals are immunized randomly, but if the most-connected individuals are targeted, immunization is much more effective. However one big problem is that these key individuals are very hard to identify. Similar problems apply to virus spreading over communication networks where such identification is more easily achieved. Yet, the search for even more efficient algorithms that will prevent widely spread viruses (i.e. Conflicker infected around 15 million Microsoft server systems in November 21, 2008), is continuous.

In communication systems priority strategies can be needed in cases of limited bandwidth or abnormally high temporal flow. Such events might occur during holiday times (i.e. year changing hours) in sms messages, breakdowns of main communication lines and use of smaller backup ones in data transmission, as well as viruses or multimedia applications transmitting large volumes of data over limited bandwidth. By applying a priority in the propagation of certain types of information it is possible to preserve a significant portion of the bandwidth for the high priority information. It is important to find the optimal scenario for each system, thus allowing for a quality of service.

In economic systems, the primary function of financial markets is to bear risk, enabling the transfer of resources from suppliers of liquidity to entrepreneurs and risk-takers. However, collective behavior that is shown by adaptation to market changes, and in extreme cases to response to unexpected events, is leading to changes in stock prices and even public hysteria. Such responses depend on the structures underlying information flow. Better understanding of the behavior of this information flow would inform market regulatory policies.

Predominantly the work carried out by the Complexity Science SSC will be support for the production exploitation of European Distributed Computing Infrastructures focusing primarily on the EGI Infrastructure. A roadmap for the continued presence of the Complex Science community within EGI even after the Project timeline will be put in place and activated through the SSC Project.

1.3. Aims and Expected results

The overall scope of the Complex Science SSC is to strengthen the multi disciplinary collaboration of the European research community of Complex Science through the creation and deployment of services and tools which will be build mainly upon the EGI Infrastructure with the aim of both facilitating new

research groups joining the community and increasing the research capacities and capabilities.

In specific we plan to,

i. further increase the usage of Grid technology by porting more applications and by introducing more users through seminars, workshops and personal contact.
ii. develop basic Grid usage tools that will help us:

    - introduce new immunization methods to improve our existing immunization strategies.
    - study the optimal path length, under different conditions, to further improve global transport.
    - optimize search in networks by exploiting the properties of the shortest paths.
    - suggest and explore different mechanisms for the evolution of networks to be scale-free, which is important since the reason, or incentive, for so many networks in nature to grow to be scale-free is not fully understood yet.
    - study the mechanisms governing the formation and evolution of social networks.
    - study economic and financial networks with methodologies based on the estimation of the cross-correlation matrix obtained from the return time series of pairs of stocks.
    - study communication networks like the Internet and the World Wide Web.

iii. develop and deploy a Web portal for the registration of new users and the support of existing ones through the implementation of a wiki interface
iv. build a data repository containing scientific data and code samples specific to the SSC needs deploying the AMGA metadata service
v. build parallel (based on MPI) and hybrid (based on MPI and openMP) versions of basic algorithms which will help us optimize the usage of the EGI DCI.

1.4. Consortium

The Organizations involved in the Complex Science SSC include AUTH (Aristotle University of Thessaloniki, Greece) as project coordinator and BIU (Bar-Ilan University, Israel), UNIPA (Università Degli Studi Di Palermo, Italy), JLUG (Justus Liebig University, Germany) and UA (University of Aveiro, Portugal) as project partners.

1.5. Background

All participating groups are active in the field of complex networks during the last years, with important contributions. The AUTH Computational Physics group has an expertise in large scale simulations of complex systems such as disordered lattices, fractals, random walks, neural networks and different structures of other networks, such as random and scale-free networks. The

group emphasizes the use of numerical methods and computer experiments to study the topological properties of complex systems as well as the dynamical/kinetic processes that take place on such systems, e.g. diffusion, spreading phenomena, propagation of information or epidemics and other types of transport phenomena on heterogeneous structures. The group has extensive experience in algorithm parallelization, and grid computing and in applying modern methods of Statistical Physics, such as scaling theory and Monte Carlo techniques, to problems on complex structures, commonly encountered in Solid State Physics.

The BIU group is one of the leading groups in the field of complex systems, with emphasis in mathematical modeling and analytical solutions. This group pioneered many fundamental results in transport in disordered systems, in long term memory in biological and climate systems. In the last ten years the group is a leading international figure in topology, stability and immunization of complex networks.

The UNIPA hosts the Observatory of Complex Systems (OCS), which is a research group of the Dipartimento di Fisica e Tecnologie Relative of Palermo University. The OCS is one of the leading teams focused on the application of methods of statistical physics to physical, social and biological complex systems. The research activity of OCS deals with empirical characterization and theoretical modeling of stylized facts in social systems. In the field of econophysics OCS research activity includes topics such as (ii) correlation based networks in social systems, (ii) microstrucure and order book dynamics in competitive markets, and (iii) dynamics of the firm growth rate.

The Institut fur Theoretische Physik III which is part of the Justus-Liebig University in Giessen (JLUG) is one of the leading groups in Germany in Statistical Physics and its interdisciplinary applications in materials science, geoscience, and physiology.

The University of Aveiro (UA) group has been very active in the field of evolving complex networks with some of the leading scientists on this hot field, contributing to important exact results, namely the exact solution of the BA model. This, among other results were given in a series of more than 50 papers in the last 8 years published in the top refereed journals, including a reference, two review articles which is strongly quoted, and the first scientific book in the topic.

With respect to its Grid related operations AUTH has been operating two clusters (GR-01-AUTH and HG-03-AUTH) that are part of the HellasGrid Infrastructure. As members of the HellasGrid NGI and the SEE ROC, we have been operating a great number of core Grid services such as the HellasGrid CA, SEE-GRID CA, VOMS, MyProxy, WMS, Hydra, Top BDII, LFC and the regional and national Site Monitoring Services.

AUTH has been operating a regional help-desk since early 2006 focusing on providing effective solutions to daily user problems and challenges. Moreover, AUTH has been offering application support services to the University's research

communities making Grid technology easily accessible and manageable. Internally AUTH hosts regular Grid tutorials and training events. Based on our extensive experience in developing, running and porting to the Grid infrastructure both MPI and OpenMP applications we believe that we can provide essential services to the wider SSC community.

1.6. Governance model

The SSC user community will be the primary driving force in the course of the SSC as most of the work invested will be focused on serving it needs and on laying down and creating the basis of a sustainability plan.

It is foreseen to have a Steering Committee (SC) composed by one representative for each NGI that supports the SSC. A SC chair will be nominated within the SC. Technical SSC bodies such as a User Technical Support (UTS) and a Front Desk will also be formed in the context of the SSC.

Stakeholders of the SSC project are currently identified as the

a. Project coordinator and partners
b. Users who will benefit from the SSC
c. Owners of SSC resources
d. Funding sources
e. EGI.org and NGIs

1.7. Legitimacy

At this point it is expected that all identified partners will contact and get the endorsement of their local NGIs and their local research community unless they have already done so already. Discussions of signing a multilateral agreement in the form of a MoU as a project milestone have, in addition, begun.

The MoU under discussion will clearly define a procedure for both the addition and removal of partners. Partners wishing to join the SSC Project will have to coordinate their efforts with the governing parties and stakeholders prior to their admission. Upon joining the SSC Project they will have to sign the MoU in coordination with their corresponding NGI.

With respect to EGI policies the SSC will explicitly adhere to them and participate through its Steering Committee in their future evolution contributing as a vital part of the overall EGI.

1.8. Work Plan and Budget

A summary of activities and a short description thereof is given in the following table.

Activity	Description
SSC Coordination (1FTE)	Coordinate activities within the SSC to ensure that Project aims are met.
Training and Dissemination Plan (2FTE)	Expand the usage statistics of the EGI Infrastructure within the Complex Science user community through the

	arrangement of training events and the dissemination of services and success stories.
Web portal development and deployment (2FTE)	Develop a single point of entry for EGI Infrastructure users stemming from the field of the Complex Science community exposing the procedures, tools and services supported by the SSC.
Front desk (1FTE)	Provide First Line Support to Complex Science community users and interface with GGUS service
Scientific database design and deployment (2FTE)	Create a database of scientific data with specific levels of accessibility and support for metadata using the AMGA tool
Grid applications development and porting (2FTE)	Develop Grid workflows that can leverage also existing applications as well as parallel algorithms in order to optimize Grid usage

1.9. Computing and Data resources

The Project partners and the NGIs will provide the computational and storage resources required for the scientific missions of the SSC. The Project partners will in addition provide the scientific data and the collaborative resources needed in the context of the SSC Project.

1.10. Sustainability Plan

The SSC will interact with EGI during the course of its lifetime in order to consolidate the presence of the Complexity Science community within this body. It will also expand in time by involving Complex Science groups of all NGIs within EGI. Consequently, all NGIs will have representation within the SSC Steering Committee.