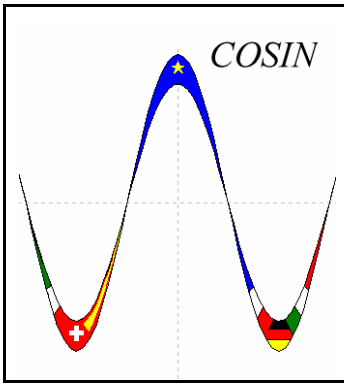


COSIN

IST–2001-33555

Coevolution and Self-Organization in Dynamical Networks

http://www.cosin.org

Periodic Progress Report

Covering period 1.3.2004-31.8.2005

Report Version: 1

Report Preparation Date: 15 August 2005

Classification: Public

Contract Start Date: 1 March 2002 Duration: 42 Months

Project Co-ordinator: Guido Caldarelli (INFM) *Guido.Caldarelli@roma1.infn.it*

Partners:

CO1 (INFM) INFM *Italy*

CR2 (UDRLS) Università "La Sapienza" *Italy*,

CR3 (UB) Universitat de Barcelona *Spain*

CR5 (ENS) École Normale Supérieure, Paris *France*

CR7 (UNIKARL) Universität Karlsruhe *Germany*

CR8 (UPSUD) Université de Paris Sud *France*

CR9 (EPFL) École Polytechnique Federale de Lausanne *Switzerland*

Project funded by the European Community under the "Information Society Technologies" Programme (1998-2002)

Table of Contents

1. EXECUTIVE SUMMARY

In this latest period of the project we worked to deliver the main objectives of COSIN, that is to say to provide a better description and an analysis of the Internet and WWW by means of a multidisciplinary approach that could represent a part of the new science of Complexity.

This objective is of course very ambitious and requires a very long work, still we believe to have set up a series of important milestones (see final report for a detailed description). Please also note that very likely we can expect other refinements to come during the development of other European projects (namely DELIS that in the words of 2 years reviewers is in large part the continuation of COSIN).

From the theoretical point of view of modelling, it is now clear from the various publication of the consortium that the statistical properties of the technological graph analysed cannot be fully explained by a simple and unique mechanisms. Rather, different rules as that of the preferential attachment, the global minimisation of cost functions or quality of the vertices shape the network and form the peculiar distributions of degree, clustering coefficient and correlations between vertices. In the specific case of the WWW the "quality" of a vertex is possibly a vectorial quantity reflecting the fact that contents of a Web page can be very different. In this way one deals with a multi-layer description of the system that seems to reproduce most of the properties of the network.

From the point of view of data analysis and collection we already discussed in the last report that the claim of being able to collect a snapshot of the Web was too strong for the potentiality of the consortium so that we decided to start a collaboration with external institution in order to be able to have sensible subgraphs of the Web. During this year, the Consortium was involved with the Centro Studi e Ricerche Enrico Fermi in Rome and the Department of Computer Science in Milan to obtain respectively a thematic subset and geographical subsets. New data sets expecially biologically and social have been added to the site.

From the point of view of visualisation tools we addressed the suggestions of the last report, and we tried to obtain a device that was suitable for the visualization of large systems. We tried to overcome the problem by means of two different strategies. The first traditional one, wants to preserve all the information of the graph, trying to rearrange in a suitable way the edges. On this strategy we can present some new results obtained by the group of Karlsruhe (CR7 UNIKARL). Alternatively, one can reduce the requirements and accept to loose some information by deleting "less important" edges. On this idea collaborating with CR7 UNIKARL, both coordinating node C01 INFM and CR8 UPSUD realised different "simplification" procedures.

Finally, as regard analysing tools, we also prepared a code that has already been downloaded and used by different people at least in the statistical physics community. A common problem in this area is that to create different instance of networks with specified characteristics in order to test model and ideas. The code put on the site, works under Linux with the use of specific libraries that can downloaded as well from the site and produces random graphs, scale-free networks, small world networks of desired size, visualize them and produce the plot of degree, clustering and correlation distributions.

As also explained in the section related to the world wide state of the art we are now witnessing a progressive expansion of the scale-free network studies to the areas of Biology, Social Science and Economics. While specific deliverables in these areas have not been presented (also because they are of rather poor interest for the information technology) nevertheless their importance in the building of a Complexity Science cannot be underestimated. As scientists interested in Complexity, almost all the participants to COSIN devoted a little part of their efforts in this new directions that probably will represent one possible future of this multidisciplinary field. This kind of activity is for the above reasons the one that gives more visibility to Consortium (publications on Nature and PNAS) and attracted a new series of scientist (Biologists or Economists) to crawl the project site, and to download the data and the analytical and visualization tools in order to test these new ideas.

2. WORK PROGRESS OVERVIEW

2.1 SPECIFIC OBJECTIVES MET IN THE PERIOD

As regards the objective

"efficient visualizing methods for [..] large networks" we tried to follow the reviewers suggestion to have such instrument well in advance the end of the project. We came up with three different possibilities that are already usable and will be probably refined during the activity in the European project DELIS.

- One form of clustering and grouping are nested decompositions, i.e., sequences of subsets, where every subset contains all following ones. They are a commonly used tool to model hierarchical structures and express structural importance or core-periphery compositions. Unfortunately, in most real networks, this kind of information is only implicitly given. Since manually classifying the elements of these instances is not possible, one needs to find proper graph-theoretic decompositions that approximate or synthesize the original information. Such an instance is the physical Internet at the Autonomous System level. ASes can be roughly classified into: backbone, national, regional, and local providers as well as customers. Node CR7 UNIKARL verified that this structure is well related to an already known and efficiently computable decomposition called k-cores (see below). Based on this decomposition, it has been established one of the first non-trivial and readable drawings for the AS graph that showed all nodes and edges.

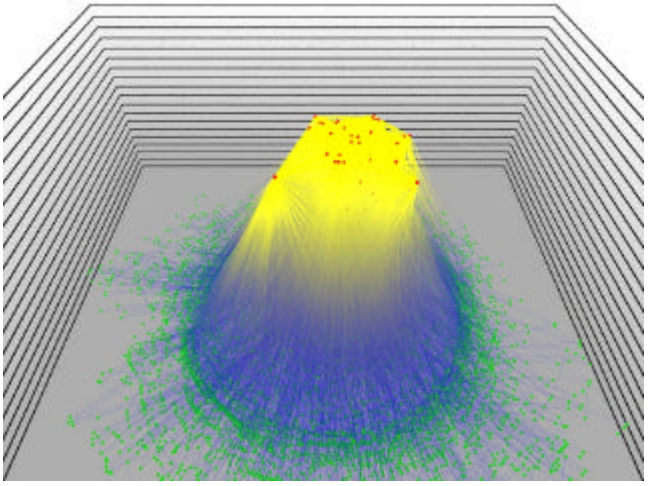


***Figure** Hierarchical visualization of the Autonomous System network in 2.5D*

- An alternative way is made by considering a k-core decomposition. This decomposition, based on a recursive pruning of the least connected vertices, allows to disentangle the hierarchical structure of networks by progressively focusing on their central cores. By using this strategy we develop a general visualization algorithm that can be used to compare the structure of various networks and highlight their hierarchical structure. The low computational complexity of the algorithm O(n), where n is the size of the network, makes it suitable for the visualization of very large networks. We apply the proposed visualization tool to several real and synthetic graphs, showing its utility in finding specific structural fingerprints of computer generated and real world networks. layout several topological and hierarchical properties of large scale networks. The k-core decomposition consists in identifying particular subsets of the graph, called k-cores, each one obtained by recursively removing all the vertices of degree smaller than k, until the degree of all remaining vertices is larger than or equal to k. Larger values of core-ness clearly correspond to vertices with larger degree and more central position in the network's structure. When applied to the graphical analysis of real and computer-generated networks, this visualization tool allows the identification of networks' fingerprints, according to properties such as hierarchical arrangement, degree correlations and centrality, etc

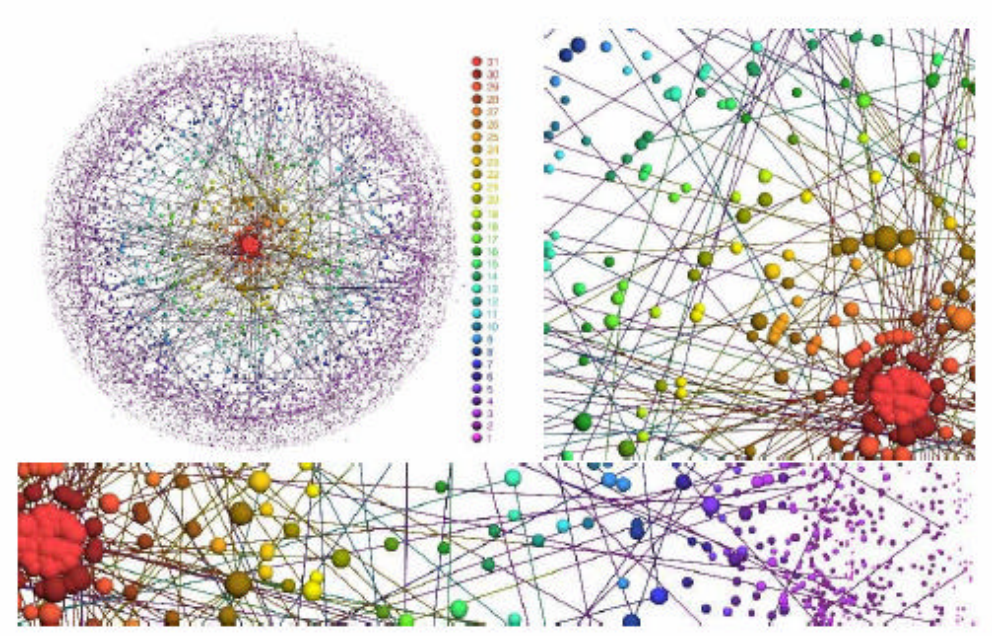


Figure *A k-core decomposition representing the AS system, after Ref[1].*

- Another possibility is that to decompose the graph in order to keep only the "relevant" edges as defined by a centrality measure as that of the betweenness. The procedure works as in the case of the Renormalization Group in physics alternating the two process of *decimation* where the edges are removed according to their value of betweenness (low value means deletion) and *rescaling*, that is to say a new computation of the various betweennesses in order to have a ``Rescaled Graph''. From analytical computation and computer simulation this method seem to preserve the main statistical properties of graphs, as degree distribution, clustering coefficient and correlation. The practical drawback is the rescaling procedure where for large graphs we cannot repeat the computation at every time step. In all the cases of interest it seems from preliminary analysis that this condition of rescaling can be relaxed allowing to re-compute this quantity only after a certain number of steps.

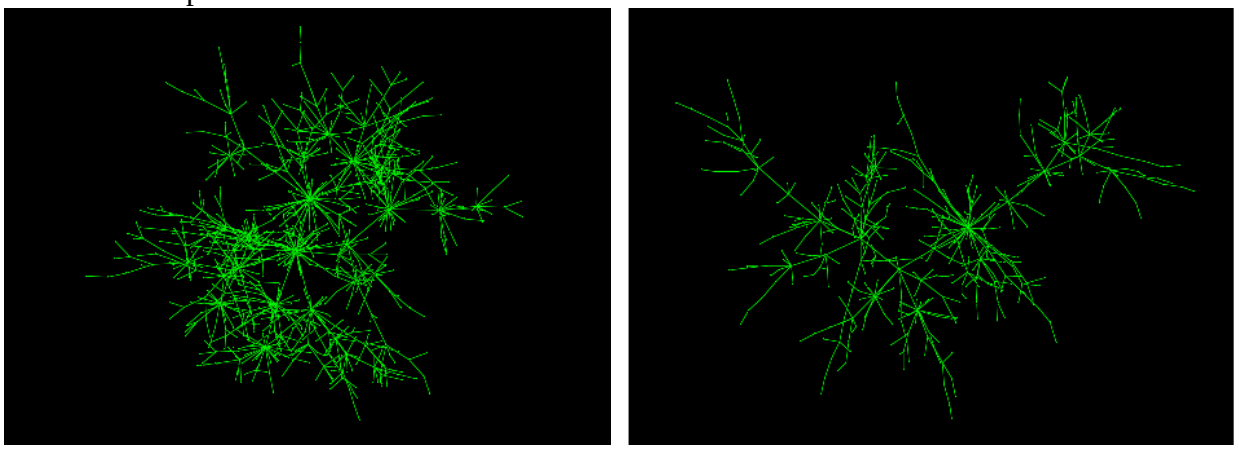


Figure: *A network of 3000 vertices reduced to 500 vertices, by means of betweenness decimation and rescaling. Networks, rescaling and Images are obtained by NetIni code produced by COSIN. Algorithm is described in this report and is presented in Ref [2]*

On the other hand we also tried to arrive to a final version of the Web site, shaped in such a way to be as friendly as possible, but still full of the information required.
The activity on the WWW site was headed mainly to

- Introduce and comment new data (biological networks and crawls of the WWW)
- Comment and make available a program NetIni for the realization of graphs with desired properties
- Present the various publications of the consortium

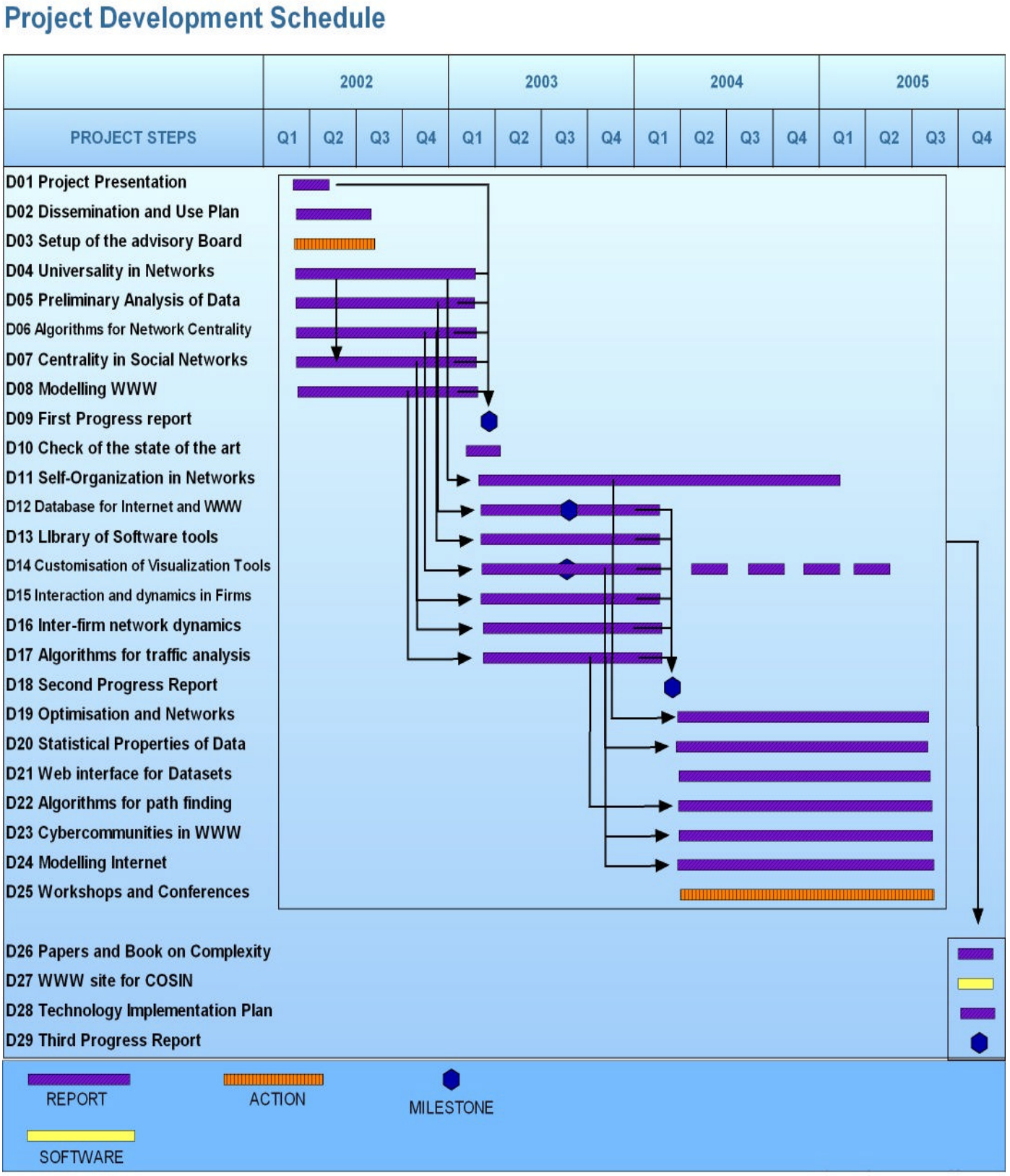
- Advertise conference and positions mainly for the students community.

Finally we tried to contribute to the formation of a *complexity* community by the publication of a book with the basic methodologies used in the project. The summary of such a book in press on World Scientific is the following

- BASIC GRAPH THEORY (*G. Caldarelli and A. Vespignani*)
- ELEMENTARY STATISTICAL MODELS (*P. De Los Rios*)
- WEIGHTED NETWORKS (*A. Barrat, M. Barthelemy, A.Vespignani*)
- COMMUNITY DETECTION (*L. Danon, J. Dutch, A. Arenas. A. Diaz-Guilera*)
- STUDY OF THE INTERNET (*R. Pastor-Satorras, A. Vespignani*)
- STUDY OF THE WWW (*D. Donato, L. Laura, S. Millozzi, S. Leonardi*)
- ECOLOGICAL NETWORKS (*G. Caldarelli, C. Caretta-Cartozo, D. Garlaschelli*)
- FINANCIAL NETWORKS (*S. Battiston, G. Caldarelli, M. Catanzaro*)

2.2 PROGRESS IN THE PERIOD

Updated GANNT chart



SHORT DESCRIPTION OF DELIVERABLES

OLD ONES DUE THIS PERIOD

- **D11 Self-organisation in Networks (WP1).**

Complex network found in nature and society show lack of characteristic scales and have grown following rules that depend on the behavior of single nodes, not on the whole structure of the network. This is what makes many complex networks to be viewed as self-organized critical systems. These aspects are made evident usually in the form of power-law distributions of node connectivities; however, some other properties, as the size distribution of community sizes, have become quite important. On the other hand, simple self-organizing network models that can explain the characteristics of observed data are still necessary. This is in fact the goal of two of the works conducted by the consortium: one is a model of the evolution of the Internet at the Autonomous System level based on competition and adaptation; and the second one is a model of signalling networks for which the complex pattern of connexions is an essential ingredient for the emergence of complex dynamics. Finally, we have also focused on the self-organization of node properties keeping fixed the topology of the network, related to well-known models of neural networks.

- **D14 Customisation of visualization tools for large networks (WP3).**

The ability of drawing very large networks as e.g. large computer networks is of great significance in visualizing the evolution of stochastic models for evolving networks. One focuses on designing and implementing new algorithms and innovative software systems that display a large graph at different abstraction levels. For example, there is an increasing need of systems that show maps of the Web and support the user during her navigation, of systems that display and monitor the traffic on the Internet, and of systems that draw portions of the Internet as a graph. Until now, the vast majority of graph drawing algorithms that have been deeply studied and experimentally tested in the literature, like for instance for database schemes, can effciently handle graphs of only hundreds of vertices. We aim at devising general algorithmic techniques for drawing large graphs and at experimenting their usage in new visualization systems, thus contributing to devising the technology transfer from the algorithmic research on graph drawing to its application in networks visualization. As part of this goal, we developed analysis-enhancing layouts and created in a cooperation with CR8 Universit´e de Paris Sud a novel technique that preserves the readability of abstract visualizations while showing all elements. On a different level we also report the activity that has been done in collaboration with Universite de Paris Sud and C01 Istituto Nazionale Fisica per la Materia in Rome. In the first case through k-core decomposition we can significantly reduce the complexity of the graph, still preserving some information. In the latter case the reduction is made by selecting the vertices to preserve according to their betweennes value.

- **D16 Self-organisation in Networks (WP1).**

For this deliverable node CR5 (ENS, Paris), responsible for WP4, has worked in close collaboration with C01 (Rome) and CR3(Barcelona) focusing on the study of two kinds of firm networks: the network of corporate boards and directors and the network of firm ownership in the stock market during years during the first two years of the contract(2003-2004). The first network is involved in strategic decision making while the second one concerns the capital control structure. We have worked both at the level of characterizing the topological properties of such networks and at the level of developing models of dynamical processes taking place on them. The structure of corporate board network has also an impact on the internal dynamics within ¯rms, a topic which belongs to deliverable D15. For the convenience of the reader the description of this topic in D15 and D16 have some overlap.
Other eralier directions of research developed by node CR5 in deliverable D16 include exploring the effect of network externality in a simple monopolistic market model and the dynamics of continuous opinion propagation in networks of economic agents. We have been able more recently (2005) to study avalanches of failures and bankrupcies in firms credit and production networks.

- **D17 Algorithms for Network Traffic Analysis (WP3).**

As routing in the Internet follows a hierarchical scheme, the analysis of the Autonomous System graph, where routing is determined at the higher level, is the first step towards the study of traffic flows, routing changes, and routing instabilities occurring in the Internet. In order to consolidate the theoretical foundations

of such studies, we first address the problem of obtaining correct data from the available data sources. Second, we investigate the problem of computing the types of the relationships between Autonomous Systems (ASes), showing the NP-hardness of the problem and producing effective and efficient heuristics to approach it. Finally, we study how clustering techniques can be adapted and improved in order to be used in this domain and show how the clustered view of the AS graph can provide high level information about the network evolution at different time scales.

- **D19 Optimisation and Network Shaping (WP1).**

The macroscopic state is an emergent property of the non-lineal interaction between the units that form the system; in our case the network is characterized by some macroscopic observables: degree distributions, different sorts of measures of cycles, community distribution, and so on. Nevertheless, for some cases it is possible to design the proper structure of the network with some purpose, being this purpose local at the node scale or global at the network scale. Along the project we have considered some dynamical properties of networks and have found the structures for which these properties are optimized. One of them is a problem of information flow and the other is related to synchronization. On the other hand, we have also tackled the issue of constructing networks according to some topological characteristics.

- **D20 Statistical Properties of Collected data (WP 2)**

Within COSIN we have analysed datasets not only for Internet and WWW but also dataset describing networks in biology, social and financial systems. The twofold goal was to provide a benchmark for the modelling community (and for Deliverable D24), and to find hints of the *first principles* that govern the formation and evolution of large complex networks. Our results, from a general perspective, show that current models fall short of providing satisfactory descriptions of any real system. Topology based models will have, in the near future, be modified to take into account the dynamics of the systems that are described using the network framework. As for example in the case of the AS graphs of the Internet we have that while it is in principle possible to reproduce the degree distribution, no model reproduces the correlation of the degree between neighbouring vertices, nor the cycle distribution.
Actually, as new scientific result (currently under debate), the exploration of the Internet, based mainly on the *traceroute* command, can be biased toward scale-free networks even if the underlying network is not scale free. If this is confirmed this could be rather worrying result, since also the project was involved in traceroute collections. Certainly we will have some results in the next future by the member of the consortium that are actively working on this topic.
The situation is even worst for financial data. these findings suggest on the one hand that many economic mathematical models currently widely used rest on wrong assumptions, and that a greater effort should be made toward a more realistic description of stock markets; on the other hand the structure of the shareholding and directors boards networks suggest the presence of different socio-economical mechanisms behind the US and Italian stock markets.

- **D21-D27 Web Interface for data set and Project site (WP 2 –WP 6)**

The database of collected data by COSIN is divided in several sections. For the Internet section we collected traceroute data (2001-2002) and ping data (2001-2004), the data available can be considered a snapshot of a part of the Internet. For the World-Wide Web section we searched and analyzed more than 300000 web pages, looking for the URLs they contained and detecting communities. We have included in the Protein Network section the first protein network data taken from the Database of Interacting Proteins. In the database are also available a series of miscellaneous data related to Food Webs, Social Networks and U.S. Patents. After our analysis we are about to make available also the data we collected on ownership network

Our future action during the third year will be to have, alongside the “data” database, a “link” database: an annotated repository of links to sites that provide high quality data about various kinds of networks. On the other hand we are also collecting sensible subsets of the WWW to be put in a downloadable form on the website. At the moment we have collected some thematic subsets by looking at all the pages related to a certain topic. We hope to be in condition (by collaboration with provider companies) at the end of the project to present also subset of the WWW as seen by single providers.

- **D22 Algorithms for path finding (WP 3)**

Geographical information plays an important role in the physical representation of the Net as well as for algorithmic problems like finding paths and connections. For query intensive applications like web searching one can benefit from geographical information. Users in such a scenario continuously enter their requests and the main goal is to reduce the (average) response time for answering a query. The algorithmic core problem that underlies the above applications is a special case of the single source shortest path problem and the method of choice is Dijkstra's algorithm. The first phase of this deliverable was devoted to studying the algorithmic issues of shortest paths computation in large networks. Techniques from route planning systems, spatial databases and web searching were considered with respect to their general applicability. In a second phase, graph layout techniques as those considered for network visualization for deliverable 14 are explored with respect to the applicability to replace geographical information. That way techniques to speed-up shortest paths computation, e.g. Dijkstra's algorithm could be successfully established for the graph of autonomous systems in the Internet.

- **D23 Cyber communities in the WWW (WP 4)**

. The first analysis that has been done is based on the state of the art analysis that has been done by Broder et al. In their work they analyse some statistical distributions of the whole system at the time. By analysing an even lager crawl (since the system has grown) are able to retrieve some of the original results and to propose a description of the system alternative to that of the bowtie. Through the new description, some interesting properties as the relative self-similarity of the web become clearer. In order to proceed further in the analysis of the communities of the webgraph we present some preliminary results obtained from geographical data sets (obtained outside the consortium) and thematic datasets collected within the project. Since the complete analysis of both is rather time consuming the results of these studies will be very likely presented in forthcoming projects (namely DELIS).

- **D24 Modelling Internet (WP 5)**

Finding a model that could reliably describe the Internet's structure and the principles shaping it would be a precious result, since it would open the possibility to play with the Internet, to see the effects of different kind of perturbations and, ultimately, to try designing a better network. Yet, this task is hindered by our ignorance of the microscopic mechanisms at work in shaping the Internet's structure. We would like to aim for a *first principles* description of the Internet, but probably a more successful approach is to use the analysis of Internet data as a benchmark against which any model that is proposed has to be tested. This has been our approach in this deliverable, and we have found that a purely topological description is very likely insufficient to describe the Internet, and that some further, finer level of details, capturing the intrinsic qualities of nodes and edges, should be included in the models to go beyond simplistic self-referential topological mechanisms.

- **D25 Workshops and Conferences (WP 6)**

COSIN sponsored the SELF-STAR conference (International workshop on self-* Properties in Complex Information Systems) held in Bertinoro residential Center (FC) Italy from 31 May to 2 June 2004. The proceeding of the meeting appear as Volume 3460 in the Springer Verlag Lecture Notes in Computer Science. COSIN also sponsored the European conference on complex Systems held in ISI foundation in Turin from 5 to 7 December 2004.
We want also to mention the series of lectures held by A. Vespignani for the the ESAS Master in Methods for Management of Complex Systems at the University of Pavia, Italy.

- **D26 Algorithms for Network Traffic Analysis (WP5)**

As routing in the Internet follows a hierarchical scheme, the analysis of the Autonomous System graph, where routing is determined at the higher level, is the first step towards the study of traffic flows, routing changes, and routing instabilities occurring in the Internet. In order to consolidate the theoretical foundations of such studies, we first address the problem of obtaining correct data from the available data sources. Second, we investigate the problem of computing the types of the relationships between Autonomous Systems (ASes), showing the NP-hardness of the problem and producing effective and efficient heuristics to approach it. Finally, we study how clustering techniques can be adapted and improved in order to be used in

this domain and show how the clustered view of the AS graph can provide high level information about the network evolution at different time scales

- **D27 See D21-D27 above**

- **D28 Technology Implementation Plan (WP6)** We followed the instruction on the Web site of the Commission in order to fill this Document. As a summary here we list the various results indicated by participants to the project
    1 New Model for Scale-free Networks
    2 Customisation of visualization tools
    3 Algorithms for large data sets
    4 Book on Internet
    5 Web site
    6 Mathematical characterisation of scale-free networks
    7 Socio-Economic Networks.

- **D29 Third Progress Report** (this document)

DELIVERABLES TABLE

Project Number: IST-2001-33555

Project Acronym: COSIN

Title: Coevolution and Self-Organisation in Dynamical Networks

Del. No.	Revision	Title	Type[1]	Classification[2]	Due Date	Issue Date
D14	October 04	Customisation in visualisation tools	R	Public	24	42
D15	September 05	Modeling interaction and dynamics inside firms	R	Public	24	42
D16	September 05	Interfirm network dynamics	R	Public	24	42
D17	October 04	Algorithms for network traffic analysis	R	Public	24	42
D19		Optimisation and Network Shaping	R	Public	42	42
D20		Statistical Properties of Collected data	R	Public	42	42
D21		Web Interface for Data sets	S	Public	42	42
D22		Algorithms for path finding	R	Public	42	42
D23		Cyber communities in WWW	R	Public	42	42
D24		Modelling Internet	R	Public	42	42
D26		Papers and Book on Networks and Complexity	R	Public	42	42
D27		WWW site for COSIN results	S	Public	42	42
D28		Technology Implementation Plan	R	Public	42	42
D29		Third Progress Report	R	Public	42	42

[1] *R: Report; D: Demonstrator; S: Software; W: Workshop; O: Other – Specify in footnote*

[2] *Int.: Internal circulation within project (and Commission Project Officer + reviewers if requested)*
Rest.: Restricted circulation list (specify in footnote) and Commission SO + reviewers only
IST: Circulation within IST Programme participants

2.3 COMPARISON WITH PLANNED ACTIVITIES

In the third period we had of course to terminate all the activities of the project, since no delay would have been allowed for the delivery of the results. In some cases (see Gannt chart attached) the work proceeded smoothly based on the progresses already made in the previous years.
In some cases as for the deliverable D14 an extra effort has been necessary in order to meet the suggestions that have been given from the referees. As regards this point the work has been made essentially by the node responsible that is CR7 UNIKARL (formerly CR6 UKON). Besides their activity some more studies made mainly by the CR8 UPSUD node. Some activity also made by C01 INFM has been added to the results of this deliverable. In this case the site in charge of the deliverable kept the main responsibility of the report.
In other cases different sites agreed in exchanging efforts since during the time of the evolution of the project, the various scientific interest changed. This result in a increased interest in new topics for the various participants.
In the case of the deliverable D23 for example, the node of CR5 ENS was considerably affected by the impossibility for the consortium to obtain easily thematic data sets (activity still running). The interest of the consortium then shifted to the analytical computation of the communities rather than interpreting the social aspects of them. In this field most of the activity was done by the groups of C01 INFM and CR2 UDRLS so they naturally took the responsibility of the report.
Similarly in the deliverable D24 the analysis has been mainly conducted by the node of CR9 EPFL who took in charge the writing of the report.

2.4 ACTIVITY IN THE PERIOD

The activity in the various nodes has been summarized as requested in the following Work Progress Overview. Here we present the activity of the various Work Packages. Since a different Work Package has been assigned to every node, a partial overlap between the two reports is present.

WP1 **Mathematical Tools for Complex Systems.** This is the Work Package where we can witness a great activity and therefore the feedback with other scientists is necessary in order to keep research on the state of the art. Many sites are working on these topics and the scientific production of the project is very large. Amongst the many papers produced (often between different sites) we can already find some very important and interesting contributions.

Weighted Networks The study of real network made necessary the consideration of weighted networks and therefore the definition of specific models. During this year of activity new models have been introduced and tested.

Community Structure In order to quantify and better describe the various technological networks the consortium started to study the mathematical properties of clustering and communities in graphs. One of the results is the possibility to describe the spectral properties of Laplacian Matrix by means of an optimisation process.

WP2 **Data Collection and Analysis.** The largest efforts has been paid in order to obtain some subgraphs of the WWW. In the case of geographic subsets we decide to cooperate as indicated in the last report with an external institution. Contrarily to what we indicated in the report the institution in charge of this activity is the University of Milan who collected some differents crawls of Italy and Indochina countries. Analysis of this data has been primarily conducted by node CR2 UDRLS. A link to these data has been added to COSIN page.

In the case of thematic subgraphs we collected also different crawls of the WWW under the requirement that html documents contain a specific word. The analysis on these data collected by Centro Fermi together with CR9 EPFL is in progress and the data will be made available shortly after completion of the analysis. Some other data have been added to the site, mainly biological data. They are

Protein Interaction Networks These data refer to positive interaction detected through two-hybrid method in *Escherichia Coli, Caenorhabditis Elegans, Saccharomyces Cerevisiae, Helicobacter Pylori.* Data have been collected from Database of Interacting Proteins (DIP). The interaction have been confirmed by reciprocal tagging and purifications. In some cases by repeat analysis.

Taxonomy Networks These data refer to the Linnean classification of species found in the same environment. When clustering together different species in the same genus and so on one obtains a self-similar tree with universal properties.

Metabolic Networks These data for *Escherichia Coli* have been developed from Kyoto Encyclopedia of Genes and Genomes. Vertices are metabolites connected each other if they are involved in the same catalytic reaction.

WP3 **Large Networks Visualization Tools.** Following the suggestions of the referees we worked specifically on this topic. As already mentioned in this report and in the revised version of deliverable D14 the activity followed two distinct directions. From one side node CR7 UNIKARL maintained the initial intention of finding a suitable tool in order to represent all the edges present in a large graph. This work is based on nested decomposition. On the other hand there has been also an activity in the field of simplification, that is to say a representation of large graphs where part of the information is deleted. This of course can be a very dangerous way of proceeding if removal has no physical or intrinsic motivation. For that reason two different methods have been tested. The first is based on K-core decomposition and has practical application for hierarchical networks. In the case of scale-free networks another method based on the scale-invariance of the network has been introduced. The idea is similar to that of Renormalization Group in Physics and describe the graph on a coarse grained scale, by recursively substituting vertices with group of vertices sharing similar properties.

WP4 **Dynamics of Social Networks.** The largest effort from Paris group was devoted to the dynamics of inter-firm production networks D16. Firms are connected through production links when the products of one firm are used as input for the production of connected firms. We studied how these links in a noisy environment result in a strong localisation of activities: the firm network display localised patterns of activity which distribution is scale free. Credit connection among firms result in similar dynamics. On the other hand the first trials to use opinion dynamics inspired algorithm for community detection give inferior results to those obtained with spectral methods. The work for deliverable D23 on cyber-communities assumed then a more mathematical nature regarding the topological properties encountered in the WWW. This work conducted to the ``daisy representation of the World Wide Web realised on the WebBase dataset owned by the project and successively confirmed by the analysis on geographical subsets. The activity of collection on ``thematic subsets of the web is still under consideration and very preliminary results have been presented in the Deliverable D23**.**

WP5 **Models for communication Networks.** Together with the analysis of the WWW described in the previous Work package, the work of the consortium proceeded also by considering an agent based model able to explain some of the Internet Properties. This model introduces a better *microscopic* description of the nodes of the Internet, by taking into account the hierarchical organization in users and Autonomous Systems. Moreover, also the dynamics of the vertices and edges is richer: both new users and AS join the network, although at different rates, users are allowed to change providers and AS can adapt the number of their edges so to satisfy the connectivity demands of their users. Each part of the dynamics being characterized by specific rates, partly fitted to the empirical growth rates of the real Internet, the network of Autonomous Systems turns out to be scale-free and the power-law degree distribution decays with an exponent close to 2, as measured in real data. Starting from these premises, node CR3 UB (Ángeles Serrano and co-workers) then refine their model placing AS in two-dimensional space in such that they cover a fractal set, as measured for the Internet

WP6 **Dissemination of Results.** The dissemination of the results has been assigned as usual to the traditional scientific way, through publications and lectures. The list of the various lectures and talks is reported in the various PROGRESS OVERVIEW SHEETS. The total list of publications is reported in the Appendix. It is worth to mention the fact that COSIN cosponsored two important conferences. The first one is the self-* conference held in Bertinoro, while the second one is the conference on Complex Systems held in Turin in December 2004. Finally, all the activity of the project will be presented in a book published by World Scientific.

WP7-WP8 **Management, Assessment and evaluation.** In this case as already specified in various parts of this report, most of the activity of management was headed to finalize the various activities already started. A basic action has been to require an amendment to the contract in order to obtain a 6 months extension for the project. The reason of that extension is twofold: firstly it is related to the delay with which post-doc were hired in the various nodes. Furthermore the composition of the consortium had several changes that required a series of administrative procedures whose effect resulted in an effective delay for some nodes (CR7 UNIKARL and CR8 UPSUD). For the assessment as usual we required a general overview on the results obtained to our scientific advisor Dr. M. Buchanan.

Progress Overview Sheet (Partner CO1 INFM)

PROGRESS OVERVIEW SHEET[1]

Organisation: Istituto Nazionale Fisica Per la Materia

Workpackage/ Task	Planned effort[2]	Planned Date[3]		Actual Date[4]		Resources employed[2]	Cumulative Resources[2]
	Whole Project	Start	End	Start	End	This Period	Since start
WP 1	14	1	36	1	42	6	14
WP 2	6	1	36	1	42	2	6
WP 3	0	1	36	1	42	0	0
WP 4	20	1	36	1	42	9	20
WP 5	6	1	36	1	42	2	6
WP 6	8	1	36	1	42	2	8
WP 7	7	1	36	1	42	3	7
WP 8	3	1	36	1	42	1	3
Total	64					25	64
One person month is equal to		170 [5]		Person hours			

Main contribution during this period	
Workpackage/Task	**Action**
WP 1	***Mathematical Tools for Complex Systems***
Task 1.1 1.2 1.3	We showed that the standard determination of communities through spectral properties of adjacency matrix can be put in detail with minimisation procedures.
WP 2	***Data Collection and Analysis***
Task 2.1	We added new data to the section of the site (in collaboration with nodes CR2 UDRLS and CR4 UNIL-EPFL) and commented those already existing. In collaboration with node CR4 we started a thematic collection of WWW pages.
Task 2.3	See Task 2.1
WP 4	***Dynamics of Social Networks***
Task 4.1	We kept on working on the financial data analysis started in the second year. We also started a project of text analysis that could be applied to WWW analysis
WP 5	***Model for Communication Networks***
Task 5.1	See Task 1.2
WP 6	***Dissemination of the Results***
Task 6.1-6.2	See following list of publication and talks
WP 7-8	***Management-Assessment and Evaluation***
	See section 5 for conference and workshops.

Deliverables due this period		
Deliverable number	**Title of Deliverable**	**Status (Draft Final, Pending)**
D25	Workshops Schools and Conferences	Final
D26	Papers and book on Networks and Complexity	Pending (Book in Press)
D27	WWW site of the project	Final

[1] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[2] In person months (or in person hours)
[3] Project month when the activity was planned to be started or to be completed
[4] Project month when the activity was actually started or completed
[5] Give a figure used for converting person hours to a person month

D28	Technology Implementation Plan	Final
D29	Third Progress report	Final

Dissemination actions (articles, workshops, conferences etc.)

Publications:

1. Preferential Exchange: Strengthening Connections in Comple x Networks
   G. Caldarelli, F. Coccetti and P. De Los Rios,
   Physical Review E, **70** 027102 (2004)
2. Assortative model for social networks.
   M. Catanzaro **G. Caldarelli**, L. Pietronero,
   Physical Review E **70** 037101 (2004).
3. Vertex Intrinsic fitness: How to produce arbitrary scale-free networks
   V.D.P. Servedio **G. Caldarelli**, P. Buttà,
   Physical Review E **70** 056126 (2004).
4. The Corporate board networks
   G. Caldarelli, M. Catanzaro,
   Physica A **338** 98-106 (2004).
5. Social network growth with assortative mixing
   M. Catanzaro, **G. Caldarelli**, L. Pietronero,
   Physica A **338** 119-124 (2004).
6. The scale-free Topology of market investments.
   D. Garlaschelli, S. Battiston, M. Castri, V.D.P. Servedio and **G. Caldarelli**,
   Physica A **350** 491-499 (2005).
7. Detecting communities in large networks.
   A. Capocci, V.D.P. Servedio, **G. Caldarelli** and F. Colaiori
   Physica A **350** 491-499 (2005).
8. Food Web Topology.
   D. Garlaschelli, **G. Caldarelli**, L. Pietronero,
   Nature **435** E4 (2005).
9. Number of *h*-cycles in the Internet at the Autonomous System Level.
   G. Bianconi, **G. Caldarelli**, A. Capocci,
   Physical Review E **71,** 066116 (2005).
10. Mixing Properties and the Simpson Paradox.
    A. Capocci, F. Colaiori
    Submitted to *Physical Review Letters* (2005).

Lectures:

G. Caldarelli series of lectures at School: *Structure and Function of Complex Networks*, Trieste, Italy, May 23-28, 2005.

G. Caldarelli *Statistical properties of scale-free graphs* Erice 9-11 December 2004

G. Caldarelli held a course of statistical mechanics of networks in the PhD programme of the university of Rome la Sapienza.

G. Caldarelli Organised a session on Complex Networks on Material and Device Meeting in Genova 22-25 June 2005.

A. Capocci had an invited talk on the conference on Statistical Mechanics held in Crete in August 2005.

Deviations from the planned work schedule/reasons/corrective actions/special attention required

As already mentioned in the last report the creation of a new node from the budget of node C01, substantially changed the schedule of the planned activities. Wit the support left we decided study text networks, the results of these studies have application both for WWW and social networks structure.

Planned actions for the next period

Progress Overview Sheet (CR2 UDRLS)

PROGRESS OVERVIEW SHEET[6]

Organisation:

Workpackage/ Task	Planned effort[7]	Planned Date[8]		Actual Date[9]		Resources employed[2]	Cumulative Resources[2]
	Whole Project	Start	End	Start	End	This Period	Since start
WP 1	2					0	2
WP 2	6					6	21
WP 3	13					6	16
WP 4	0					6	6
WP 5	36					12	36
WP 6	2					2	2
WP 7	1					0.3	1
WP 8	1					0.3	1
Total	61						
One person month is equal to		110[10]		Person hours			

Main contribution during this period	
Workpackage/Task	**Action**
WP 2	
Task 1.2	Integration of the library of software tools with features for the computation of connected components and of the Bow-Tie Structure of the Web.
WP 3	
Task 3.2	Integration of the visualization tools for the analysis of the fluctuations of Internet Routes with classification of the type of relationships between Autonomous Systems
WP4	
Task 4.3	Study of the structure of the connected components of the World Wide Web
WP5	
Task 5.2	Study of the Bow Tie Structure of the World Wide Web on differents data sets available inside and outside the consortium.
WP6	
Task 6.1	Organization of the 3rd International Workshop on Models and Algorithms for the Webgraph

[6] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[7] In person months (or in person hours)
[8] Project month when the activity was planned to be started or to be completed
[9] Project month when the activity was actually started or completed
[10] Give a figure used for converting person hours to a person month

Deliverables due this period

Deliverable number	Title of Deliverable	Status (Draft Final, Pending)
D 23	Cyber Communities in the World Wide Web	Final

Dissemination actions (articles, workshops, conferences etc.)

Organization of the 3rd International Workshop on Models and Algorithms for the Webgraph, 16 October 2004, Rome, Italy

Stefano Leonardi: Algorithms and Models for the Web-Graph: Third International Workshop, WAW 2004, Rome, Italy, October 16, 2004, Proceeedings Springer, 2004

Debora Donato, Stefano Leonardi, Stefano Millozzi, Panayiotis Tsaparas: Mining the inner structure of the Web graph. WebDB 2005: 145-150

D. Donato, L. Laura, S. Leonardi, S. Millozzi. Large Scale properties of the Webgraph. European Journal of Physics B, 2004.

Marco Gaertler and Maurizio Patrignani, ***Dynamic Analysis of the Autonomous System Graph,*** IPS 2004, International Workshop on Inter-domain Performance and Simulation, Budapest, Hungary, 22-23 March, 2004.

Massimo Rimondini, Maurizio Pizzonia, Giuseppe Di Battista and Maurizio Patrignani. ***Algorithms for the Inference of the Commercial Relationships between Autonomous Systems: Results Analysis and Model Validation***, IPS 2004, International Workshop on Inter-domain Performance and Simulation, Budapest, Hungary, 22-23 March, 2004.

L.Buriol, D. Donato, S. Leonardi, S. Millozzi. Link and Temporal Analysis of Wikigraphs. Submitted for publication.

Deviations from the planned work schedule/reasons/corrective actions/special attention required

No substantial deviation from the planned work. Increased effort on mining the social structure of the Web and on the visualization of the Internet at the Autonomous System level.

Planned actions for the next period

Progress Overview Sheet (CR3 UB)

PROGRESS OVERVIEW SHEET[11]

Organisation:

Workpackage/ Task	Planned effort[12]	Planned Date[13]		Actual Date[14]		Resources employed[2]	Cumulative Resources[2]
	Whole Project	Start	End	Start	End	This Period	Since start
WP 1							
Task 1.1	12	01-03-02	28-02-03	01-03-02	31-08-05	6	24
Task 1.2	24	01-03-02	28-02-04	01-03-03	31-08-05	9	21
Task 1.3	24	01-03-03	28-02-05	01-03-02	31-08-05	6	21
	60					21	66
Total							
One person month is equal to		Xxx[15]		Person hours			

Main contribution during this period	
Workpackage/Task	**Action**
WP 1	
Task 1.1: Quantitative characterization of different networks in Nature	• Although this Task was completed in previous periods we have continued getting results in this context: o Community identification: two new methods have been proposed (spectral algorithm and extremal optimization) and a review has been prepared. o New characterization of networks: we have introduced novel properties of networks concerning the informational transfer o Discussion about scaling and universality in food-webs o Structure of cycles o Analysis of the cut-off in finite size scale-free networks
Task 1.2: Onset of complexity from microscopic interactions	• We have proposed several microscopic models that enables to reproduce some of the known characteristics of the networks found in Nature: o A model of the evolution of the Internet based on competition and adaptation o A model of collaboration networks o A model of signalling networks
Task 1.3: Optimisation	• During the previous periods we studied optimal network structures where packet flow was considered. Further considerations: o Design of optimal network structures for the purpose of synchronization o Role of communities (characterized in Task 1.1) in the dynamical properties of he networks, these properties can be either the search of information or the onset of synchronization. o A model in which one can tune clustering distribution as

[11] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[12] In person months (or in person hours)
[13] Project month when the activity was planned to be started or to be completed
[14] Project month when the activity was actually started or completed
[15] Give a figure used for converting person hours to a person month

	well as degree distribution at the same time has also been produced. o A model of uncorrelated random scale-free networks
Deliverables due this period	
Deliverable number	**Title of Deliverable**
D4	Universality in networks

Dissemination actions (articles, workshops, conferences etc.)	o J. Duch, A. Arenas. Community detection in complex networks using extremal oprimization. *Phys. Rev. E* **72**: 027104, 2005. o L. Donetti, M.A. Muñoz. Detecting network communities: a new systematic and efficient algorithm. *J. Stat. Mech*. P10012, 2005. o L. Donetti, M.A. Muñoz. Improved spectral algorithm for the detection of network communities. Preprint arXiv:physics/0504059. o L. Danon, J. Duch, A. Arenas, A. Diaz-Guilera, Community structure identification. Preprint arXiv:cond-mat/0505245. o I. Vragovic, E. Louis, A. Diaz-Guilera. Efficiency of informational transfer in regular and complex networks. *Phys. Rev. E* **71**: 036122, 2005. o J. Camacho, A. Arenas. Universal scaling in food-web structure? *Nature*, **435**: E3 (2005). o M. Catanzaro, R. Pastor-Satorras. Analytical solution of a static scale-free network model. *Eur. Phys. J. B* **44**:241 (2005).	**Status (Draft Final, Pending)**
		Final

Deviations from the planned work schedule/reasons/corrective actions/special attention required

The importance of the problems tackled in this deliverable have made that the time devoted to it be extended during the last two years of the project. Universality in complex networks is still one of the main open problems in characterizing network topologies.

Planned actions for the next period

Nothing

Deliverables due this period	
Deliverable number	**Title of Deliverable**
D11	Self-organization of networks

Dissemination actions (articles, workshops, conferences etc.)	o M. A. Serrano, M. Boguñà, A. Diaz-Guilera. Competition and adaptation in an Internet Evolution Model. *Phys. Rev. Lett.* **94**: 038701 (2005). o J.J. Ramasco, S.N. Dorogovtsev, R. Pastor-Satorras. Self-organization of collaboration networks. *Phys. Rev. E* **70**: 036106 (2004).	**Status (Draft Final, Pending)**

	o M. Boguñá, R. Pastor-Satorras, A. Díaz-Guilera, and A. Arenas. Models of social networks based on social distance attachment. *Phys. Rev. E* **70**: 056122 (2004). o M. Boguñà, M.A. Serrano. Generalized percolation in random directed networks. *Phys. Rev. E* 72: 016106 (2005). o L.A.N. Amaral, A. Diaz-Guilera, A.A. Moreira, A.L. Goldberger, L.A. Lipsitz. Emergence of complex dynamics in a simple model of signalling networks.	
		Final

Deviations from the planned work schedule/reasons/corrective actions/special attention required

Due to the delay in contracting the post-docs we experienced some problems in this deliverable during the first year. Nevertheless, during the second year we obtained some very interesting results (about social models and neural networks) that have been extended during the current period, and hence accomplishing the objectives proposed in the project.

Planned actions for the next period

Nothing

Deliverables due this period	
Deliverable number	**Title of Deliverable**
D19	Universality in networks

Dissemination actions (articles, workshops, conferences etc.)	o L. Donetti, M.A. Muñoz. Entangled networks, super-homogeneity and optimal network topology. Preprint arXiv:cond-mat/0502230. o M.A. Serrano, M. Boguñà. Tuning clustering in random networks with arbitrary degree distributions. *Phys. Rev*. E (in press). o M. Catanzaro, M. Boguñà, R. Pastor-Satorras. Generation of uncorrelated random scale-free networks. *Phys. Rev. E* **71**: 027103 (2005). o M.A. Serrano, M. Boguñà. Weighted configuration model. Preprint arXiv:cond-mat/0501750.	**Status (Draft Final, Pending)**
		Final

Deviations from the planned work schedule/reasons/corrective actions/special attention required

Planned actions for the next period

Nothing

Progress Overview Sheet (Partner CR5 ENS)

PROGRESS OVERVIEW SHEET[16]

Organisation: Ecole Normale Superiéure

Workpackage/ Task	Planned effort[17]	Planned Date[18]		Actual Date[19]		Resources employed[2]		Cumulative Resources[2]	
	Whole Project	Start	End	Start	End	This Period		Since start	
WP 1	4	1	36	1	36	1	1	2	3
WP 2	7	1	36	1	36	3	3	5	8
WP 3	5.5	1	36	1	36	2	1.5	4	5.5
WP 4	36	1	36	1	36	13	12	24	36
WP 5	2	1	36	1	36	X		X	
WP 6	2	1	36	1	36	1	1	1	2
WP 7	1	1	36	1	36	X		X	
WP 8	1	1	36	1	36	X		X	
Total	**58.5**					20		42	
One person month is equal to		**170**[20]		Person hours		16.5		54.5	

Main contribution during this period	
Workpackage/Task	**Action**
WP 1	***Mathematical Tool for Complex Systems***
Task 1.3	Investigating economic application of the differential game model developed in the previous period
WP 2	***Data Collection***
Task 2.1	We have collected information on firm onwership and management from commercial databases. Access granted by Univ. Cattolica of Milan. Based on this information have build databases for the network of ownership and the network of boards of directors in Italy and Europe. The database also allows to study the evolutio of the network in time.
WP 3	***Large Network Visualization Tools***
Task 3.1	Adaptation to firm networks of algorithms for network visualization based on spectral methods investigated by CR1 and CR7
WP 4	***Dynamics of Social Networks***
Task 4.1	We developed two models of supply networks to investigate scaling laws in propagation of delivery failures on one hand and bankruptcy on the other hand. Empirical study of the network of investment across regions in Europe.
WP 6	***Dissemination of the Results***
Task 6.1 Task 6.2	organization of a conference, participation to 6 conferences, contribution to COSIN book > 3 submitted papers,

Deliverables due this period		
Deliverable number	**Title of Deliverable**	**Status (Draft Final, Pending)**
D16 (update)	Firm network dynamics	Final
D23	Communities in the www	Final

Dissemination actions (articles, workshops, conferences etc.)

1) Weisbuch G. and Battiston S., Production networks and failure avalanches submitted to JEBO (Journal of Economic Behavior and Organization), talk accepted to European Conference on Complex Systems (Paris November 2005).

[16] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[17] In person months (or in person hours)
[18] Project month when the activity was planned to be started or to be completed
[19] Project month when the activity was actually started or completed
[20] Give a figure used for converting person hours to a person month

2) Battiston S., Delli Gatti D., Gallegati M., Greenwald B., Stiglitz J.E., Credit Chains and Bankruptcies Avalanches in Supply Networks, presented to WHEIA conference (Essex, June 2005), paper selected for submission to Journ. of Economic Dynamics and Control(JEDC)
3) Battiston S., Rodrigues J.F. and Zeytinoglu H., The Network of Inter-Regional Direct Investment Stocks across Europe, submitted to Advances in Complex Systems
4) Participation and presentation of work in 4 Exystence Thematic Institutes: Budapest (May 2004), Dresden (August 2004), Ancona (April 2005), Goldrain (July 2005).
5) Organization of Exystence Thematic Insitute CHIEF in Ancona (April 2005) : Complexity and Heterogeneity in Economics and Finance
6) Participation to COSIN final conference Salou (February 2005)
7) Participation to International Conference on Networks and Markets in the honour of Alan Kirman, June 2005
7) Invited Lecture at Interdisciplinar Seminar origanized by Prof. Ricottili in Bologna Univ., Dept. Economy, May 2005.

Deviations from the planned work schedule/reasons/corrective actions/special attention required

D15 It was not possible, before the end of the project, to find data sets to validate out model on decision making processes within single firms and across firms.
D23 At the second year of the project we have been aware that some European Projects had been funded to work entirely on this topic. Based on our intermediate results we decided not to proceed further and to redirect some effort on continuing deliverable D16
D16 Some additional effort has been directed to D16 on the topic of production networks and risk propagation.

Planned actions for the next period

PROGRESS OVERVIEW SHEET (Partner CR7 UNIKARL)

PROGRESS OVERVIEW SHEET[21]

Organisation: Universitaet Karlsruhe (TH)

Workpackage/ Task	**Planned effort[22]**	**Planned Date[23]**		**Actual Date[24]**		**Resources employed[2]**	**Cumulative Resources[2]**
	Whole Project	**Start**	**End**	**Start**	**End**	**This Period**	**Since start**
WP 2							
Task 2.1	1	11	12	28	30	2	2
WP 3	36	0	36	0	36	12,5	24
Total							
One person month is equal to		164[25]		Person hours			

Main contribution during this period	
Workpackage/Task	**Action**
WP 2	
Task 2.1	• Cooperation with DFG-Schwerpunktprogramm 1126 to build a database that stores various collected and generated networks
WP 3	
Task 3.1 + 3.2	• development of a new analysis driven visualization in cooperation with Université Paris Sud • improvement and generalizations of analysis-enhancing visualizations for hierarchical decomposed networks

Deliverables due this period		
Deliverable number	**Title of Deliverable**	**Status (Draft Final, Pending)**
D22	Algorithms to find paths and connections from local information	Final

Dissemination actions (articles, workshops, conferences etc.)
—
Deviations from the planned work schedule/reasons/corrective actions/special attention required
—
Planned actions for the next period
----

[21] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[22] In person months (or in person hours)
[23] Project month when the activity was planned to be started or to be completed
[24] Project month when the activity was actually started or completed
[25] Give a figure used for converting person hours to a person month

Progress Overview Sheet CR8 UPSUD

PROGRESS OVERVIEW SHEET[26]

Organisation: Université de Paris Sud

Workpackage/ Task	Planned effort[27]	Planned Date[28]		Actual Date[29]		Resources employed[2]	Cumulative Resources[2]
	Whole Project	Start	End	Start	End	This Period	Since start
WP 1	**4**	**12**	**36**	**12**	**42**	**1**	**4**
Task 1.1	2					0	2
Task 1.2	2					1	2
WP 2	**2**	**12**	**36**	**12**	**42**	**1**	**2**
Task 2.1	1					1	1
Task 2.2	1					0	1
WP 3	**0**	**12**	**36**	**12**	**42**	**0**	**0**
WP 4	**0**	**12**	**36**	**12**	**42**	**0**	**0**
WP 5	**6**	**12**	**36**	**12**	**42**	**5**	**6**
Task 5.1	1					2	2
Task 5.2	1					1	2
Task 5.3	1					2	2
WP 6	**2**	**12**	**36**	**12**	**42**	**1**	**2**
Task 6.1	1					0.5	1
Task 6.2	1					0.5	1
WP 7	**2**	**12**	**36**	**12**	**42**	**1**	**2**
WP 8	**5**	**12**	**36**	**12**	**42**	**3**	**5**
Total	**21**					**12**	**21**
One person month is equal to		170[30]		Person hours			

[26] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.
[27] In person months (or in person hours)
[28] Project month when the activity was planned to be started or to be completed
[29] Project month when the activity was actually started or completed
[30] Give a figure used for converting person hours to a person month

Main contribution during this period	
Workpackage/Task	**Action**
WP 1	Modelling of weighted networks
WP 6	Dissemination of the results
Task 6.1	• Editing of the book "Structure and dynamics of complex networks" to be published with Imperial college and World Scientific at the end of 2005. The book collects contributed chapters on the activities of the various groups involved in the project (A. Vespignani and G. Caldarelli Eds). • School and workshop on "the structure and function of complex networks" held in Trieste, Italy on May 16- 28 2005 (A. Vespignani, organizer). • Focus session on Complex networks at the American Physical Society March Meeting in Los Angeles, March 21-25 2005 (A. Vespignani organizer). • Tutorial on "Network Science" held in Cagliari, Italy on June the 27th 2005 (A. Vespignani organizer).
Task 6.2	• Series of lectures on complex networks at the ESAS Master in Methods for Management of Complex Systems at the University of Pavia, Italy 17-18 May (A. Vespignani, lecturer). • Series of lectures on complex networks at the school "From functional genomics to molecular networks", Evry, France, May 30th-June 4th (A. Vespignani, lecturer). • Development of the Lanet-vi web-site for the free downloading of a large graph visualization program developed by the node of Paris Sud in collaboration with the CNRS and Indiana University.

Deliverables due this period		
Deliverable number	**Title of Deliverable**	**Status (Draft Final, Pending)**

Dissemination actions (articles, workshops, conferences etc.

Organization or managements of workshops, conferences…

*A. Barrat is Member of the scientific committee of Algotel 2005 (7èmes Rencontres Francophones sur les aspects Algorithmiques des Télécommunications), May 11 - 13 2005, Giens, France.

*School and workshop on "the structure and function of complex networks" held in Trieste, Italy on May 16- 28 2005 (A. Vespignani, organizer).

*Focus session on Complex networks at the American Physical Society March Meeting in Los Angeles, March 21-25 2005 (A. Vespignani organizer).

*Tutorial on "Network Science" held in Cagliari, Italy on June the 27th 2005 (A. Vespignani organizer)

*A.Vespignani is in the program committee of the "European conference on complex systems", Paris France 14-18 November 2005.

Invited talks, lectures

-A. Barrat:, Invited talk ``Traceroute-like exploration of unknown networks: a statistical analysis", workshop on structure and function of complex networks, Trieste, Italy, May 16-28 2005.
-A. Barrat, Lecture ``Réseaux complexes valués", thematic school ``Grands réseaux d'interactions", April 25-29 2005, Paris.
-A. Barrat, Invited talk ``Traffic-driven model of the World Wide Web Graph", Third Workshop on Algorithms and Models for the Web-Graph (WAW 2004), Rome, Italy, October 16 2004.
-A. Barrat, Invited talk ``Traceroute-like exploration of unknown networks: a statistical analysis", conference ``Combinatorial and Algorithmic Aspects of Networking and the Internet", Banff, Canada, August 5-7 2004.
-A. Barrat, Invited talk ``Graphes petit-monde", Algotel 2004 (6èmes Rencontres Francophones sur les aspects Algorithmiques des Télécommunications), May 26-28 Mai 2004, Batz-sur-mer, France.
-A. Vespignani. Invited talk, "Epidemic modelling: dealing with complexity", International Conference on "Complex Systems Across Disciplines", Northwestern University, Chicago, Illinois, October 29-30, 2004.
-A. Vespignani, Invited Talk, "Computer virus epidemics in complex technological networks", International Workshop on "Adaptive and Resilient Computing Security (ARCS04)", Santa Fe Institute, New Mexico, November 3-4, 2004.
-A. Vespignani, Invited Talk,"Epidemic modelling in complex networks" MiDAS consultation Group on Social Networks, Brookings Institution, Washington DC, USA 5-6 January 2005.
-A. Vespignani, Invited talk "Epidemic modelling dealing with complexity", "understanding and preventing infectious diseases", University of British Columbia and Canadian center for Disease Control, Vancouver 19-22, Canada, January 2005.
-A. Vespignani, Invited talk, "Evolution and structure of the Internet", American Physical Society March Meeting, Los Angeles, March 21-25 2005.
-A. Vespignani, Invited Talk, "Evolution and structure of the Internet", Santa Fe research Collaboration Program "Robustness of multiple overlapping networks" , Santa Fe, New Mexico, USA 25-29 April 2005.
-A. Vespignani, Invited Talk, Epidemic modelling: dealing with complex networks" Symposium on Biological and Social Networks, Physik seit Einstein, 69th Annual meeting of the German physical Society, Berlin Germany, 4-9 March 2005.
-A. Vespignani, Invited Talk, "Epidemic modelling in complex networks", Conference "Complex Networks and Random Graphs", Physikzentrum Bad Honnef, Germany, 11-13 July, 2005.

Publications:
*Inhomogeneous percolation models for spreading phenomena in random graphs
L. Dall'Asta, J Stat Mech (2005) P08011.
*Comparison of voter and Glauber ordering dynamics on networks
C. Castellano, V. Loreto, A. Barrat, F. Cecconi, D. Parisi, Phys. Rev. E 71 (2005) 066107.
*The effects of spatial constraints in the evolution of weighted complex networks
A. Barrat, M. Barthélemy and A. Vespignani, J. Stat. Mech. (2005) P05003.
*Rate equation approach for correlations in growing network models
A. Barrat and R. Pastor-Satorras, Phys. Rev. E 71 (2005) 036127.
Selected by the Virtual Journal of Biology (http://www.vjbio.org)
*Statistical theory of Internet exploration
L. Dall'Asta, I. Alvarez-Hamelin, A. Barrat, A. Vazquez, and A. Vespignani
Phys. Rev. E 71 (2005) 036135.
*Dynamical patterns of epidemic outbreaks in complex heterogeneous networks
M. Barthélemy, A. Barrat, R. Pastor-Satorras and A. Vespignani, J. Theor. Bio. 235 (2005) 275.
*Modeling the evolution of weighted networks
A. Barrat, M. Barthélemy and A. Vespignani, Phys. Rev. E 70 (2004) 066149.
Selected by the Virtual Journal of Biology (http://www.vjbio.org)
*Traffic-driven model of the World Wide Web Graph
A. Barrat, M. Barthélemy and A. Vespignani, Lecture Notes in Computer Science 3243 (2004) 56.
*Weighted evolving networks: coupling topology and weights dynamics
A. Barrat, M. Barthelemy and A. Vespignani, Phys. Rev. Lett. 92 (2004) 228701.
Selected by the Virtual Journal of Biology (http://www.vjbio.org)
*Velocity and hierarchical spread of epidemic outbreaks in scale-free networks
M. Barthélemy, A. Barrat, R. Pastor-Satorras and A. Vespignani, Phys. Rev. Lett. 92 (2004) 178701.
Selected by the Virtual Journal of Biology (http://www.vjbio.org)
Selected by the Vaccine adverse report system web-site
(http://www.vaers.org/bibliographies/vaersbib0704.htm)

Deviations from the planned work schedule/reasons/corrective actions/special attention required

No deviations have been made

Planned actions for the next period

Progress Overview Sheet CR9 EPFL

PROGRESS OVERVIEW SHEET[31]

Organisation: Ecole Polytechnique de Lausanne

Workpackage/ Task	Planned effort[32]	Planned Date[33]		Actual Date[34]		Resources employed[2]	Cumulative Resources[2]
	Whole Project	Start	End	Start	End	This Period	Since start
WP 1	2	24	42	28	42	2	2
WP 2	12	24	42	28	42	12	12
WP 3	0	24	42	28	42	0	0
WP 4	1	24	42	28	42	1	1
WP 5	1	24	42	28	42	1	1
WP 6	0	24	42	28	42	0	0
WP 7	1	24	42	28	42	1	1
WP 8	1	24	42	28	42	1	1
Total	18					18	18
One person month is equal to		170[35]		Person hours			

Main contribution during this period	
Workpackage/Task	**Action**
WP 1	**Mathematical Tools for Complex Systems**
T1.1	Generalized definition of the clustering coefficient. Fractal properties of "d-spheres" in small-world networks Definition of the stability of the community structure of complex networks
T1.2/T1.3	Geographic small-world networks compatible with cost minimization
WP 2	**Data Collection and Analysis**
T2.2	Analysis of large datasets from linguistic sciences and physical systems (protein folding landscapes)
WP 3	**Large Networks Visualization Tools**
T3.1/T3.2	Visualization of networks through their cluster structure
WP 5	**Models for Communication Networks**
	Models for Small-world networks
WP 6	**Dissemination of Results**
T6.1	Participation at schools and conferences

Deliverables due this period		
Deliverable number	**Title of Deliverable**	**Status (Draft Final, Pending)**
D20	Statistical properties of collected data	Final
D21	Web interface for datasets	Final

Dissemination actions (articles, workshops, conferences etc.)

Publications

T. Petermann, *A Statistical Physics Perspective of Complex Networks: from the architecture of the internet and the brain to the spreading of an epidemic*, PhD Thesis 2005.

D. Gfeller, J.-C. Chappelier and P. De Los Rios, *Synonym Dictionary Improvement through Markov Clustering and Clustering Stability*, Proceedings of "Applied Stochastic Models and Data Analysis 2005".

D. Gfeller, J.-C. Chappelier and P. De Los Rios, *Finding instabilities in the community structure of large complex networks*, arXiv:cond-mat/0503593

[31] Each partner should fill in its own Progress Overview Sheet for a period in question. The Project Co-ordinator will check and approve the forms and attach them to the corresponding PPR.

[32] In person months (or in person hours)

[33] Project month when the activity was planned to be started or to be completed

[34] Project month when the activity was actually started or completed

[35] Give a figure used for converting person hours to a person month

T. Petermann and P. De Los Rios, *Spatial small world networks: a wiring cost perspective*, arXiv:cond-mat/0501420
J. Corbo and T. Petermann, *Selfish peering and routing in the Internet*, arXiv:cs.GT/0410069

Conferences and lectures
School: *Structure and Function of Complex Networks*, Trieste, Italy, May 23-28, 2005.
Conference: *Complex Networks: Evolution and Statistical Properties*, Salou, Spain. March 14-18, 2005.
Lecture: IBM T.J. Watson Research Center, Yorktown Heights NY, USA, March 4, 2005.
Lecture: Cold Spring Harbor Laboratory Cold Spring Harbor NY, USA, March 2, 2005.
Lecture: National Institutes of Health (NIH), Bethesda, MD, USA, February 28, 2005.
Lecture: European Molecular Biology Laboratory, Heidelberg, Germany, October 15, 2004.
Conference: *Science of Complex Networks: From Biology to the Internet and WWW*, Aveiro, Portugal. August 30, 2004.

PhD students
Mr. Thomas Petermann earned his PhD in theoretical physics in July 2005 with a thesis on Complex Networks, supported by COSIN. Mrs. Cecile Caretta Cartozo has been paid for 6 months with COSIN funds and is now supported, for her PhD, by the Swiss National Research Foundation

Deviations from the planned work schedule/reasons/corrective actions/special attention required

Planned actions for the next period

Comparative Information on Resources (Person months)

Effort in person months reporting period 01/03/2003-29/02/2004

	CO1 INFM				CR2 UDRLS				CR3 UB				CR5 ENS			
	Period		Total		Period		Total		Period		Total		Period		Total	
WP/Task	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.
WP1	**6**	**6**	**14**	**14**	**0**	**0**	**0**	**0**	**0**	**21**	**60**	**65**	**2**	**1**	**4**	**3**
Task 1.1	2	2	4	4	0	0	0	0	0	6	12	24	0	0	0	0
Task 1.2	2	2	6	6	0	0	0	0	0	9	24	21	0	0	0	0
Task 1.3	2	2	4	4	0	0	0	0	12	6	24	21	2	1	4	3
WP2	**2**	**2**	**6**	**6**	**0**	**6**	**4**	**16**	**0**	**0**	**0**	**0**	**2**	**3**	**7**	**8**
Task 2.1	0	0	2	2	0	0	1	2	0	0	0	0	2	3	7	8
Task 2.2	2	2	2	2	0	3	3	11	0	0	0	0	0	0	0	0
Task 2.3	0	0	2	2	0	3	0	3	0	0	0	0	0	0	0	0
WP3	**0**	**0**	**0**	**0**	**3**	**6**	**19**	**19**	**0**	**0**	**0**	**0**	**1.5**	**1.5**	**5.5**	**5.5**
Task 3.1	0	0	0	0	3	6	19	19	0	0	0	0	1.5	1.5	5.5	5.5
WP4	**6**	**9**	**20**	**20**	**0**	**6**	**0**	**6**	**0**	**0**	**0**	**0**	**12**	**12**	**36**	**36**
Task 4.1	6	9	20	20	0	6	0	6	0	0	0	0	0	0	0	0
WP5	**2**	**1**	**6**	**6**	**12**	**12**	**25**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**
Task 5.1	2	1	6	6	6	6	19	18	0	0	0	0	0	0	2	0
Task 5.2	0	0	0	0	6	6	6	6	0	0	0	0	0	0	0	0
Task 5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WP6	**2**	**2**	**8**	**8**	**0.3**	**0.3**	**0.9**	**0.9**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**4**
WP7 - WP8	**4**	**4**	**10**	**10**	**0.3**	**0.3**	**1.1**	**1.1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**
Total	**25**	**25**	**64**	**64**	**15.6**	**30.6**	**50**	**57**	**12**	**21**	**60**	**66**	**17.5**	**18.5**	**59.5**	**56.5**

Effort in person months period 01/03/2004-31/08/2005

	CR7 UNIKARL				CR8 UPSUD				CR9 EPFL				Total			
	Period		Total		Period		Total		Period		Total		Period		Total	
WP/Task	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.
WP1	**0**	**0**	**0**	**0**	**2**	**1**	**4**	**4**	**2**	**2**	**2**	**2**	**12**	**31**	**84**	**88**
Task 1.1	0	0	0	0	1	0	2	2	0	0	0	0	3	8	18	30
Task 1.2	0	0	0	0	1	1	2	2	2	2	2	2	5	14	34	31
Task 1.3	0	0	0	0	0	0	0	0	0	0	0	0	4	9	32	27
WP2	**1**	**2**	**1**	**2**	**1**	**1**	**2**	**2**	**12**	**12**	**12**	**12**	**18**	**26**	**32**	**46**
Task 2.1	1	2	1	2	1	1	2	2	12	12	12	12	16	18	25	28
Task 2.2	0	0	0	0	0	0	0	0	0	0	0	0	2	5	5	13
Task 2.3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	5
WP3	**12**	**12,5**	**24**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**16.5**	**20**	**48.5**	**48.5**
Task 3.1	12	12,5	24	24	0	0	0	0	0	0	0	0	16.5	20	48.5	48.5
WP4	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**19**	**18**	**57**	**57**
Task 4.1	0	0	0	0	0	0	0	0	0	0	0	0	19	18	57	57
WP5	**0**	**0**	**0**	**0**	**3**	**5**	**6**	**6**	**1**	**1**	**1**	**1**	**18**	**19**	**38**	**37**
Task 5.1	0	0	0	0	0	2	3	3	0	0	0	0	8	9	30	27
Task 5.2	0	0	0	0	2	2	2	2	0	0	0	0	4	4	4	4
Task 5.3	0	0	0	0	1	1	1	1	0	0	0	0	6	6	4	6
WP6	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**2**	0	0	0	0	**3.5**	**4.5**	**12.9**	**14.9**
WP7 - WP8	**0**	**0**	**0**	**0**	**4**	**4**	**7**	**7**	**2**	**2**	**2**	**2**	**10.3**	**10.3**	**18**	**18**
Total	**13**	**14,5**	**25**	**26**	**11**	**12**	**21**	**21**	**18**	**18**	**18**	**18**	**97.3**	**128.8**	**291.4**	**309,4**

Period: Est.: estimated effort in contract for period Act.: effort actually spent in period
Total: Est.: estimated cumulative effort to date in contract Act.: cumulative effort to date actually spent

2.5 WORLD WIDE STATE OF THE ART

A large number of the members of the COSIN project can be considered as leading figure in the area of complex dynamical networks. PIs and researchers have participation to a large number of conferences and several papers with major impact in the community. It is therefore not an overstatement to say that COSIN has largely contributed to define the state of the art in the field at the World-wide level. In the initial stage, the COSIN project has provided key research product in the area of modelling of complex networks (static fitness model, hidden variable model etc.). The project has stimulated and contributed to open the issue of the development of mathematical tools for a characterization of networks beyond the sole degree distribution. The consortium has been at the forefront of the analysis and modelling of high order correlations and their role in the understanding on network structures. A major focus of the International community has concerned

the developments of community detection algorithms with a hectic research activity in which even large company such as HP have put substantial efforts. In this area the group of Rome and Barcellona have without doubts contributed with major research papers. The application of spectral analysis in community detection is one of the basic strategies adopted world-wide. As well the practical application to organizational structure and chart analysis made by the group of Barcellona are among the most popular examples of community detection applications. COSIN has also been able to establish a European leadership in the analysis of Internet and WWW data. The large WebGraph dataset analysis by the node in Rome La Sapienza represents the state of the art for the topological analysis of WWW data. Similarly, the collaboration within Ecole Normale and INFM has been among the precursors and standard setting event for the research directions in Economical networks. The last years has finally witnessed several developments in the visualization of large networks, with the collaborations among several groups. The use of graph theory and statistical methods along with the skills and knowledge of the Karlsruhe group has opened some research directions that appears not matched at the moment. Noticeably the tools developed in this effort are already publicly available and used by the community at large. In this sense I is important to stress that the COSIN consortium has surely established an unprecedented and unmatched level of inter-disciplinary interaction among the partners. At present, such a level of inter-disciplinary collaboration among physicists, computer scientists and other researchers is an added value of a handful of institutions world-wide.

Finally, it has to be stressed that COSIN has been a major actor in defining the present and future research agenda at the world-wide level. Several of the promising research directions of the moment has been prompted by COSIN activities; e.g. weighted networks analysis, ecological applications, semantic and lexical networks, WWW topical analysis and modelling etc. The conference held in Rome in 2003 and the ensuing special issue on Networks of EPJB is considered as one of the most significant scientific gathering in the network research community. The paper on the ten leading questions in network research has reverberated in many US institutions and can be even found on the web pages of important complex network research centres such as NICO and CNet. In summary, we believe that it is possible to easily identify the impact and the leadership that COSIN has been able to achieve world-wide.

2.6 SUGGESTION BY REVIEWERS IN THE LAST REPORT

In the Appendix A we report the whole second year report. For the sake of introducing the next section we summarize here the main points on which the activity has been focussed.

1. Rewrite Deliverables D14 (i.e. find solution for visualizing large networks) and D17 (i.e. present in a coherent form the results obtained).
2. An instrument to deal with large scale network is required (see first point as regards D14)
3. Work on which D15 and D16 are based needs to be reconsidered
4. An analysis of social networks extended to larger systems and based on the instruments produced by consortium (see previous point).
5. More coordination between nodes is requested
6. A better quality of reports presented

2.7 ACTIONS TAKEN TO ANSWER CRITICISMS

As for the various points raised we made a series of different actions.

1-2 The most immediate problem seemed to be to have an instrument in order to represent large networks. The most difficult and interesting solution is to preserve all the edges and therefore all the information in the graph. This problem is of course of such difficulty that one cannot think to solve it completely for any possible instance of networks. For rather large graphs CR7 UNIKARL has provided a new way to cluster and represent edges.

Other solutions are possible by softening the requirements. For example allowing a simplification of the graph, one loses some information but can still have a fair view of the system. C01 INFM in collaboration with CR7 UNIKARL has developed a method to reduce in a sensible way the number of edges by making use of a tool called “decimation” used in the context of Renormalization Group.

3-4 When engaging on research on inter-firms networks dynamics some 3 years ago we were aware of one challenge:

- Dynamics studies (monitoring and modeling) are more difficult than structural studies; in most sciences, and especially in physics, they lag behind structural studies (cf. X rays structure of crystals 1910's versus electronic properties 1920's to 1960's). We were less aware of a second difficulty concernine empirical studies: One often lacks inter-temporal data: comparing the prediction of a dynamical model with empirical data would requie "movies" with the spatio-temporal dynamics of those phenomena occurring on empirical networks, or at least of some time series of relevant properties. Time series exist in finance for instance which explains the success of econophysics, but this case is exceptional. In our case, although we obtained empirical data about the structure of firms networks, we never were able to obtain those time series which could have e.g. "validated" our predictions on decision dynamics across boards networks. The lack of empirical data is the reason why we stopped working on D15: carrying on our studies on decision dynamics inside the firm would have necessitated data that we could not access. On the other hand, scientific discussions with a group of research based in Ancona (Mauro Gallegatti et al) opened the door to a field of research which was already in COSIN proposal: the study of avalanches of failures in production networks, reported in D16.

5 We made different actions as specific meetings and suggestions to participate to same conference in order to make the people cooperate between them and to exchange results on similar topics. In particular as already discussed in points 1-2 we organised two specific meetings in order to meet referees requirements. The first one has been made in May 2005 in Trieste. The second one has been hosted by node UPSUD in Paris and consisted in an informal series of talks followed by a common activity to meet the goals of deliverable D14 on customisation to large networks of existing visualization tools.

6 We tried as much as possible to present in an simple yet complete way all the results obtained by the consortium in short and self-consistent documents that are the reports on the various deliverables for this last period. As already mentioned to Project Officer and reviewers we apologise again if anyone felt an arrogant attitude from the consortium. Consortium had no idea whatsoever to offend anyone’s sensibility. What the community of statistical physicist can witness from previous project experience (i.e. Fractals-TMR Network FMRXCT980183) is that reviewers wanted to check the real papers rather than reports. Only for that reason we presented a collection of papers that was felt as an arrogant action. We now understood that is not what is required and we proceed accordingly.

Nevertheless as *a latere* comment after the end of this project we dare say for the sake of a future planning (in a common effort for a multi-disciplinary science), maybe this good tradition from Statistical Physics can be considered and maybe the form of reports (at least in some cases) could be changed. A possibility could be to present them in the more traditional and comfortable shape of Talks (I.e. power-point files). This would make possible (with very little effort) to use the report on deliverables (from various projects) as Lectures in workshops and possibly kept in a specific part of Commission Web site (actually that can be done also with the present form of deliverables).

2.8 ASSESSMENT OF PROJECT RESULTS AND ACHIEVEMENTS

Project's Achievements Fiche

Questions about project's outcomes	Number	Comments
1. Scientific and technological achievements of the project (and why are they so ?)		
Question 1.1. Which is the 'Breakthrough' or 'real' innovation achieved in the considered period	3	Brief description: A new set of visualization Tools available on-line A computer code to generate graphs according to specific requests A web interface for data sets
2. Impact on Science and Technology: Scientific Publications in scientific magazines		
Question 2.1. Scientific or technical publications on reviewed journals and conferences	25	Title and journals/conference and partners involved[1] See attached list of publications
Question 2.2. Scientific or technical publications on non-reviewed journals and conferences	6	Title and journals/conference and partners involved[2] See in the attached list of publications the preprint submitted to archive (i.e. cond-mat, physics ecc.)
Question 2.3. Invited papers published in scientific or technical journal or conference.	No	Title and journals/conference and partners involved[3]

[1] Please submit these information in an 'excel' sheet with title of publication/authors/journal or conference/date etc.
[2] Please submit these information in an 'excel' sheet with title of publication/authors/journal or conference/date etc.
[3] Please submit these information in an 'excel' sheet with title of publication/authors/journal or conference/date etc.

3. Impact on Innovation and Micro-economy		
A – Patents		
Question 3.1. Patents filed and pending	0	When and in which country(ies): Brief explanation of the field covered by the patent:
Question 3.2. Patents awarded	0	When and in which country(ies): Brief explanation of the field covered by the patent* (if different from above):
Question 3.3. Patents sold	0	When and in which country(ies): Brief explanation of the field covered by the patent* (if different from above):
Questions about project's outcomes	**Number**	**Comments or suggestions for further investigation**
B - Start-ups		
Question 3.4. Creation of start-up	No	If YES, details: - date of creation: - company name - subject of activity: - location: - headcount: - turnover: - profitable : yes / no / when expected
Question 3.5. Creation of new department of research (ie: organisational change)	No	Name of department:
C – Technology transfer of project's results		

Question 3.6. Collaboration/ partnership with a company ?	No	Which partner : Which company : What kind of collaboration ?
4. Other effects		
A - Participation to Conferences/Symposium/Workshops or other dissemination events		
Question 4.1. Active participation[4] to Conferences in EU Member states, Candidate countries and NAS. (specify if one partner or "collaborative" between partners)	Yes	Names/ Dates/ Subject area / Country: Conference on Complex Systems Torino Villa Gualino 5-7 December 2004 Final conference of COSIN Salou Spain March 14-18 2005
Question 4.2. Active participation to Conferences outside the above countries (specify if one partner or "collaborative" between partners)	yes	Names/ Dates/ Subject area / Country: American Physical Society March Meeting Los Angeles March 21-25 USA
B – Training effect		
Question 4.3. Number of PhD students hired for project's completion	3	In what field : Theoretical Physics
Questions about project's outcomes	**Number**	**Comments or suggestions for further investigation**
C - Public Visibility		
Question 4.4. Media appearances and general		References:

[4] 'Active Participation' in the means of organising a workshop / session / stand / exhibition directly related to the project (apart from events presented in section 2).

publications (articles, press releases, etc.)		(Please attach relevant information)
Question 4.5. Web-pages created or other web-site links related to the project	1	References: http://www.cosin.org (Please attach relevant links)
Question 4.6. Video produced or other dissemination material	1	References: Book in press on World Scientific Press (Please attach relevant material)
Question 4.7. Key pictures of results	No	References: (Please attach relevant material .jpeg or .gif)
D - Spill-over effects		
Question 4.8. Any spill-over to national programs	No	If YES, which national programme(s):
Question 4.9. Any spill-over to another part of EU IST Programme	No	If YES, which IST programme(s):
Question 4.10. Are other team(s) involved in the same type of research as the one in your project ?	Yes	If YES, which organisation(s): Notre Dame University, North Western University, Los Alamos National Laboratory, University of Cambridge, Indiana University, University of Porto

3. PROJECT MANAGEMENT AND COORDINATION

In order to achieve the results of the last year of the project some change of activity has been necessary. As already pointed out in the previous sections some partners have been more involved than scheduled in some deliverables. The most important change we witnessed has been related to the problems of bandwidth and storage necessary in order to produce the crawls of the WWW that we intended.

Given this problem, we had to give up the idea of collecting several large crawls and we concentrated on thematic and geographic subsets. As reported in the latest Periodic Progress Report we also decided to collaborate with external institution to obtain the resources necessary for that initiative. In particular the data set related to the crawl of the pages corresponding to html documents on Italian domain (*.it), those related to the UK domain (*.uk) and those related to the Indochinese domain (*.vt,*.la,*.kh) have been collected by a group in the Department of Computer Science in the University of Milan. That data have been analysed by the participants to node CR2 UDRLS. The collection of thematic subsets has been more complicated since the statistical properties of the data sets were strongly dependent upon the topic considered, passing from a totally disconnected set of pages to a gigantic cluster. The preliminary analysis of some of this datasets confirms the scale-invariance of the system.

For this reason the Deliverable that has been mostly affected with respect to the original plan is the D23 on cyber-communities of the WWW. Given the new mathematical rather than social shape that has been given to this activity nodes C01 INFM and CR2 UDRLS decided to be in charge of that deliverable.

The node CR5 ENS worked then on the revised versions of the deliverables D15 and D16 for which no particular action of management have been necessary.

The other action of coordination was to put together in a coherent way all the efforts for the visualization of large networks. The node active in this scientific research have been CR7 UNIKARL and the node C01 INFM and CR8 UPSUD. The latter two nodes decided to work on a simpler version of the problem, by reducing in a suitable way the complexity of the objects. The node CR7 that was in charge of the deliverable produced instead a software that projecting the graph in “2.5” dimensions (i.e. makes use of the hierarchical nature of some networks) keeps all the vertices and edges in the system, and still produces informative pictures. To decide how to share the various parts of this investigation an extra meeting in Paris on 25-27 June has been organised. Amongst the participants to that meeting were A. Barrat, G. Caldarelli, L. Dall’Asta., M. Gaertler, I. Alvarez-Hamelin A. Vespignani, D. Wagner

4COST BREAKDOWN

Appendix 4 (b) - Comparative Information on Resources (Costs)

Costs in euro for reporting period 1/3/2004 -31/8/2005

	CO1 INFM				CR2 UDRLS (*)				CR3 UB				CR5 ENS (*)			
	Period		Total		Period		Total		Period		Total		Period		Total	
Cost category	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.	Est.	Act.
Direct costs																
1. Personnel	42697	67228	126702	126702	69910	68140	220131	220131	33915	74.171,67	133000	129.636,22	78186	61 000	231108	
2. Durable equipment	0	1437.03	4000	400 0	0	0	12000	12000	0	4.333	13000	7.193	0		0	
3. Subcontracting	0	0	0	0	0		7300	7300	0		0		0		0	
4. Travel and subsistence	3434	3600	9434	9600	5626	7615	16866	16866	6000	8.236,31	18000	19.149,63	0		0	
5. Consumables	0	0	0	0	0	0	0	0	0		0		0		0	
6. Computing	0	0	0	0	0	0	0	0	0		0		0		0	
7. Protection of knowledge	0	0	0	0	0	0	0	0	0		0		0		0	
8. Other specific costs	0	0	0	0	8000	8000	8000	8000		2.281,59	0	2.281,59	8000		8000	
Subtotal	**46131**	**72265,03**	**140136**	**140302**	83536	83755	264297	264297	39915	89022,57	164000	158260,44	86186	61 000	239108	
Indirect costs	0	0	0	0	0	0	0	0	0		0		0		0	
9. Overheads	9226	8885	28028	28022	55927	54511	176104	176104	7983	17.804,52	32800	31.652,09	62549	58 000	184888	
Adjustments**	0	0	0	0	0	0	0	0	0	6.967,99	0	6967,99	0	15 000	0	
Total	**55357**	**81150**	**168164**	**168324**	**139463**	**138266**	**440401**	**440401**	**47898**	**113.795,08**	**196800**	**196.880,52**	**148735**	**134000**	**423996**	

Period: Est.: estimated costs in contract for period Act.: actual costs in period
Total: Est.: estimated cumulative costs to date in contract Act.: cumulative actual costs to date
(*) Requested contribution to EU = 50 % of figures (FF cost basis) (**)under the category "adjustments to costs previously reported" of the next cost statement you should claim the amount of EUR 5.806,66 (being the difference between the correct depreciation for period 1 & 2 and the amount already accepted for both periods ==> 8.666,66 - 2.860,00) + the 20% overheads (EUR 1.161,33).

Appendix 4 (b) - Comparative Information on Resources (Costs)

Costs in euro for reporting period 1/3/2004 -31/8/2005

	CR7 UNIKARL				CR8 UPSUD				CR9 EPFL (*)				TOTAL			
	Period		Total		Period		Total		Period		Total		Period		Total	
Cost category	Est	Act	Est	Act	Est	Act	Est	Act	Est	Act	Est	Act	Est	Act	Est	Act
Direct costs																
1. Personnel	59.136,00	67.258,32	116.239,00	117.828,42	21473	37016.82	42946	37016.82	57053	0	57053	0	364674		1069795	
2. Durable equipment	0	0	0	0	0	1360.43	1333	1360.43	0	0	0	0	0		30333	
3. Subcontracting	0	0	0	0	0	0	0	0	0	0	0	0	0		7300	
4. Travel and subsistence	6.000,00	5.318,20	11.634,00	7.861,94	2803	6373.74	5586	6373.74	4722	0	4722	0	30380		81176	
5. Consumables	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
6. Computing	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
7. Protection of knowledge	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
8. Other specific costs	0	0	0	0	0	0	0	0	0	0	0	0	16000		16000	
Subtotal	69235	0	136362	0	24276	44750.99	49865	44750.99	61775	0	61775	0	411054		1204604	
Indirect costs	0	0	0	0	0	0	0	0	0	0	0	0	0		0	
9. Overheads	13.027,00	15.024,47	25.574,00	25.138,07	4855	8950.2	9973	8950.2	6178	0	6178	0	160565		483596	
Total	**78.163,00**	**87.600,99**	**153.447,00**	**150.828,43**	**29131**	**53701.19**	**59838**	**53701.19**	**67953**	**0**	**67953**	**0**	**571619**		**1688200**	

Period: Est.: estimated costs in contract for period Act.: actual costs in period
Total: Est.: estimated cumulative costs to date in contract Act.: cumulative actual costs to date

5. INFORMATION, DISSEMINATION AND EXPLOITATION OF RESULTS

The following list of activities of the consortium is divided according to publications, conferences and schools. Most of the publications produced are downloadable from the project site at http://www.cosin.org/publications.html

PUBLICATIONS

- Tuning clustering in random networks with arbitrary degree distributions
  Angeles Serrano M, and Boguna M, cond-mat/0507535
- Weighted Configuration Model
  Angeles Serrano M, and Boguna M, cond-mat/0501750
- Competition and Adaptation in an Internet Evolution Model
  Angeles Serrano M, Boguna M, and Diaz-Guilera A, Phys. Rev. Lett. **94**, 038701 (2005)
- Rate equation approach for correlations in growing network models
  Barrat A, and Pastor-Satorras R, Phys. Rev. E **71**, 036127 (2005)
- The effects of spatial constraints on the evolution of weighted complex networks
  Barrat A, Barthelemy M, Vespignani A J. Stat. Mech. P05003 (2005)
- Dynamical patterns of epidemic outbreaks in complex heterogeneous networks
  Barthelemy M, Barrat A, Pastor-Satorras R, Vespignani A, J. of Theor. Biol. **235**, 275-288 (2005)
- Characterization and modeling of weighted networks
  Barthelemy M, Barrat A, Pastor-Satorras R, Vespignani A, Physica A **346**, 34-43 (2005)
- Efficient generation of large random networks
  Batagelj V, Brandes U, Phys. Rev. E **71** 036113 (2005)
- Parallel scheduling problems in next generation wireless networks
  Becchetti L, Leonardi S, Marchetti-Spaccamela A, et al. Networks **45** 9-22 (2005)
- Generalized percolation in random directed networks
  Boguna M, and Angeles Serrano M, Phys. Rev. E **72**, 016106 (2005)
- Studying the emerging global brain Analyzing and visualizing the impact of co-authorship teams
  Borner K, Dall'Asta L, Ke WM, et al. Complexity **10** 57-67 (2005)
- Centrality measures based on current flow
  Brandes U, Fleischer D, Lect. Comp. Sci. **3404** 533-544 (2005)
- Network analysis - Methodological foundations - Introduction
  Brandes U, Erlebach T, Lect. Comp. Sci. **3418** 1 (2005)
- Fundamentals
  Brandes U, Erlebach T, Lect. Comp. Sci. **3418** 7-15 (2005)
- Universal scaling in food-web structure
  Camacho J and A. Arenas A, Nature **435**, E3-4 (2005)
- Comparison of voter and Glauber ordering dynamics on networks
  Castellano C, Loreto V, Barrat A, et al. Phys. Rev. E **71** 066107 (2005)
- Generation of uncorrelated random scale-free networks
  Catanzaro M, Boguna M, and Pastor-Satorras R, Phys. Rev. E **71**, 027103 (2005)
- Analytic solution of a static scale-free network model
  Catanzaro M, and Pastor-Satorras R, Eur. Phys. J. B **44**, 241-248 (2005)
- Characterization and modeling of protein-protein interaction networks
  Colizza V, Flammini A, Maritan A, et al., Phys. A **352** 1-27 (2005)
- Statistical theory of Internet exploration
  Dall'Asta L, Alvarez-Hamelin I, Barrat A, et al., Phys. Rev. E **71** 036135 (2005)
- Community structure identification
  Danon L, Duch J, Arenas A, and Diaz-Guilera A, cond-mat/0505245
- Improved spectral algorithm for the detection of communities
  Donetti L, and A Munoz M, physics/0504059

- Entangled networks, super-homogeneity and optimal network topology
  Donetti L, I Hurtado P, and A Munoz M, cond-mat/0502230
- Community detection in complex networks using Extremal Optimization
  Duch J, and Arenas A, Phys. Rev. E **72**, 027104 (2005)
- Spectral methods cluster words of the same class in a syntactic dependency network
  Ferrer i Cancho R, Capocci A and Caldarelli G, cond-mat/0504165
- The variation of Zipf's law in human language
  Ferrer i Cancho R, Eur. Phys. J. B **44** 249-257 (2005)
- The consequences of Zipf's law for syntax and symbolic reference
  Ferrer i Cancho R, Bollobas B and Riordan O, Proc. R. Soc. Lond. Series B 272, 561-565 (2005)
- Universal scaling in food-web structure
  Garlaschelli D, Caldarelli G and Pietronero L , Nature **435**, E4 (2005)
- The Scale-free topology of market investments.
  Garlaschelli D, Battiston S, Castri M, Servedio VDP, Caldarelli G, Physica A **350** 491 (2005)
- Efficiency of informational transfer in regular and complex networks
  Vragovic I, Louis E, and Diaz-Guilera A, Phys. Rev. E **71**, 036122 2005
- Persuasion dynamics
  Weisbuch G, Deffuant G, Amblard F, Phys. A **353** 555-575 (2005)

LECTURES AND CONFERENCES

A. Barrat:, Invited talk ``Traceroute-like exploration of unknown networks: a statistical analysis'', workshop on structure and function of complex networks, Trieste, Italy, May 16-28 2005.
A. Barrat, Lecture ``Réseaux complexes valués'', thematic school ``Grands réseaux d'interactions'', April 25-29 2005, Paris.
A. Barrat, Invited talk ``Traffic-driven model of the World Wide Web Graph'', Third Workshop on Algorithms and Models for the Web-Graph (WAW 2004), Rome, Italy, October 16 2004.
A. Barrat, Invited talk ``Traceroute-like exploration of unknown networks: a statistical analysis'', conference ``Combinatorial and Algorithmic Aspects of Networking and the Internet'', Banff, Canada, August 5-7 2004.
A. Barrat, Invited talk ``Graphes petit-monde'', Algotel 2004 (6èmes Rencontres Francophones sur les aspects Algorithmiques des Télécommunications), May 26-28 Mai 2004, Batz-sur-mer, France.
G. Caldarelli series of lectures at School: *Structure and Function of Complex Networks*, Trieste, Italy, May 23-28, 2005.
G. Caldarelli *Statistical properties of scale-free graphs* Erice 9-11 December 2004
G.Caldarelli Conference: *Science of Complex Networks: From Biology to the Internet and WWW*, Aveiro, Portugal. August 30, 2004.
G. Caldarelli *Scale-free networks in Social Science* Cagliari 27 June 2005
A. Capocci had an invited talk on the conference on Statistical Mechanics held in Crete in August 2005.
A. Capocci Algorithm for Community Detection *Science of Complex Network* Aveiro August 2004.
P. De Los Rios School: *Structure and Function of Complex Networks*, Trieste, Italy, May 23-28, 2005.
P. De Los Rios Conference: *Complex Networks: Evolution and Statistical Properties*, Salou, Spain. March 14-18, 2005.
P. De Los Rios Lecture at IBM T.J. Watson Research Center, Yorktown Heights NY, USA, March 4, 2005.
P. De Los Rios Lecture at Cold Spring Harbor Laboratory Cold Spring Harbor NY, USA, March 2, 2005.
P. De Los Rios Lecture at National Institutes of Health (NIH), Bethesda, MD, USA, February 28, 2005.
P. De Los Rios Lecture at European Molecular Biology Laboratory, Heidelberg, Germany, October 15, 2004.
P. De Los Rios Conference: *Science of Complex Networks: From Biology to the Internet and WWW*, Aveiro, Portugal. August 30, 2004.
A. Vespignani series of lectures at School: *Structure and Function of Complex Networks*, Trieste, Italy, May 23-28, 2005.
A. Vespignani, Focus session on Complex networks at the American Physical Society March Meeting in Los Angeles, March 21-25 2005 (organizer).
A. Vespignani. Invited talk, "Epidemic modelling: dealing with complexity", International Conference on "Complex Systems Across Disciplines", Northwestern University, Chicago, Illinois, October 29-30, 2004.
A. Vespignani, Invited Talk, "Computer virus epidemics in complex technological networks", International Workshop on "Adaptive and Resilient Computing Security (ARCS04)", Santa Fe Institute, New Mexico, November 3-4, 2004.
A. Vespignani, Invited Talk,"Epidemic modelling in complex networks" MiDAS consultation Group on Social Networks, Brookings Institution, Washington DC, USA 5-6 January 2005.
A. Vespignani, Invited talk "Epidemic modelling dealing with complexity", "understanding and preventing infectious diseases", University of British Columbia and Canadian center for Disease Control, Vancouver 19-22, Canada, January 2005.

A. Vespignani, Invited talk, "Evolution and structure of the Internet", American Physical Society March Meeting, Los Angeles, March 21-25 2005.
A. Vespignani, Invited Talk, "Evolution and structure of the Internet", Santa Fe research Collaboration Program "Robustness of multiple overlapping networks" , Santa Fe, New Mexico, USA 25-29 April 2005.
A. Vespignani, Invited Talk, Epidemic modelling: dealing with complex networks" Symposium on Biological and Social Networks, Physik seit Einstein, 69th Annual meeting of the German physical Society, Berlin Germany, 4-9 March 2005.
A. Vespignani, Invited Talk, "Epidemic modelling in complex networks", Conference "Complex Networks and Random Graphs", Physikzentrum Bad Honnef, Germany, 11-13 July, 2005

SCHOOLS

G. Caldarelli held a course of statistical mechanics of networks in the PhD programme of the university of Rome la Sapienza.
A. Vespignani Tutorial on "Network Science" held in Cagliari, Italy on June the 27th 2005 (organizer)
A. Vespignani School and workshop on "the structure and function of complex networks" held in Trieste, Italy on May 16- 28 2005 (organizer).

CONFERENCES

G. Caldarelli Organised a session on Complex Networks on Material and Device Meeting in Genova 22-25 June 2005.
A. Diaz-Guilera Final COSIN meeting held in Salou March 2005.
A. Vespignani Focus session on Complex networks at the American Physical Society March Meeting in Los Angeles, March 21-25 2005 (organizer).

BOOKS

Editing of the book "Structure and dynamics of complex networks" to be published with Imperial college and World Scientific at the end of 2005. The book collects contributed chapters on the activities of the various groups involved in the project (A. Vespignani and G. Caldarelli Eds). The contents of the book are the following

- BASIC GRAPH THEORY (*G. Caldarelli and A. Vespignani*)
- ELEMENTARY STATISTICAL MODELS (*P. De Los Rios*)
- WEIGHTED NETWORKS (*A. Barrat, M. Barthelemy, A.Vespignani*)
- COMMUNITY DETECTION (*L. Danon, J. Dutch, A. Arenas, A. Diaz-Guilera*)
- STUDY OF THE INTERNET (*R. Pastor-Satorras, A. Vespignani*)
- STUDY OF THE WWW (*D. Donato, L. Laura, S. Millozzi, S. Leonardi*)
- ECOLOGICAL NETWORKS (*G. Caldarelli, C. Caretta-Cartozo, D. Garlaschelli*)
- FINANCIAL NETWORKS (*S. Battiston, G. Caldarelli, M. Catanzaro*)

U. Brandes and T. Petermann Book on Graph Methodologies, Springer 2005.

WEBSITE

The site is divided in three main regions,

- the part on publications,
- the part on datasets, together with analysis interface and code for generation
- the part on dissemination through lectures and deliverables.

All the components of the site have been reshaped and refurbished with the activity done in the last year of the project. A particular interest in the dataset of networks has been paid by the scientific community. A complete description of the WWW site is reported in the Deliverable D21-D27.

APPENDIX A: COMMENT FROM PREVIOUS REVIEW

Summary description of the project

The COSIN project is dedicated to developing the theory of complex networks, tools to analyze the structure of networks, and applications of this theory and these tools to characterize the structure of actual technological and social networks.

1 General Aspects

Overall appraisal of the status of the project

In its second year, COSIN research has achieved several important results and milestones. In particular, it has made substantial progress in providing alternative explanations for the seeming ubiquity of technological, biological and social networks with long-tailed degree distributions, invoking "disorder" rather than growth and preferential attachment, which Barabasi and his collaborators had claimed as a necessary and sufficient cause for power-law degree distributions.

In addition, COSIN researchers have very successfully constructed data structures and algorithms that make it easier to develop standardized data bases for very large networks, which are too large to be simultaneously present in core. It will be interesting to see them applied to real-world data sets.

Another group of COSIN researchers attempt to completely overhaul the visione program that allows visualization of networks, in order to accommodate very large networks (millions or even billions of nodes), and have created additional visualization tools, based on spectral analyses, that may yield greater insight into the structure of large networks.

Several groups of COSIN are independently exploring algorithms for the discovery of "community structure" in large networks, a new and rapidly expanding research area that was not envisioned in the original COSIN plan but is highly.

Finally, work has begun on applying ideas of "complex network theory" to social systems, through an attempt to model the effects of underlying network structures on corporate board decision making.

Work on mapping the structure of internet and WWW has been put aside, as this has turned out be more difficult than envisioned and beyond the budget and capacity of the project consortium. The project has attempted to add to its internal capabilities in this area by allying with a CNR Rome-based laboratory and externally by establishing links with larger scale projects like CAIDA.

COSIN has responded very well to the criticism from the first-year review of its website, which now is quite informative, with lots of links to other interesting related sites, and also easy to navigate. Probably it is also frequently consulted.

While the overall scientific level of the second year research results is without any doubt very high, several troubling issues emerged during the review. First, the communication within the project does not seem to be functioning as well as it might. In particular, the different groups working on algorithms for discovering community structure did not seem aware of each other's efforts or accomplishments. Also, there did not seem to be coordination between the development of techniques to represent and analyze very large networks and of techniques to visualize them. Finally, while nearly all the theoretical developments, representational and visualization seemed to be directed towards very large networks and, in particular, issues about their topologies, the work on modeling social systems was based on rather small networks, had little to do with the aspects of topology towards which the theoretical work was primarily oriented (large-tailed degree distributions, the relevance of different notions of betweenness and centrality, discovering hidden community structure), and made no use of the representation and visualization technologies developed by the project.

Second, while COSIN researchers seem to be in close contact with other top researchers in network theory coming from the statistical physics community, they don't seem to be interacting at all with network researchers from the social science community, where some very interesting new developments are happening, especially in studying how network structure changes over time and how these changes affect socially important processes that are supported by networks. Also it is an open question whether very large networks are necessarily the most important for understanding how social systems function – or, in fact, whether we are in position to learn anything interesting in the foreseeable future from such networks, while the work of the researchers listed above shows conclusively that we have much to learn by asking good questions and developing appropriate technology to analyze "moderate-size" networks of hundreds to thousands of nodes.

In summary, while COSIN managed to make impressive and important progress in the science of networks, what seems lacking at this stage is demonstrating how methods or ideas from that science can impact other scientific enterprises. Such a demonstration is crucial as otherwise the current interest in this research could burst as quickly as it appeared. This is of course a criticism which should be extended to all researchers in this field, but as COSIN happens to define the state of the art of this type of research in Europe it is also up to them to demonstrate its potential impact. So far, work that attempts to use the ideas of the "new science of networks", have been of very limited value in providing rich insights – with the signal exception of technological networks, in particular Internet and WWW, as the Pastor-Satorras and Vespignani book so clearly demonstrates.

Relevance of the work carried out and planned to the current state-of-the-art in the field
The work in the area of analyzing existing engineered networks is state-of-the-art and is contributing to defining the direction of the field as a whole.
In the social networks area, the field is undergoing active development, but it hasn't yet gone much beyond phenomenology in exploiting the new discoveries in network topology that COSIN's theorists are exploring. In this regard, projects like COSIN could provide an important impetus in this direction. However, they have not chosen to do so, instead producing studies that have intermediate results which are intended as challenges to other social modellers. We do not find these results very compelling, and wonder if others will.
In visualization, the COSIN partners have been state-of-the-art but this field is changing. As networks become too large to visualize directly the emphasis is shifting to more use of online analytic tools, based on algorithms which extract significant information while looking at only a fraction of the actual data. The COSIN effort is only starting to move in this direction.

List of Deliverables: Status and overall assessment

The following deliverables were reviewed, some at our meeting, and others read after the review, as the discussion did not permit close study:
D10 check of the state of the art – this provides a nice brief overview of the field, and reports on a survey developed at COSIN's mid-course meeting
D11 self-organization in networks – this item, as well as Deliverable 04 from the first year, have been extended and have not yet been met. They are scheduled for delivery March 2005. It is not clear if these will be reviewed at that time or will be considered at the time of the final annual review.
D12 database of collected data – describes effectively the data sets that COSIN has made available or utilized from others' work. It also lists the new efforts that have started as a result of collaborations
D13 library of software tools for performing measurements on large networks – this is very nice work which will be recognized in its field. The tools appear to be useable and in use. Effort should be continued to make them available (and usable) to a large group of researchers.
D14 Customization of visualization tools– this deliverable is not acceptable in its present form. Although the work underlying this area – streamlining Visione and redirecting effort towards less graphical tools is of first quality, the report that constitutes the Deliverable does not show this. It consists of excerpts from a report on the contents of the Visione package, which is attached. That report appears to

predate Prof. Wagner's move to Uni-Karlsruhe. The deliverable should be redrafted. It does not need to be long, but should report the work that is specific to COSIN and detail the interactions that have occurred within the project as a result of FET's support. Our suggested deadline for this is October 2004.

D15 Modelling interaction and dynamics within firms – as we state in detail elsewhere in this report, we have doubts about the direction of this work, as well as its links to the rest of COSIN. We recommend to rework this deliverable. See recommendations for details.

D16 Firm networks dynamics – limited time prevented much discussion of this work during the review meeting. We instead focussed on the related deliverable 15.

D17 Algorithms for network analysis –there appears to be excellent work done in COSIN under this heading. Unfortunately, it is not possibly to judge the quality of D17. The Deliverable summarizes the content of five or six pieces of work published in various conferences, but does not even attach the papers described. A further paper is attached, but with no comment or summary. We propose that this deliverable be redrafted to give more detail, and the underlying material attached. Again, links within the COSIN effort could be made more clear. A October 2004 deadline seems appropriate. See recommendations for detail.

Remark: It is important to realise that work done should be put into a context which makes the results accessible and ultimately usable. Major improvements were made by the consortium with respect to year. It is, however, in the best interest of the consortium necessary to further improve the way they present results.

Project management and co-operation

The first year review, which is attached as Appendix C to the second year's progress report, identified several key shortcomings in COSIN which were challenges to its management and coordination:

* Lack of close collaboration between the three areas identified above, with the Konstanz (now Karlsruhe) and ENS social networks efforts proceeding independently.
* Several first year deliverables were presented as simple collections of papers, not as a coherent body of work resulting from the COSIN collaboration. And in one case the collection of papers is not even included. This seems, well, arrogant.

Both issues were tackled in the second year and considerable improvement was achieved, although there is still room for further improvement: Again several deliverables consisted only of collections of published papers (D14, D17) with no attempt to fit these publications within the overall goal of the project..

A number of COSIN meetings were held during the past year, the Rome conference brought the group (and the whole field) together, and the Self-* workshop held in Bertinoro shortly after our review meeting also should help to integrate this effort.

The objections on lack of collaboration between certain partners raised in the first year review are equally valid at the end of the second year, as we found that the visualization effort and the social networks activities still showed little overlap with the stronger program in the first area.

Relation to other projects

COSIN and BISON planned and held a joint workshop in Bertinoro (the Self-*) meeting, and are producing a book from the position papers and lectures delivered there. The DELIS integrated FP6 project is in large part a descendant of COSIN. A greater effort is being placed in the FP6 integrated projects to ensure that all four FET-funded activities meet together at regular intervals and present a united approach where this is technically appropriate.

Plans for dissemination of results

The public website for COSIN was static during the second year of the project, unchanged from the form that it took at the first year review. However, the private website pages underwent significant development and this much richer site is now on public display. Much of this is intended to continue in the public view during the last year of the project. We did not hear about plans to ensure continuation of the website as an active force. This should be addressed in the final year of the project.

Book publication is a very positive result of the COSIN effort and should ensure a lasting impact of this work. The book published so far and the Rome conference proceedings give an excellent overview of the field. The Self-* conference intends to publish a book, and one more collection is planned, in conjunction with the final conference that COSIN will hold. Several COSIN participants have been active program committee members in Web-related and complexity conferences, and as a result there is a good presence among invited speakers in these two areas.

Impact assessment of project results
This work will continue to have an impact in the academic fields that are attracted to the study of networks, through its strong publication record and involvement in conferences.

Tasks and Activities: Scientific evaluation and performance
Looking at the five technical workpackages in Annex-1 of the IST – COSIN contract, we conclude that WP3, 4, and 5 are proceeding smoothly, although with less coordination and synergy than was hoped for. WP2, the measurement program to generate new data and data with a European emphasis, is just beginning to happen, through collaboration with the activities under Dr. Coccetti, who is part of a different project. WP1, called "mathematical tools for complex systems," has not produced any of its intended results. Although there were tools discussed for analyzing large graphs when access to offline media storage becomes an issue, these have not been used to the point of providing progress towards answers to the questions of universality and self-organized criticality that the COSIN proposal targets.

More detailed comments are provided in the discussion of the list of Deliverables**.**

Application - Exploitation Perspectives
Many COSIN participants have consulting roles and industrial support for their activities, so this work will be exposed to industrial management. But it is fundamentally analytic in its emphasis, not directed at inventing new ways to do things. Thus we do not expect to see start-up activities spun off, although surprise applications could always surface when there is new information available, and the participants actively look for the implications of it.

4 Summary conclusions and recommendations

As several deliverables will need to be worked on, the recommendations concern mainly these deliverables.

1. We recommend that in
    a. WP1: Developed algorithms are used to analyse networks (in order to ensure that D4 will be fulfilled by end of project; see also point 6)
    b. WP3: As it is crucial to have a visualisation SW for large scale networks attempts need to be made to deliver on D14 well before end of the project (see point 5).
    c. WP4: In the light of remarks of reviewers, it seems important to reconsider the approach of deliverables D15 and D16. Important to put it in perspective of research done elsewhere on social networks and to work on clearly identified measurable quantities to confirm/reject predictions of the method chosen. D15 and D16 should be resubmitted for the final review.
    d. WP5: D17 produced extremely valuable scientific results. It is a pity that the full impact of these results is not visible in the report submitted as the results were not put into context and analysed in their entirety. It is there fore recommended to resubmit report on D17 describing in a concise way the achievements and the impact of the results on the analysis of networks. (see also point 3)

2. In its third year, the project needs to work harder on integrating and consolidating its results. In particular, the various teams should use and test each others' data representation, visualization and analysis algorithms and report the successes and shortcomings experienced with these techniques.

3. Several of the deliverables are written as if no one would ever read them. Yet they form the permanent record of this effort, and should be constructed to be valuable to students, succeeding researchers, and the complex systems community. We ask that they be redrafted in order to communicate the work as it deserves, and to reflect the true status of the underlying technical work.

4. The work on social systems should attempt to apply the new ideas on network topology and its effects on processes "running" on networks developed by the theoretical work on complex networks. So far, this is not happening, and this is the principle reason that we recommend to rework deliverable D15. The whole project should take responsibility for developing strategies to apply what the theoretical and algorithmic work they are doing. In addition, they should make some effort to connect with the communities of researchers in the social and biological sciences that have been thinking about networks for decades, to try to discover the kinds of problems for which their concepts and methods might yield scientific breakthroughs. Since this will require a lot of work, we think the deadline for resubmission of D15 should be at the end of the project's third year. The investigation of social networks within COSIN would need to answer a couple of questions by the end of the third year: First, it is not clear that the models proposed in D15 and D16 lead to the prediction of any observable quantities, which at least raises the issue of how they could possibly lead to testable hypotheses about social processes. Second, the questions posed in WP4 do not seem to be answered, perhaps even addressed, by these deliverables. This could be a serious problem for the project, if the aim of their research is to show that the complex network theory and analytic tools they are developing may be useful in the general scientific community (here, in particular to social scientists): the work described in D15 and D16 does NOT apply the theory or the tools with which the other COSIN scientists are engaged, and does not in its present form seem likely to compete successfully for the attention of social scientists. It might be of use for the leaders of WP5 to position themselves with respect to work by John Padgett, Doug White, Woody Powell and Jason Owen-Smith and perhaps even to discuss with them how their work might be coordinated with what these investigators are doing.

5. Since there is additional work in the COSIN technical annex that depends on having a visualization tool ready for use in the final year of the project, a performance improvement of Visone to a point where that work can be carried out is part of completing the project successfully. A better collaboration between Barcelona and Karlsruhe will help in this respect. The report on deliverable D14 should be redrafted so as to give a better picture of achievements. Apply the algorithms and tools developed to analyse large datasets to real world data in order to demonstrate their value-added. Also try to link up with work in DELIS