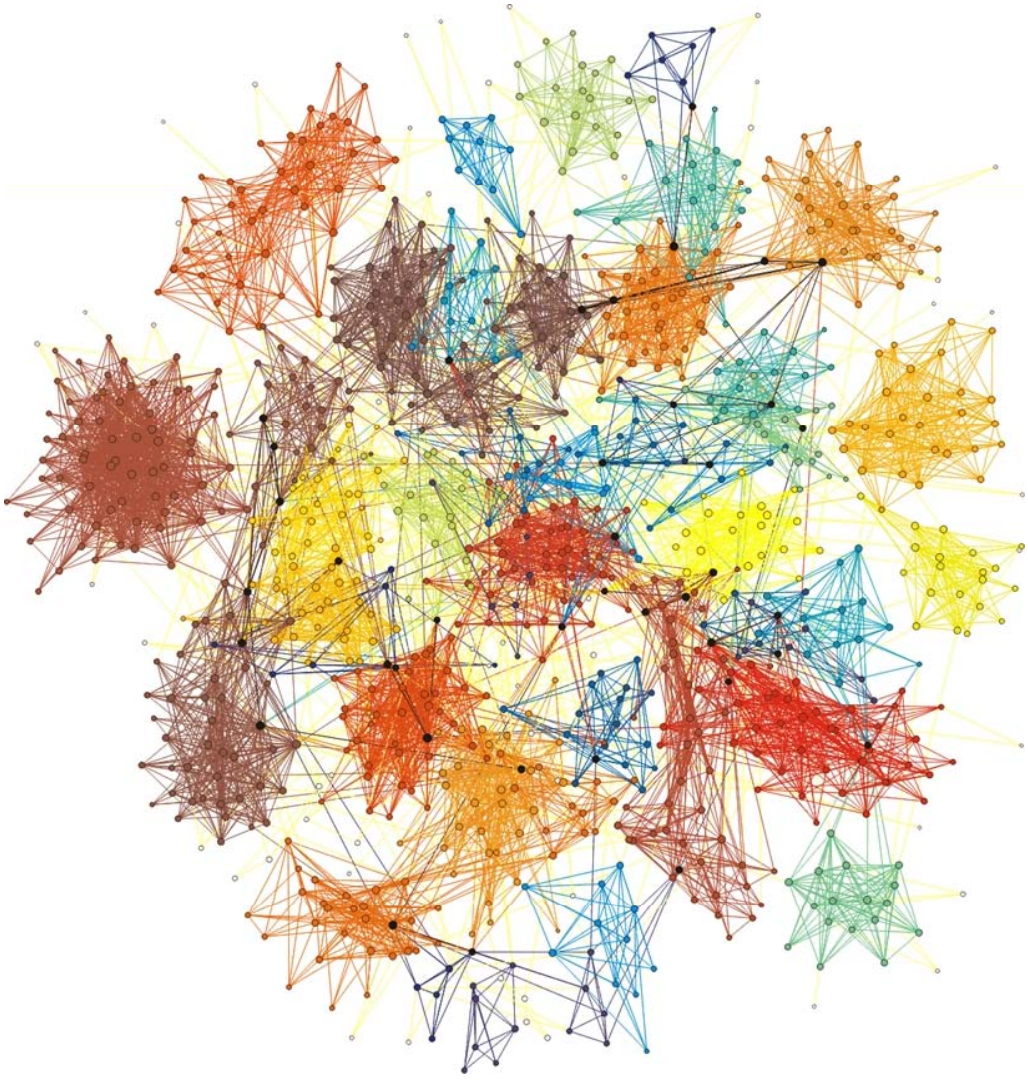
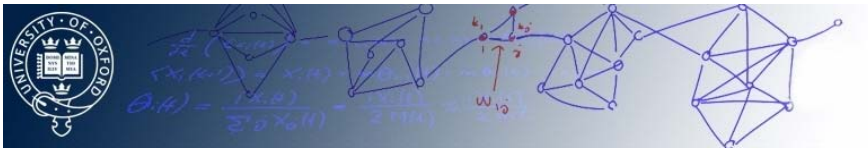
UNIVERSITY OF OXFORD

Complexity Centre

ANNUAL REPORT 2009/2010





The CABDyN Complexity Centre was established in July 2003 with seed funding under the EPSRC Novel Computation Initiative.

The acronym CABDyN stands for **C**omplex **A**gent-**B**ased **Dy**namic **N**etworks, and reflects our shared interest in network dynamics and agent-based models of complex systems across a broad range of application domains.

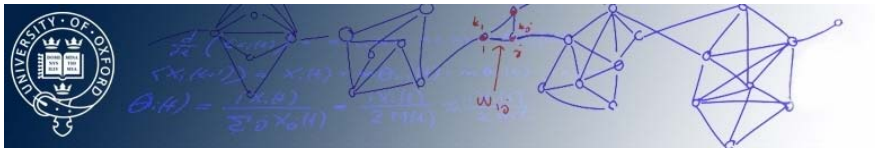
CABDyN brings together a truly multi-disciplinary group of researchers in Oxford, ranging from the physical, biological and computational sciences to the social, economic and political sciences.

This document reports on its activities for the period 1st October 2009 to 30th September 2010.

Dr Felix Reed-Tsochas and Dr Janet Smart
Co-Directors,
CABDyN Complexity Centre,
Saïd Business School,
University of Oxford

May 2011

Cover image courtesy of Nick Jones, Department of Physics and Centre for Integrative Systems Biology, University of Oxford



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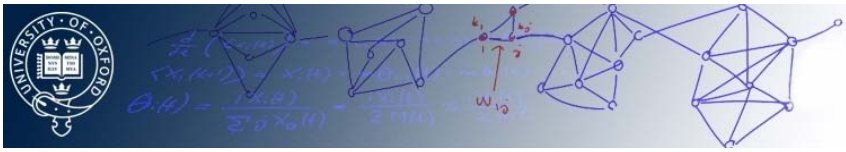
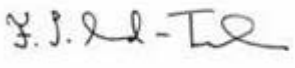


This second annual report covering the academic year 2009/10 shows that the level of interest across Oxford in complex systems research remains undiminished, as reflected by a large number of activities, publications, and externally funded research projects. Articles with CABDyN authors or co-authors have appeared in journals including *Science*, *Nature*, *Proceedings of the National Academy of Sciences of the USA*, *Proceedings of the Royal Society B*, *PLoS Computational Biology*, *Ecology Letters*, and the *Annual Review of Sociology.* We are very pleased that it has been possible to maintain visibility in journals with high impact, across an unusually diverse set of topics that reflect the broad scope of research interests represented within CABDyN. Of course, publishing in the most highly regarded disciplinary and interdisciplinary journals is what most researchers would seek to do as a matter of course, and in itself is not sufficient to demonstrate the good health of an interdisciplinary research community. Over the next couple of years, we hope that CABDyN members will reassemble in novel and previously untried combinations to work on new research projects and publications, so that the structure of collaborations within CABDyN evolves, with new links between different topics and departments.

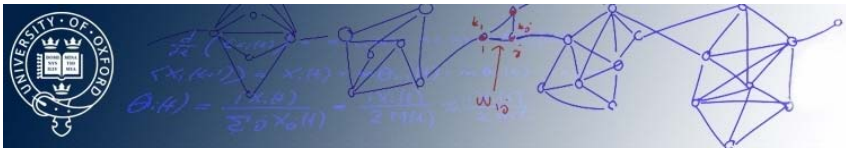
The CABDyN seminar series continues to provide a focal point for a cross-disciplinary research community in Oxford with shared interests in complex systems. This year, speakers included Duncan Watts (Yahoo!), Alan McKane (Manchester), Nicholas Christakis (Harvard), David Strang (Cornell), Alex Arenas (Tarragona), and Rodney Garrett (UCSB). In addition to the regular schedule of talks, as an experiment that should help build increasingly strong links with the Oxford Martin School, we co-organised a high profile special seminar series on "Complexity and Systemic Risk." The series, held at the Oxford Martin School, opened with a talk by Lord May on "Stability and Complexity in Model Banking Systems", and continued with an extremely distinguished roster of speakers including Geoffrey West (Santa Fe Institute), Mike Batty (UCL), Alessandro Vespignani (Bloomington), and Dirk Helbing (ETH Zürich). With audience numbers in excess of one hundred at some of these talks, and with much attention paid to the coverage in blogs hosted by the Oxford Martin School, it is clear that interest in these topics within Oxford exceeds currently active CABDyN membership. Hence, there should be ample opportunities for growth as we more forward.

The academic year 2009/10 also saw the start of a number of new externally funded research projects. ICTeCollective, funded by the European Commission under the 7th Framework, is exploring social systems in which social interactions are mediated by information and communication technology (ICT). Some preliminary findings from research carried out in Oxford on how Facebook applications spread received prominent coverage in a story in the New Scientist entitled "Social Web" The Great Tipping Point Test." The international partners for ICTeCollective are based at Aalto University (Finland), the Institute for Scientific Interchange (Turin), Budapest University of Technology and Economics, and the University of Warsaw. In addition, ICTeCollective has provided an opportunity to initiate a new collaboration within Oxford with Robin Dunbar's group at the Institute for Cognitive and Evolutionary Anthropology. Mason Porter's new project on communities of social and political networks in the United States Congress, funded by a $420,000 grant from the James S. McDonnell Foundation, started in October 2009 and will run until September 2013. SATURN (Self-Organising Adaptive Technology Underlying Resilient Networks), a project funded by the EPSRC and the Technology Strategy Board, started in November 2009 and will run for three years. The objective is to develop new techniques that can help make critical infrastructure networks more robust, and in addition to CABDyN the project involves two other university partners (Warwick University, Imperial College London) and two industrial partners (British Telecommunication, Northrup Grumman UK). Finally, just before the period covered by this report draws to a close, a new project called FOC (Forecasting Financial Crises) funded by the European Commission under the 7th Framework is starting up. The National Research Council of Italy (CNR), City University London, ETZ Zürich, Universitá Politecnica delle Marche, Fundació Barcelona Media, and the European Central Bank are the other consortium partners for FOC, and CABDyN's contribution in particular will build on a strong existing collaboration with HSBC Global Research.

As always, the year marked a number of arrivals and departures. Quentin Atkinson, based at the Institute for Cognitive and Evolutionary Anthropology while in Oxford, moved to a Lectureship in the Department of Psychology at the University of Auckland in New Zealand. Jukka-Pekka Onnela, previously on leave at the Kennedy School at Harvard as a Fullbright Visiting Scholar, accepted a Postdoctoral Fellowship in the group of Nicholas Christakis at Harvard Medical School. Serguei Saavedra, based at the Department of Engineering Science and the Saïd Business School, was appointed to a Postdoctoral Fellowship at the Norhwestern Institute on Complex Systems (NICO) and the Kellogg School at Northwestern University. As someone who straddles the categories of arrivals and departures, Diego Garlaschelli arrived in Oxford from Sienna in October 2009 for a brief but very productive six-month Postdoctoral Fellowship to work on the ICTeCollective project before taking up a previously arranged appointment at the School of Advanced Studies in Pisa. Alexandra Brintrup, who holds a PhD in computer science from Cranfield University, joined CABDyN and the Saïd Business School from the Institute for Manufacturing at Cambridge University to work on the SATURN project. Finally, Elizabeth Leicht joined CABDyN from the University of California at Davis, where she worked with Raissa D'Souza, having previously completed a PhD with Mark Newman at the University of Michigan. Elizabeth is a Research Fellow in Complex Networks at Wolfson College and the Saïd Business School, funded through a collaborative agreement with Aalto University for which we are extremely grateful. Although it is exciting to see CABDyN members move on to different positions and challenges at other institutions, it is also gratifying that we are able to attract such excellent new researchers to Oxford.



Felix Reed-Tsochas



PEOPLE

CABDyN Co-Directors

Dr Felix Reed -Tsochas, James Martin Lecturer in Complex Systems and Co-Director of the CABDyN Complexity Centre.

Dr Janet Smart, Research Fellow, Saïd Business School and Co-Director of the CABDyN Complexity Centre.

CABDyN Members

Prof Samson Abramsky, Christopher Strachey Professor of Computing, Oxford University Computing Laboratory.

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Dr Dan Bebber, Junior Research Fellow in Biology, St. Peter's College at the University of Oxford and Head of Climate Change Research, Earthwatch Institute.

Dr Michael Biggs, University Lecturer, Department of Sociology, University of Oxford.

Prof Paul C Bressloff, Professor of Mathematical and Computational Neuroscience, Oxford Centre for Collaborative Applied Mathematics, University of Oxford.

Dr Alexandra Brintrup, Senior Research Fellow in Complex Networks, CABDyN Complexity Centre, Saïd Business School, University of Oxford.

Dr Hugh Cartwright, Laboratory Officer of the Physical & Theoretical Chemistry Laboratory, University of Oxford.

Prof Iain Couzin, Assistant Professor, Department of Ecology and Evolutionary Biology , Princeton University.

Prof Jerker Denrell, Professor of Strategy and Decision Making, Saïd Business School, University of Oxford.

Dr Thomas E Downing, Executive Director of the Oxford Office of the Stockholm Environment Institute.

Dr Mark Fricker, University Lecturer in Plant Science and Tutorial Fellow Department of Plant Sciences, University of Oxford.

Ben Fulcher, Doctoral Student, Department of Physics, University of Oxford.

Dr Diego Garlaschelli, Research Fellow in Complexity Science, CABDyN Complexity Centre, Saïd Business School, University of Oxford.

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Prof Neil Johnson, Professor of Physics, University of Miami.

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Prof Alex Kacelnik, Professor of Behavioural Ecology, Department of Zoology, University of Oxford.

Dr Ken Kahn, Senior Researcher, Learning Technologies Group, Oxford University Computing Services.

Prof Kimmo Kaski, Professor of Computational Science and Engineering, Aalto University/Helsinki University of Technology & Supernumerary Fellow Wolfson College, University of Oxford.

Dr Tomomi Kito, Research Fellow BT Centre, Saïd Business School, University of Oxford.

Dr Eduardo López, Research Fellow in Complexity Science, CABDyN Complexity Centre, Saïd Business School, University of Oxford.

Prof Philip Maini, Professor of Mathematical Biology, Centre for Mathematical Biology ,University of Oxford.

Dr Patrick McSharry, Smith School of Enterprise and the Enviroment, Centre for Catastrophe Risk Financing, University of Oxford.

Dr Antonis Papachristodoulou, Departmental Lecturer in Control Engineering, Department of Engineering Science, University of Oxford.

Dr Mason Alexander Porter, University Lecturer, Oxford Centre for Industrial and Applied Mathematics (OCIAM), University of Oxford.

Griffith Rees, Doctoral Student, Department of Sociology, St. Cross College, University of Oxford.

Prof Gesine Reinert, Professor of Statistics, Department of Statistics, University of Oxford.

Nick Sabin, Doctoral Student in Management Studies, Saïd Business School, University of Oxford.

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Dr Takeshi Takama, Research Fellow, Oxford Office of the Stockholm Environment Institute.

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Dr Jeff Tseng, University Lecturer, Department of Physics, University of Oxford.

Dr Nir Vulkan, University Reader in Business Economics, Saïd Business School, University of Oxford.

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Prof Paul A David, Senior Fellow of the Standford Institute for Economic Policy Research (SIEPR), and Associate Fellow of the Institute for Science, Innovation and Society. Professor Emeritus of Economics at the Universities of Oxford and Stanford.

Dr Serguei Saavedra, Post-Doctoral Research Fellow, Northwestern Institute on Complex Systems (NICO), Kellogg School of Management, Northwestern University.

Prof Geoffrey West, Distinguished Professor at the Santa Fe Institute in New Mexico (USA).

CABDyN Visiting Fellows

Dr Robert Ghanea-Hercock, Chief Research Scientist at BT Laboratories, Chartered Engineer and a Fellow of the British Computer Society.

CABDyN Visitors

Prof Geoffrey West
Santa Fe Institute, New Mexico, USA
8th- 11th July 2010

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Institute for Scientific Interchange Foundation, Torino, Italy
15th-19th May 2010

Dr Wiesław Bartkowski
Institute for Social Science, University of Warsaw, Poland
14th – 17th March 2010

Dr Santo Fortunato
Institute for Scientific Interchange ,Torino, Italy
14th – 17th March 2010

Prof Kimmo Kaski
Helsinki University of Technology, Finland
14th – 17th March2010

Dr Márton Karsai
Department of Biomedical Engineering and Computational Science, Helsinki University of Technology, Finland
14th – 17th March 2010

Prof János Kertész
Institute of Physics, Budapest University of Technology and Economics, Hungary
14th – 17th March 2010

Dr Elizabeth Leicht
Department of Mechanical & Aeronautical Engineering, University of California, Davies, USA
14th – 17th March 2010

Dr Jukka-Pekka Onnela
Medical School, Harvard University, USA
14th – 17th March 2010

Dr Jari Saramäki
Department of Biomedical Engineering and Computational Science, Helsinki University of Technology, Finland
14th – 17th March 2010

Robert Sumi
Budapest University of Technology and Economics, Hungary
14th – 17th March 2010

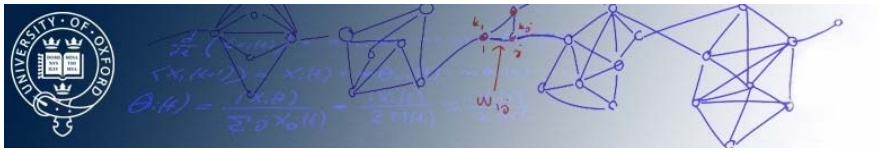
Dr Michał Ziembowicz
Faculty of Psychology, University of Warsaw, Poland
14th – 17th March 2010

Dr Serguei Saavedra
Northwestern Institute on Complex Systems (NICO), Northwestern University, USA
7th – 12th March 2010

Prof José Fernando Mendes
Department of Physics, University of Aveiro, Portugal
13th -17th February 2010

Prof Geoffrey West
Santa Fe Institute, New Mexico, USA
17th December 2009 – 4th January 2010

Prof Alan Baker
Department of Philosophy, Swarthmore College, USA
22nd December 2009 – 16th January 2010



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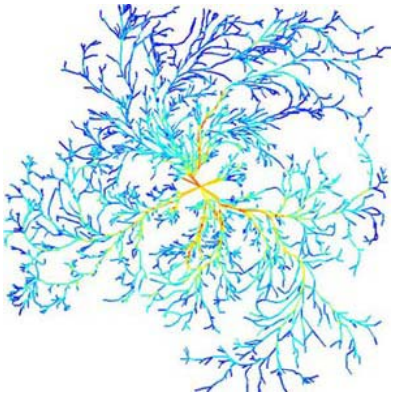
RESEARCH ACTIVITIES

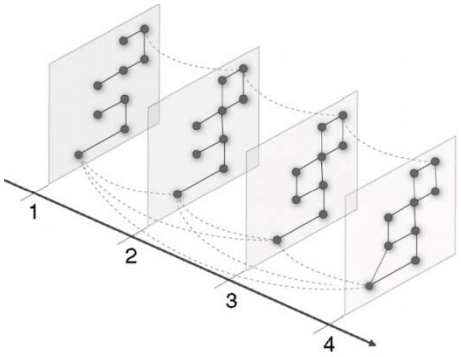
Research Projects Showcase

Growth-induced Mass Flows in Fungal Networks



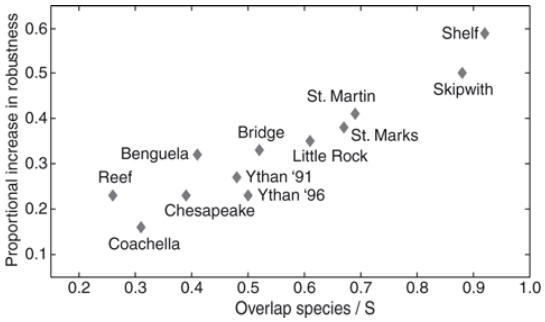
Cord-forming fungi form extensive networks that continuously adapt to maintain an efficient transport system. As osmotically driven water uptake is often distal from the tips, and aqueous fluids are incompressible, we propose that growth induces mass flows across the mycelium, whether or not there are intrahyphal concentration gradients. We imaged the temporal evolution of networks formed by *Phanerochaete velutina*, and at each stage calculated the unique set of currents that account for the observed changes in cord volume, while minimizing the work required to overcome viscous drag. Predicted speeds were in reasonable agreement with experimental data, and the pressure gradients needed to produce these flows are small. Furthermore, cords that were predicted to carry fast-moving or large currents were significantly more likely to increase in size than cords with slow-moving or small currents. The incompressibility of the fluids within fungi means there is a rapid global response to local fluid movements. Hence velocity of fluid flow is a local signal that conveys quasi-global information about the role of a cord within the mycelium. We suggest that fluid incompressibility and the coupling of growth and mass flow are critical physical features that enable the development of efficient, adaptive biological transport networks.
Reference: Proceedings of The Royal Society B (2010)
Contact: Nick S. Jones (CABDyN) and Eduardo López (CABDyN)
Collaborators: Luke L. M. Heaton, Philip K. Maini (CABDyN), Mark D. Fricker (CABDyN)

Community Structure in Time-Dependent, Multiscale, and Multiplex Networks



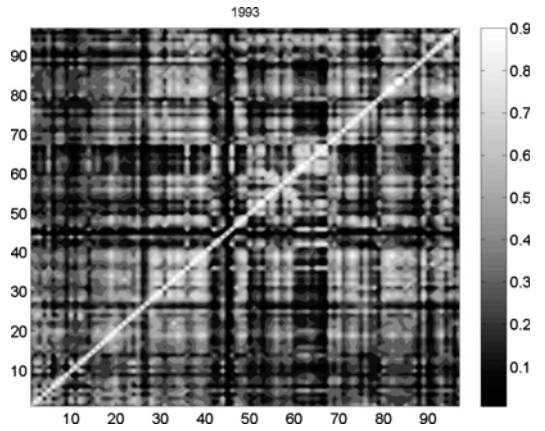
Network science is an interdisciplinary endeavor, with methods and applications drawn from across the natural, social, and information sciences. A prominent problem in network science is the algorithmic detection of tightly connected groups of nodes known as communities. We developed a generalized framework of network quality functions that allowed us to study the community structure of arbitrary multislice networks, which are combinations of individual networks coupled through links that connect each node in one network slice to itself in other slices. This framework allows studies of community structure in a general setting encompassing networks that evolve over time, have multiple types of links (multiplexity), and have multiple scales.
References: Science Vol. 328 (2010)
Contact: Mason A. Porter (CABDyN)
Collaborators: Peter J. Mucha, Thomas Richardson, Kevin Macon, Jukka-Pekka Onnela (CABDyN)

Structural Dynamics and Robustness of Food Webs



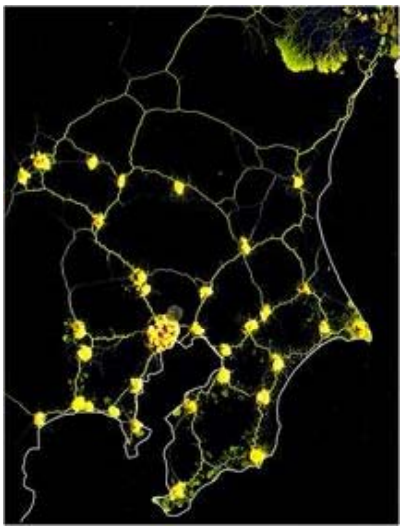
Food web structure plays an important role when determining robustness to cascading secondary extinctions. However, existing food web models do not take into account likely changes in trophic interactions ('rewiring') following species loss. We investigated structural dynamics in 12 empirically documented food webs by simulating primary species loss using three realistic removal criteria, and measured robustness in terms of subsequent secondary extinctions. In our model, novel trophic interactions can be established between predators and food items not previously consumed following the loss of competing predator species. By considering the increase in robustness conferred through rewiring, we identify a new category of species – overlap species – which promote robustness as shown by comparing simulations incorporating structural dynamics to those with static topologies. The fraction of overlap species in a food web is highly correlated with this increase in robustness; whereas species richness and connectance are uncorrelated with increased robustness. Our findings underline the importance of compensatory mechanisms that may buffer ecosystems against environmental change, and highlight the likely role of particular species that are expected to facilitate this buffering.
Reference: Ecology Letters (2010) Contact: Phillip Staniczenko (CABDyN)
Collaborators: Owen T. Lewis, Nick S. Jones (CABDyN), Felix Reed-Tsochas (CABDyN).

Multinetwork of International Trade: A Commodity-Specific Analysis



We study the topological properties of the multinetwork of commodity-specific trade relations among world countries over the 1992–2003 period, comparing them with those of the aggregate-trade network, known in the literature as the international-trade network (ITN). We show that link-weight distributions of commodity-specific networks are extremely heterogeneous and (quasi) log normality of aggregate link-weight distribution is generated as a sheer outcome of aggregation. Commodity-specific networks also display average connectivity, clustering, and centrality levels very different from their aggregate counterpart. We also find that ITN complete connectivity is mainly achieved through the presence of many weak links that keep commodity-specific networks together and that the correlation structure existing between topological statistics within each single network is fairly robust and mimics that of the aggregate network. Finally, we employ cross-commodity correlations between link weights to build hierarchies of commodities. Our results suggest that on the top of a relatively time-invariant “intrinsic” taxonomy (based on inherent between-commodity similarities), the roles played by different commodities in the ITN have become more and more dissimilar, possibly as the result of an increased trade specialization. Our approach is general and can be used to characterize any multinetwork emerging as a nontrivial aggregation of several interdependent layers.
Reference: Physical Review E81 (2010)
Contact: Diego Garlaschelli (CABDyN)
Collaborators: Mateo Barigozzi, Giorgio Fagiolo.

Rules for Biologically Inspired Adaptive Networks Design



Transport networks are ubiquitous in both social and biological systems. Robust network performance involves a complex trade-off involving cost, transport efficiency, and fault tolerance. Biological networks have been honed by many cycles of evolutionary selection pressure and are likely to yield reasonable solutions to such combinatorial optimization problems. Furthermore, they develop without centralized control and may represent a readily scalable solution for growing networks in general. We show that the slime mold *Physarum polycephalum* forms networks with comparable efficiency, fault tolerance, and cost to those of real-world infrastructure networks—in this case, the Tokyo rail system. The core mechanisms needed for adaptive network formation can be captured in a biologically inspired mathematical model that may be useful to guide network construction in other domains.
References: Science Vol. 327 (2010)
Contact: Mark D. Fricker (CABDyN)
Collaborators: Atsushi Tero, Seiji Takagi, Tetsu Saigusa, Kentaro Ito, Dan P. Bebber (CABDyN).

Publications

2010

Optimization of Transport Protocols with Path-Length Constrains in Complex Networks, José J. Ramasco, Martha S. de La Lama, Eduardo López, Stefan Boettcher, Physical Review E82, 036119 (2010), DOI: 10.1103/PhysRevE.82.036119
September 28, 2010

Information Use and the Evolution of Collective Migration, Vishwesha Guttal, Iain D. Couzin, Proceedings of the National Academy of Sciences USA, vol 107 no 37, pp. 16172-16177. DOI: 10.1073/pnas.1006874107
September 14, 2010

How Threshold Behaviour Affects the use of Subgraphs for Network Comparison, Tiago Rito, Zi Wang, Charlotte M. Deane, Gesine Reinert
Bioinformatics 26 (18): i611-i617. DOI: 10.1093/bioinformatics/btq386
September 7, 2010

Differences in Nutrient Requirements Imply a Non-Linear Emergence of Leaders in Animal Groups, Cédric Sueur, Jean-Louis Deneubourg, Odile Petit, Iain D. Couzin. PLoS Computational Biology 6(9): e1000917. DOI:10.1371/journal.pcbi.1000917
September 2, 2010

Nutritional State and Collective Motion: From Individuals to Mass Migration. Sepideh Bazazi, Pawel Romanczuk, Thomas S. Deisboeck., Lutz Schimansky-Geier, Joseph J. Hale, Gabriel A. Miller, Gregory A. Sword, Stephen J. Simpson, Iain D. Couzin. Proceedings of the Royal Society of London Series B. DOI:10.1098/rspb.2010.1447
August 25, 2010

The Structure of Financial Networks. Stefano Battistion, James B. Glattfelder, Diego Garlaschelli, Fabrizio Lillo, Guido Caldarelli. Chapter in **Network Science: Complexity In Nature and Technology** (edited by Ernesto Estrada, Maria Fox, Desmond J. Higham, Gian-Luca Oppo), Springer, ISBN: 978-1-84996-395-4. DOI: 10.1007/978-1-84996-396—1_7
August 24, 2010

Ergodic Directional Switching in Mobile Insect Groups. Carlos Escudero, Christian Yates, Jerome Buhl, Iain D. Couzin, Radek Erban, Ioannis Kevrekidis, Philip K. Maini, Physical Review E, 011926, Vol. 82, Issue 1, DOI: 10.1103/PhysRevE.82.011926
July 29, 2010

The Function of Communities in Protein Interaction Networks at Multiple Scales, Anna C.F. Lewis, Nick S. Jones, Mason A. Porter, Charlotte M. Deane, BMC Systems Biology 2010, **4:**100, DOI:10.1186/1752-0509-4-100
July 22, 2010

Casual Mechanism in the Social Science, Peter Hedström, Petri Ylikoski, Annual Review of Sociolog, Vol. 36, pp. 49-67. DOI:10.1146/annurev.soc.012809.102632
June 2010

Fungal Network Responses to Grazing, Lynne Boddy, Jonathan Wood, Emily Redman, Juliet Hynes, Mark D. Fricker, Fungal Genetics and Biology, Vol. 47, Issue 6, June 2010, Pages 522-530, DOI:10.1016/j.fgb.2010.01.006
June 2010

Revisiting Date and Party Hubs: Novel Approaches to Role Assignment in Protein Interaction Networks, Sumeet Agarwal, Charlotte M. Deane, Mason A. Porter, Nick S. Jones, PLoS Computational Biology, June 2010, Vol. 6, Issue 6, e1000817
June 2010

Growth-Induced Mass Flow in Fungal Networks, Luke L. M. Heaton, Eduardo López, Philip K. Maini, Mark D. Fricker, Nick S. Jones, Proceedings of the Royal Society 2010, DOI: 10.1098/rspb.2010.0735
June 10, 2010

Community Structure in Time-Dependent, Multiscale, and Multiplex Networks, Peter J. Mucha, Thomas Richardson, Kevin Macon, Mason A. Porter, Jukka-Pekka Onnela, Science Vol. 328, No 5980, pp.876-878, DOI: 10.1126/science.1184819
May 14, 2010

Structural Dynamics and Robustness of Food Webs, Phillip P.A. Staniczenko, Owen T. Lewis, Nick S. Jones, Felix Reed-Tsochas, Ecology Letters Vol. 13 pp.891+ (2010), DOI: 10.1111/j.1461-0248.2010.01485.x
May 12, 2010

The World Trade Web: Structure, Evolution and Modelling, M. A. Serano, Diego Garlaschelli, M Boguna, M.I. Loffredo, Chapter in **The Encyclopaedia of Life Support Systems**, EOLSS, UNESCO
May 6, 2010

Complex Systems: An Informative Itinerary, Iain D. Couzin, Science, Vol. 328, No. 5977, pp430, DOI: 10.1126/science.1187332
April 23, 2010

Oscillatory Dynamics in a Model of Vascular Tumour Growth - Implications for Chemotherapy, Johanna I. Stamper, Markus R. Owen, Philip K. Maini, Helen M. Byrne. Biology Direct, 5 (27). pp. 1-17. DOI: 10.1186/1745-6150-5-27
April 20, 2010

Multinetwork of International Trade: A Commodity-Specific Analysis, Matteo Barigozzi, Giorgio Fagiolo, Diego Garlaschelli, Physical Review E81, 046104 (2010), DOI: 10.1103/PhysRevE.81.046104
April 9, 2010

Fluctuation-induced Collective Motion: A Single-Particle Density Analysis, Chiu Fan Lee. Physical Review E81, 031125 (2010), DOI: 10.1103/PhysRevE.81.031125
March 26, 2010

Sparse Bayesian Step-Filtering for High-Throughput Analysis of Molecular Machine Dynamics, Max. A. Little, Nick S. Jones, 2010 IEEE International Conference on Acoustics, Speech and Signal Processing. ICASSP 2010 Proceedings Dallas, Texas, USA. pp. 4162-4165
March 14-19, 2010

Mutually-Antagonistic Interactions in Baseball Networks.,Serguei Saavedra, Scott Powers, Trent McCotter, Mason A. Porter, Peter J. Mucha. Physica A, Vol. 389, No. 5, pp. 1131-1141.
DOI: doi:10.1016/j.physa.2009.10.038
March 1, 2010

Rules for Biologically Inspired Adaptive Network Design, Atsushi Tero, Seiji Takagi, Tetsu Siagusa, Kentaro Ito, Dan. P. Bebber, Mark D. Fricker, Science, Vol. 327, No. 5964, pp. 439-442, DOI: 10.1126/science.1177894
January 22, 2010

Deciphering Chemotaxis Pathways Using Cross Species Comparisons, Rebecca Hamer, Pao-Yang Chen, Judith P Armitage, Gesine Reinert, Charlotte M Deane, BMC Systems Biology 2010, **4:**3, DOI:10.1186/1752-0509-4-3
January 11, 2010

2009

Context-Dependent Interaction Leads to Emergent Search Behavior in Social Aggregates,Colin Torney Zoltan Neufeld, Iain D. Couzin, Proceedings of the National Academy of Sciences USA, Vol. 106, No. 52 22055-22060, DOI: 10.1073/pnas.0907929106
December 29, 2009

Common Ecology Quantifies Human Insurgency, Juan Camilo Bohorquez, Sean Gourley, Alexander R. Dixon, Michael Spagat, Neil F. Johnson (2009) Nature, Vol. 462, DOI:10.1038/nature08631
December 17, 2009

A Comparative Study of Social Network Models: Network Evolution Models and Nodal Attribute Models, Riitta Toivonen, Lauri Kovanen**,** Mikko Kivelä**,** Jukka-Pekka Onnela**,** Jari Saramäki**,** Kimmo Kaski. Social Networks, Volume 31, Issue 4, pp. 240-254. DOI: 10.1016/j.socnet.2009.06.004
October 2009

Tocqueville and Analytical Sociology, Christopher Edling, Peter Hedström, in **A Life in Sociology**, Raymond Bound, edited by Mohamed Cherkaoui, Peter Hamilton. Oxford: The Bardwell Press. ISBN -13: 978-1-905622-18-4
October 2009

A Model Invalidation-Based Approach for Elucidating Biological Signalling Pathways, Applied to the Chemotaxis Pathway in *R. sphaeroides,* Mark AJ Roberts, Elias August, Abdullah Hamadeh, Philip K Maini, Patrick E McSharry, Judith P Armitage, Antonis Papachristodoulou. BMC Syst Biol. 2009; 3: 105, DOI: 10.1186/1752-0509-3-105
October 31, 2009

Relating the Microscopic Rules in Coalescence-fragmentation Models to the Macroscopic Cluster Size Distributions which Emerge, Blazej Ruszczycki, Ben Burnett, Zhenyuan Zhao, Neil F. Johnson. The European Physical Journal B - Condensed Matter and Complex Systems, Volume 72, Number 2, pp. 289-302. DOI: 10.1140/epjb/e2009-00354-5
October 21, 2009

Elongation Dynamics of Amyloid Fibrils: A Rugged Energy Landscape Picture, Chiu Fan Lee, James Loken, Létitia Jean, David J. Vaux. Physical Review E80, 041906 (2009), DOI: 10.1103/PhysRevE.80.041906
October 6, 2009

Public Domain Preprints

2010

A Taxonomy of Networks, Jukka-Pekka Onnela, Daniel J. Fenn, Stephen Reid, Mason A. Porter, Peter J. Mucha, Mark D. Fricker, Nick S. Jones. arXiv:1006.5731
June 29, 2010

Complex Networks and Symmetry: a Review with Applications to the Evolution of World Trade, Franco Ruzzenenti, Diego Garlaschelli, Riccardo Basosi. arXiv:1066.3923
June 20, 2010

A Mathematical Model for the Dynamics and Synchronization of Cows, Jie Sun, Erik M. Bolt, Mason A. Porter, Marian S. Dawkins. arXiv:1005.1381
May 9, 2010

Evolutionary Inference for Functional Data: Using Gaussian Processes on Phylogenies to Study Shape Evolution, Nick S. Jones, John Moriarty. arXiv:1004.4668
April 26, 2010

Steps and Bumps: Precision Extraction of Discrete States of Molecular Machines Using Physically-based, High-throughput Time Series Analysis, Max A. Little, Bradley C. Steel, Fan Bai, Yoshiyuki Sowa, Thomas Bilyard, David M. Mueller, Richard M. Berry, Nick S. Jones. arXiv:1004.1234
April 8, 2010

Growth-Induced Mass Flow in Fungal Networks, Luke L. M. Heaton, Eduardo López, Philip K. Maini, Mark D. Fricker, Nick S. Jones. arXiv: 1005.5305
May 28, 2010

Sparse Bayesian Step-Filtering for High-throughput Analysis of Molecular Machine Dynamics, Max A. Little, Nick S. Jones. arXiv:1003.5535
March 29, 2010

Light-Harvesting in Bacteria Exploits a Critical Interplay Between Transport and Trapping Dynamics, Felipe Caycedo-Soler, Ferney J. Rodriguez, Luis Quiroga, Neil F. Johnson. arXiv:1003.2443
March 11, 2010

Fluctuation-induced Collective Motion: A Single-particle Density Analysis, Chiu Fan Lee. ArXiv:1001.2684
January 15, 2010

The Unreasonable Effectiveness of Tree-based Theory for Networks with Clustering, Sergey Melnik, Adam Hackett, Mason A. Porter, Peter J. Mucha, James P. Gleeson. arXiv:1001.1439
January 9, 2010

2009

The Spontaneous Emergence of Social Influence in Online Systems, Jukka-Pekka Onnela, Felix Reed-Tsochas. arXiv:0912.0045
December 1, 2009

Revisiting Date and Party Hubs: Novel Approaches to Role Assignment in Protein Interaction Networks, Sumeet Agarwal, Charlotte M. Deane, Mason A. Porter, Nick S. Jones. arXiv:0911.04808
November 2, 2009

Self-Organised Global Control of Carbon Emission, Zhrnyuan Zhao, Dann Fenn, Pak Ming Hui, Neil F. Johnson. arXiv: 0910.1552
October 8, 2009

**CABDyN co-authors in "BLUE"*

SEMINARS AND WORKSHOPS

Dissemination Events

Oxford Networks Day

The Oxford Networks Day wasdesigned to bridge research from Oxford's different departments and divisions. The event, organised by Nick Jones brought together experimentalists, analysts and theorists from across Universities' departments with the goal of increasing contact between researchers studying networked systems. The event consisted of a series of talks given by: Mauricio Baharona (Imperial College), Shoumo Bhattacharya (Cardiovascular Medicine), Paul Bressloff (OCCAM), Johan Koskinen (Nuffield College), Renaud Lambiotte (Imperial College), Gero Meisenböck (Physiology Anatomy and Genetics), Mason Porter (OCIAM) and Lee Sweetlove (Plant Sciences).
28th September 2009, Physics Department, University of Oxford

ABM Agent-Based Modeling

This event was open to everyone in Oxford interested in agent-based modelling. In this session participants were presenting in 5-mintue slots project and issues of the ABM. The aim of the meeting was also to create new collaborations and the network of informal contacts of those interested in ABM. This event was chaired by Colin Axon (Engineering Science), Felix Reed-Tsochas (CABDyN), Ken Kahn and Howard Noble (OUCS) .
16th December 2009, Department of Engineering Science, University of Oxford

ICTeCollective Workshop

The ICTeCollective project brought together an international team of experts to answer the question; how dependent have we become on modern technologies like mobile phones, and if social networking sites are significantly changing the nature of our relationships with other people. This specific targeted research project, drawn from disciplines including psychology, computer science and physics; aims to chart large-scale patterns and trend in human behaviour. Using modeling tools, the team is examining the impact of online social networking at individual, group and societal levels to discover whether our digital social life enhances, replaces or threatens face-to-face relationships. This event was chaired by Felix Reed-Tsochas, Co-Director of the CABDyN Complexity Centre, and the speakers were international experts in complex systems; Jukka-Pekka Onnela (Harvard University), Robin Dunbar (University of Oxford), Järi Saramaki (Helsinki University of Technology) and Santo Fortunato (Institute for Scientific Interchange Foundation, Torino).
15th – 16th March 2009, Saïd Business School, University of Oxford

Oxford Signals Day

The Oxford Signals Day was designed to bridge research from Oxford's different departments and divisions. The event, organised by Nick Jones brought together experimentalists, analysts and theorists from across Universities' departments with the goal of increasing contact between researchers studying signals within each division A signal is any time varying quantity, for example, the result of a repeated measurement of system through time. The event consisted of a series of sessions: Inference from Natural Signals, Forecasting, Finance and Stochastics, Biological Signals and Physical Signals.

23rd April 2010, Department of Physics, University of Oxford

ABM Agent-Based Modeling in the Social Science

This training session was designed to introduce participants to some especially user-friendly software tools for agent-based modelling. NetLogo is a freely available software package that has been developed by Uri Wilenski at Northwestern University. It has been used widely for both teaching and research purposes, and is supported by an active user community. BehaviourComposer is a web-based tool that has been developed by Ken Kahn of OUCS. It provides a highly intuitive interface to NetLogo, and allows users with no prior programming experience to build agent-based models in a very short time

6th May 2010, Saïd Business School, University of Oxford

Seminar Series

Trinity Term 2010

'Tracking Systemic Risk in the International Banking Network'
Prof Rodney Garratt, Bank of England and Department of Economics, University of California at Santa Barbara
June 15, 2010

'Structural Dynamics and Robustness of Food Webs'
Phillip Staniczenko, Department of Physics, Clarendon Laboratory, University of Oxford
June 8, 2010

'Trade, Conflict and Sentiments: Multi-relational Organisation of Large-scale Social Networks'
Dr Renaud Lambiotte, Institute for Mathematical Sciences, Imperial College of London
June 1, 2010

'Optimal Map of the Modular Structure of Complex Networks'
Prof Alexandre Arenas, Department of Computer Sciences and Mathematics, Universitat Rovira i Virgili, Tarragona
May 25, 2010

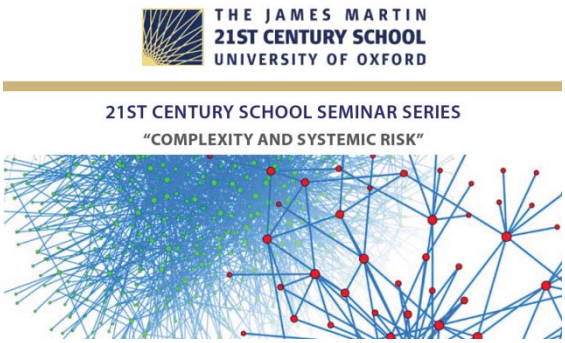
'Web Traffic: Analysis of Navigation Data and Modelling at Single User Level'
Dr José Javier Ramasco, Institute for Scientific Interchange Foundation, Torino
May 18, 2010

'Large Fluctuations and Fixation in Evolutionary Games with Non-Vanishing Selection'
Dr Mauro Mobilia, Department of Applied Mathematics, School of Mathematics, University of Leeds
May 11, 2010

'Probabilistic Consensus via Polling and Majority Rules'
Dr Ganesh Ayalvadi, Department of Mathematics, University of Bristol
May 4, 2010

'The Complex Network of Global Cargo Ship Movements'
Dr Michael Gastner, Institute for Mathematical Sciences, Imperial College of London
April 27, 2010

Hilary Term 2010



For Hilary Term 2010 CABDyN jointly organised a special seminar series on "Complexity and Systemic Risk" with the James Martin 21st Century School. In this series, leading researchers explored the implications of a complex systems approach for systemic risks in contexts including ecosystems, financial systems, and human societies.

'Contagious Extinctions and Ecosystem Collapse'
Dr Owen Petchey, Department of Animal and Plant Sciences, University of Sheffield.
March 11, 2010

'Cooperation, Norms and Conflict: Towards Simulating the Foundations of Society'
Prof Dirk Helbing, Swiss Federal Institute of Technology, Zurich
March 4, 2010

'Predicting the Behaviour of Techno-Social Systems: How Informatics and Computing Help to Fight off Global Pandemics'
Prof Alessandro Vespignani, Indiana University at Bloomington, USA
February 25, 2010

'Ocean Circulation and Climate: Observing and Modelling the Global Ocean'
Prof David Marshall, 21st Century Ocean Institute
February 18, 2010

'Anticipating Future Complexity: Are Systems Such as Cities Getting More Complex?'
Prof Mike Batty, Centre for Advanced Spatial Analysis, University College London
February 11, 2010

'Growth, Innovation, and the Pace of Life from Cells and Ecosystems to Cities and Corporations; Are They Sustainable?'
Prof Geoffrey West, Santa Fe Institute, New Mexico, USA
February 4, 2010

'Stability and Complexity in Model Banking Systems'
Prof Lord Robert May, Department of Zoology, University of Oxford
January 21, 2010

Michaelmas Term 2009

'Innovation Diffusion as a Coevolutionary Process: Adaptive Emulation Among Firms and Consultants'
Prof David Strang, Department of Sociology, Cornell University
November 24, 2009

'A Genetic Basis for Social Network Structure and Social Aspects of Social Network Function'
Prof Nicholas Christakis, Department of Health Care Policy, Harvard Medical School
November 19, 2009

'An Exact Randomization Method to Detect Patterns in Real Networks'
Dr Diego Garlaschelli, CABDyN Complexity Centre, University of Oxford
November 10, 2009

'Geometric Visual Hallucinations, Euclidean Symmetry and the Functional Architecture of Visual Cortex'
Prof Paul Bressloff, Mathematical Institute, University of Oxford
November 3, 2009

'Evolving Networks'
Prof Alan McKane, School of Physics and Astronomy, University of Manchester
October 27, 2009

'Using the Web to Do Social Science'
Prof Duncan Watts, Principal Research Scientist, Yahoo! Research *(Oxford Internet Institute lecture in collaboration with CABDyN and the Oxford eSocial Science Project)*
October 23, 2009

'Hierarchical Models of Multiscaled Dynamics on Networks and Evaluating the Model Quality of Such Multiscaled Systems'
Prof Erik Bollt, Department of Mathematics and Computer Science, Clarkson University
October 13, 2009

PROJECT FUNDING

Active Grants

FOC – "Forecasting Financial Crises"
[September 2010 – August 2013]

This €1,888,909 (University of Oxford - £249,360) project, coordinated by Professor Guido Caldarelli of the National Research Council of Italy (CNR), involves an interdisciplinary consortium of computer scientists, physicists, economists and policy makers seeking to develop novel approaches to understanding and forecasting systemic risk and global financial instabilities. By leveraging expertise in different disciplines, FOC aims to provide an integrated and network-oriented approach to these problems. FOC will develop and test a novel theoretical framework to measure systemic risk in global financial markets and financial networks. This will allow to deliver a collaborative ICT platform for monitioring systemic fragility and the propagation of financial distress across institutions and markets globally. This will allow experts to evaluate algorithms and models for forecasting financial crises, and will also provide new tools for interactive visualisation of different future scenarios. In additon to the University of Oxford and CNR, FOC involves the following consortium partners: City University London, ETH Zürich, European Central Bank, Fundació Barcelona Media (Universitat Pompeu Fabra), and Universitá Politecnica delle Marche. The project work at the University of Oxford will be conducted in close collaboration with HSBC Global Research.

SATURN – "Self-Organising Adaptive Technology Underlying Resilient Networks"
[November 2009 – October 2012]

This £3.2m (University of Oxford - £332k) project is being led by British Telecommunications in collaboration with Northrop Grumman UK, Imperial College London, Warwick University, University of Oxford, Saïd Business School and Oxford's CABDyN Complexity Centre. The project is co-funded by the EPSRC and the Technology Strategy Board Research and Development Competition under their 'Network Security Innovation Platform'.
Dr Alexandra Brintrup has been hired as an experienced post-doctoral researcher; her research interests to date have focused on the design of computational intelligence applied to operations research problems. Her published work includes the use of interactive multi-objective genetic algorithms in optimisation, multi-agent based supply network management, and the development of smart embedded systems for lean manufacturing and product lifecycle management. Recently she has been carrying out research on the evolution of complex adaptive systems, and decision making methods in multi-agent systems.

ICTeCollective – "Harnessing ICT-enabled Collective Social Behaviour"
[October 2009 – September 2012]

€2m (University of Oxford - €360k) European Commission Framework 7 "Future and Emerging Technologies" grant. The Specific Targeted Research Project is lead by Professor Kimmo Kaski, Helsinki University of Technology. The other European partners on the project are the University of Oxford, Torino Institute for Scientific Interchange, Budapest University of Technology and Economics and University of Warsaw.

"Coevolution, Interconnections and Communities of Social and Political Networks in the United Sates Congress"
[October 2009 – September 2013]

$420k grant has been awarded to CABDyN's Mason Alexander Porter. Mason is the Principal Investigator with J.H. Flower as a co-investigator on this research award which falls within the James S. McDonnell Foundation's programmes area of "Studying Complex Systems".

Scaling in Complex Systems
[May 2009 – October 2011]

£79k (University of Oxford - £38k) EPSRC research grant held jointly with Imperial College London (PI: Professor Henrik Jensen, Imperial College London; Co-PI, Felix Reed-Tsochas). The main objective of this grant is to organise a number of research visits and workshops involving Professor Geoffrey West, who is a Research Professor and the current President of the Santa Fe Institute. Professor West has built an international reputation for his work on scaling in biological systems, and has now embarked on a programme of research to develop theories of scaling in social systems. His work has not only been recognised in academia – he was chosen as one of the 100 most influential new thinkers by Time magazine. His current interests are directly relevant to the new InSIS activities on the Oxford Programme for the Futures of Cities. The project will allow us to strengthen existing links with Santa Fe Institute, and develop new links with Imperial College London.

CABDyN Seminar Series
[August 2008 – July 2011]

£13k grant is funded by the Institute for Science, Innovation and Society. The CABDyN Seminar Series is one of the activites of CABDyN Complexity Centre, and intend to provide a forum for rigorous research (in broad range of disciplines) focusing on complex adaptive systems, using methods and techniques such as agent-based modelling and complex networks analysis. Since potential areas of application for such approaches can be located across the social, natural and engineering sciences, our aim is to involve participants from a wide range of departments in Oxford. We welcome talks which focus on particular areas of application and associated technical issues, but also encourage contributions which address more fundamental conceptual or mathematical problems.

Fundamentals of Complexity Science
[April 2008 – March 2011]

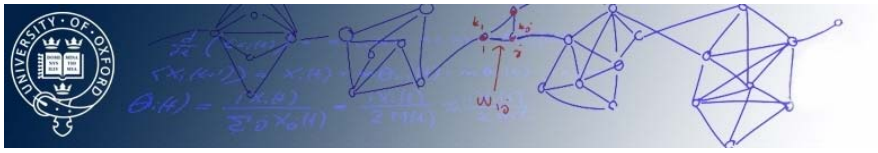
£376k EPSRC research grant on “Modelling the Temporal Dynamics of Social, Economic, and Communication Networks from Large-Scale Empirical Datasets”. Felix Reed-Tsochas is a PI, and Professor Neil Johnson (formerly Oxford, now Miami) is a Co-Investigator. Dr Eduardo López has been hired as an experienced postdoctoral researcher, and the project also involves an international collaboration with Northwestern University (Professor Brian Uzzi) and Northeastern University (Professor Albert-László Barabási).

DPhil Studentship in Computational Complex Systems and Networks Research
[October 2007 – October 2010]

Approximate value £54k. University and college fees and a standard stipend fully funded through an agreement with Helsinki University of Technology, with Nick Jones and Felix Reed-Tsochas co-supervising a student (Phillip Staniczenko) pursuing a DPhil in Physics and based in the Clarendon Laboratory.

Junior Research Fellowship in Computational Complex Systems and Network Research
[August 2006 – July 2012]

Approximate value £100k. Funded by a collaborative arrangement between Wolfson College and Helsinki University of Technology, through an initiative led by Professor Kimmo Kaski (Director, Centre of Excellence in Computational Complex Systems Research, Helsinki University of Technology). This post was held by Dr Jukka-Pekka Onnela from August 2006 till March 2009, who is affiliated with the Physics Department and the Saïd Business School. This post will be held by Elizabeth Leicht from September 2010 in conjunction with the SATURN Project.



COMMUNICATION

Website

The CABDyN Website has been established since 2003 and now contains a significant library of resources, information about the Centre as well as promoting the work of CABDyN members.
Since November 2009 CABDyN has a new, more convenient domain name www.cabdyn.ox.ac.uk

Press Coverage

'Social Web: The Great Tipping Point Test'
NewScientist, July 21, 2010

'Grow with the Flow'
SAID Internet News, June 10, 2010

'Decoding Our Networks Communities'
Science, Oxford University News, May 14, 2010

'Mould Network Match Railways'
Science, Der Spiegel, Oxford University News, January 22, 2010

'Are your friends making you fat'
The Guardian, January 17, 2010

'Making Complexity Simple'
The GTC Magazine, December 20, 2009

'Blighty to Get Own 'Cyber Range''
The Register, December 18, 2009

'Modellers Claim Wars Are Predictable'
Nature, December 19, 2009

'Les Liens Sociaux Virtuels Modifient-Ils Ceux de la Vie Réelle?'
L'Atelier, October 12, 2009

'Are Social Networking Sites Changing the Way We Behave?'
Oxford University News, October 8, 2009

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