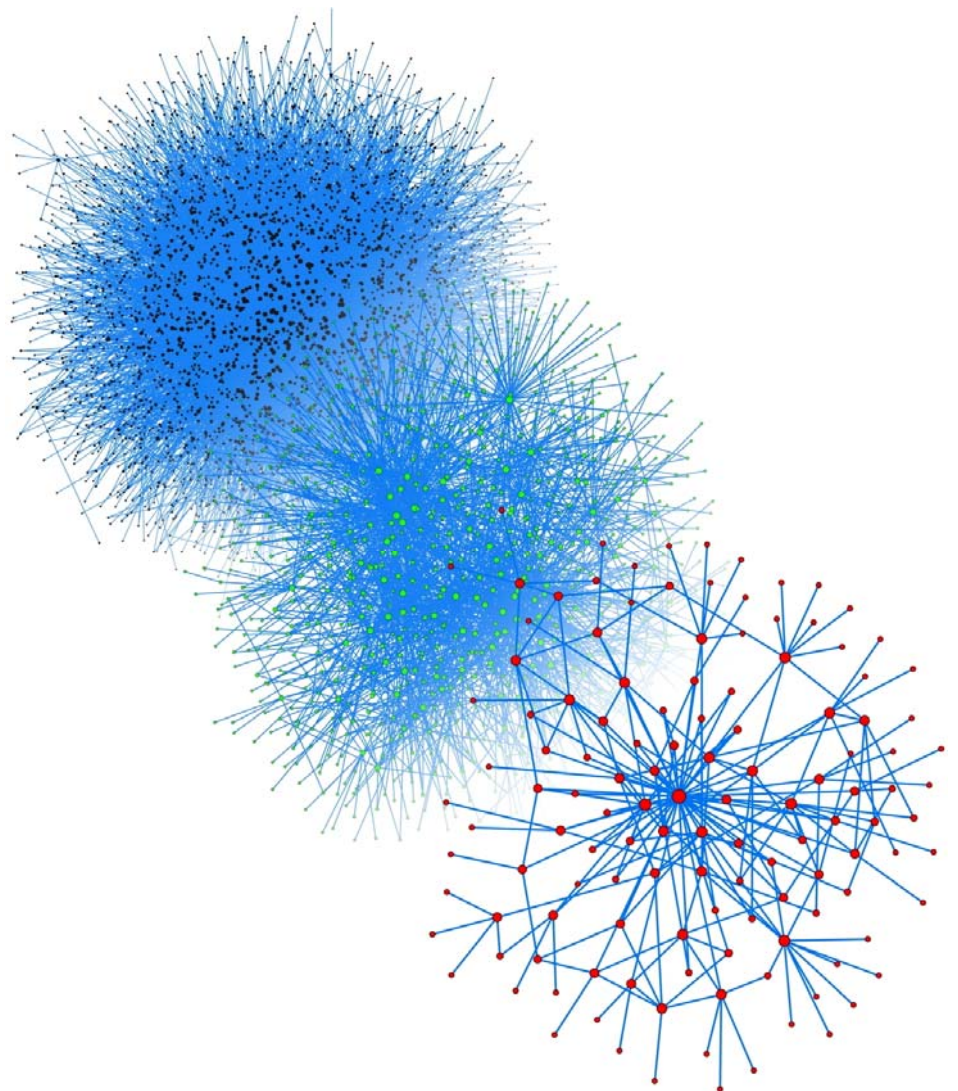


Cabodyn Complexity Centre

Annual Report 2008/2009



CABDyN COMPLEXITY CENTRE

The CABDyN Complexity Centre was established in July 2003 with seed funding under the EPSRC Novel Computation Initiative. The acronym CABDyN stands for **Complex Agent-Based Dynamic Networks**, 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 January 2008 to 30th September 2009.

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

November 2009



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OVERVIEW

This first CABDyN annual report covering the academic year 2008/09 reflects how far we have come since 2003, when a few of us thought that research on complex systems and related topics in Oxford would benefit substantially from building connections across disciplines and between University Departments. This bottom-up activity initially gave rise to a series of ad hoc meetings, and was transformed into an embryonic research cluster with seed funding from the EPSRC under the Novel Computation Initiative. Significant support from the University through the Research Development Fund, as well as grants from a variety of funding bodies, have allowed the CABDyN Complexity Centre to build scientific collaborations and activities in a more structured and coordinated fashion. It remains the case that CABDyN actively involves members of more than ten Departments within the University across different Divisions, and as a result is more strongly interdisciplinary than other centres for complex systems research in the UK. As a result, the publications listed in this report cover a broad spectrum of topics, ranging from plant sciences and zoology to sociology, management science, mathematics, physics, epidemiology, cell biology, and statistics. This disciplinary breadth is in many cases augmented by the publication of research findings in journals with high visibility and impact. During the period covered by the annual report articles with CABDyN authors or co-authors appeared in leading peer-reviewed journals, including *Journal of Theoretical Biology*, *Nature*, *Physical Review Letters*, *Proceedings of the National Academy of Sciences of the USA*, and *Proceedings of the Royal Society B*. Targeting high-profile journals that are able to reach a broad scientific audience will need to remain core to our publication strategy going forward, although this will of course be complemented by publications in more specialist journals as well as books and book chapters.

One innovation introduced in 2008/09 is the CABDyN working paper series, which is available from our website, and should help provide a more up-to-date picture of ongoing research by making preprints available prior to journal publication. Of course, in a number of disciplines it is already common practice to place preprints in public archives and digital repositories. The advantage of our working paper series, if we can convince a sufficiently large proportion of the CABDyN community to contribute, should be that it can provide an overall picture in one location of our collective research activity. If the format establishes itself, it may also convince colleagues from disciplines where placing working papers in the public domain is less common to experiment with this form of dissemination. In a related vein, the projects page of our website is meant to provide a showcase for research projects at different stages of development, ranging from entirely new ideas to ongoing projects that have already generated published research findings. More broadly, 2008 saw a major overhaul of the CABDyN website, including both a change in visual design and a significant enlargement of the content that can be accessed. The website principally needs to satisfy two needs. First, it plays a very important role in coordinating CABDyN activities in Oxford, and in supporting collaborations between researchers based in different Departments. Second, it provides the primary means for those outside Oxford to gauge what activities we are pursuing. We hope that the redesigned website already does a better job with regard to both of these requirements than its predecessor, but are already planning further significant improvements for 2009/10.

The final component of our publication and dissemination strategy is the *World Scientific* book series dedicated to “Complex Systems and Interdisciplinary Science.” At present three titles from the series are in print, and the volume edited by François Képès on *Biological Networks* is especially noteworthy. Volume 4 will appear in the first half of 2010, and a number of manuscripts for future books are currently under consideration.

The CABDyN seminar series remains one of our key activities, and as a regular event provides an important mechanism to build and sustain research collaborations and a sense of community for a group that is widely dispersed across Oxford. As in previous years, the seminar programme has been designed with two purposes in mind. First, to bring leading researchers engaged in exciting work on complex systems to Oxford, both from the UK and from further afield. In this vein the 2008/9 programme included talks by Henrik Jensen (Imperial), Shlomo Havlin (Bar-Illan), Marc Barthelemy (CEA), Giovanni Dosi (Pisa), Sanjeev Goyal (Cambridge) and Geoffrey West (Santa Fe Institute). Second, to provide a forum for CABDyN members to present interesting research findings to an interdisciplinary audience, which can help identify new collaborative opportunities. In addition to the seminar series, CABDyN now organises (or co-organises) a number of different events and activities on a regular basis. The Network Journal Club at the Department of Physics provides an opportunity on a weekly basis for graduate students, post-docs and faculty to keep on top of the research literature by discussing important and interesting journal articles. The Oxford BioNets Day and Oxford Signals Days proved extremely successful in bringing together researchers from across the University as participants in thematically focused, interdisciplinary workshops. Finally, the *Complexity in a Nutshell* event organised by the Oxford Science Enterprise Centre provided an opportunity to showcase our research on complex systems and networks to a mixed audience from business and academia. The public interest in research on complexity was clearly demonstrated by a packed lecture room, and a record number of participants. In line with plans to use such channels of communication more frequently in the future, the *Complexity in a Nutshell* seminar will become available via the University’s iTunes site.

2008/9 also saw increased efforts to strengthen collaborative links with other institutions both nationally and internationally. Individual contacts between researchers at Imperial College London and Oxford have been transformed into a more regular pattern of interactions and exchanges, with colleagues from Imperial participating both in the Oxford BioNets Day and Oxford Signals Days. A new research project funded by the EPSRC on *Scaling in complex systems* that involves Henrik Jensen (Imperial), Felix Reed-Tsochas (Oxford) and Geoffrey West (Santa Fe Institute) will further strengthen these connections, and a number of joint workshops are currently being planned. The project also allows CABDyN to build up its contacts with the Santa Fe Institute, which retains a pivotal role in complex systems research. The Northwestern Institute on Complex Systems (NICO) at Northwestern University is the other US-based institution with which CABDyN has strong collaborative links, which we hope to be able to strengthen and augment going forward. In many regards NICO is an ideal partner for CABDyN, since it shares both a commitment to genuine interdisciplinary dialogue and a broad range of disciplines and interests.

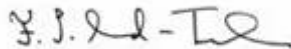
Finally, shifting to a European context, CABDyN retains strong links with the Centre of Excellence in Computational Complex Systems Research at Helsinki University of Technology. As a result of the much appreciated initiative taken by Kimmo Kaski (Helsinki), Helsinki University of Technology funds both a Junior Research Fellowship and a Doctoral Studentship in Complex Systems and Networks Research, both based at Wolfson College. These existing collaborative links with Helsinki have now been further enhanced by a new project funded by the European Commission which will start in 2009/10.

The range of activities described above requires significant resources, and CABDyN has typically addressed this problem by bundling individual research grants in a manner that benefits the wider complex systems research community in Oxford. A key project that played a major role in building the CABDyN community was MMCOMNET (Measuring and Modelling Complex Networks Across Domains). MMCOMNET was a three-year project funded under the New and Emerging Science and Technology Pathfinder Initiative of the European Commission (6th Framework), coordinated from Oxford, with partner institutions in Dresden, Paris, Stockholm, Warsaw, and Zurich. In addition to this international dimension, MMCOMNET also involved a highly diverse set of Departments in Oxford: Centre for Mathematical Biology, Nuffield College, Department of Engineering Science, Department of Physics, Department of Plant Sciences, Saïd Business School, and Department of Statistics. This very much reflects the strong interdisciplinary orientation of CABDyN activities. The MMCOMNET project concluded with a very successful workshop in April 2008. Current funding from the EPSRC includes the *Scaling in complex systems* project referred to earlier, as well as an ongoing project funded under the *Fundamentals of Complexity Science* initiative looking at the dynamics of large-scale social and economic networks. Mason Porter (Mathematical Institute) was awarded a four-year grant in 2008 by the James S McDonnell Foundation for research looking at social and political networks in the US Congress. Looking ahead, we move into 2009/10 with two new funded projects that will commence in October and November respectively. *ICTeCollective*, which is funded by the European Commission's Future and Emerging Technologies Open Scheme (7th Framework), will take a multi-scale perspective to address the question of how technologies shape and are shaped by social interactions. *SATURN*, which is funded the EPSRC in conjunction with the Technology Strategy Board, will explore the determinants of resilience in critical infrastructure networks. Although it is gratifying that we remain reasonably successful in securing research grants in a difficult funding climate, trying to support collective research activity by patching together many individual research grants is not particularly efficient, and often extremely time consuming. For that reason alone, it will be crucial actively to pursue opportunities for longer-term and larger-scale research funding in 2009/10.

In concluding this overview of the annual report for 2008/9, it is perhaps good to move from funding back to people. First, a quick word about arrivals and departures. In April 2008 we were joined by Eduardo López, who arrived from the Theory Division of Los Alamos National Laboratory, having previously completed a PhD in physics at Boston University. Jukka-Pekka Onnela, who joined us from doctoral studies at Helsinki University of Technology in 2006, spent 2008/9 at the John F Kennedy School of Government (Harvard) as a Fulbright Scholar.

Serguei Saavedra, who arrived from Mexico in April 2005 to start on a DPhil in Engineering Science funded by MMCOMNET, after a brief post-doc at the Saïd Business School, moved to Northwestern University in spring 2009 to start a post-doctoral fellowship at NICO and the Kellogg School of Management.

2008/9 also provided us with an opportunity to explore a new form of research interaction, by embedding a visiting philosopher in CABDyN. Alan Baker, Associate Professor of Philosophy at Swarthmore College, was awarded a *New Directions Fellowship* by the Andrew W Mellon Foundation to examine philosophical issues in complexity science. In order to get a sense of what complex systems research in action looks like, he divided his time between Oxford and the Complexity DTC at Warwick University. Although his sabbatical has now ended, we hope to maintain regular contact as his research develops. In bringing this section of the annual report to a close, there are two people who deserve special thanks, because our activities and this report could not exist without them. Ken Bedding made enormous contributions during his time as CABDyN Administrator, providing support for highly complex grants and funding arrangements, ensured that our day-to-day activities ran smoothly, and played a major role in revamping and improving our website. Ken has now moved on to other responsibilities, although he remains involved in aspects of grant arrangements, and retains his interest in CABDyN. Ken's role as CABDyN Administrator has more recently been taken over by Dorota Pawlik, who is providing absolutely superb support. You can be assured that without her efficiency and persistence, you would not be reading this report.



Felix Reed-Tsochas

PEOPLE

CABDyN MEMBERS

CABDyN Co-Directors

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

Dr Janet Smart, Director of the BT Centre for Major Programme Management and Co-Director of the CABDyN Complexity Centre, Saïd Business School, University of Oxford.

CABDyN Members

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

Dr Quentin Atkinson, Postdoctoral Research Fellow, Institute of Cognitive & Evolutionary Anthropology, University of Oxford.

Alan Baker, Associate Professor in the Department of Philosophy at Swarthmore College, Visiting Fellow of the Institute of Science, Innovation and Society, University of Oxford.

Dr Alexandru Baltag, University Lecturer, Oxford University Computing Laboratory.

Dr David Barron, University Reader in Organisational Sociology, Saïd Business School, University of Oxford.

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

Dr Sukaina Bharwani, Research Associate, Stockholm Environmental Institute.

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

Dr Ani Calinescu, Departmental Lecturer, Computing Laboratory, University of Oxford.

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

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

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

Dr Mark Fricker, University Lecturer in Plant Sciences, Department of Plant Sciences, University of Oxford.

Prof Peter Hedström, Professor and Official Fellow, Sociology, Nuffield College, University of Oxford.

Prof Sam Howison, Director of the Oxford Centre for Industrial and Applied Mathematics (OCIAM), University of Oxford.

Prof Paul Jeffreys, Director for Information Technology, University of Oxford.

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

Dr Nick Jones, Systems Fellow, Department of Physics and Oxford Centre for Integrative Systems Biology, University of Oxford.

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.

Dr Chiu Fan Lee, Glasstone Research Fellow in Physics, 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, Royal Academy of Engineering/EPSRC Research Fellow, Department of Engineering and the Oxford Centre for Industrial and Applied Mathematics (OCIAM).

Dr Jukka-Pekka Onnela (*on leave 2008-2009*), Junior Research Fellow in Complex Systems and Networks Research, Wolfson College, 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.

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

Dr Serguei Saavedra, Postdoctoral Research Assistant, Oxford University Centre for Corporate Reputation, Saïd Business School, University of Oxford.

Dr David Smith, Research Fellow, Centre for Mathematical Biology, University of Oxford.

Prof Tom A.B. Snijders, Professor of Statistics in the Social Sciences, University of Oxford. Professor of Methodology and Statistics in the Faculty of Behavioural and Social Sciences, University of Groningen.

Phillip Staniczenko, Doctoral Student, Department of Physics, University of Oxford.

Prof David Sumpter, Professor of Applied Mathematics, Uppsala University Sweden.

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

Prof Anne Trefethen, Director of the Oxford e-Research Centre, University of Oxford.

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

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

CABDyN Associate Fellows

Prof Paul David, Senior Fellow of the Stanford 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.

Prof Geoffrey West, President and Distinguished Professor at the Santa Fe Institute in New Mexico, USA. Associate Fellow in Complex Systems of the Institute for Science, Innovation and Society, University of Oxford.

CABDyN Administration

Ken Bedding, Administrator of the CABDyN Complexity Centre until May 2009.

Dorota Pawlik, Administrator of the CABDyN Complexity Centre from June 2009.

VISITORS

Dr Jukka-Pekka Onnela *

Harvard University
22nd – 24th July 2009, Saïd Business School,
University of Oxford

Prof Neil Johnson * *

University of Miami
26th June - 19th July 2009, Saïd Business School,
University of Oxford

Prof Geoffrey West

Santa Fe Institute, New Mexico
25th- 30th May 2009, Saïd Business School,
University of Oxford

Dr Vittoria Colizza

Complex Systems Lagrange Lab, ISI Foundation, Italy
16th- 20th March 2009, Saïd Business School,
University of Oxford

Dr Marc Barthelemy

Commissariat à L'Energie Atomique - Département de Physique
16th- 18th February 2009, Saïd Business School,
University of Oxford

Prof Shlomo Havlin

Bar Ilan University, Ramat-Gan, Israel
26th - 27th January 2009, Saïd Business School,
University of Oxford

Dr Santo Fortunato

Complex Systems Lagrange Lab, ISI Foundation, Italy
12th- 20th January 2009, Saïd Business School,
University of Oxford

Dr Daniel Stouffer

Estación Biológica de Doñana, Spain
23rd- 28th November 2008, Saïd Business School,
University of Oxford

Prof Alan Baker

Department of Philosophy at Swarthmore College
Academic year 2008/2009, Saïd Business School,
University of Oxford

* visiting Oxford while on leave at Harvard University

* * member of CABDyN Scientific Management Board no longer based in Oxford.

SCIENTIFIC MANAGEMENT BOARD AND INTERNATIONAL AND INDUSTRIAL ADVISORY BOARDS

MEMBERS OF THE SCIENTIFIC MANAGEMENT BOARD

Prof Samson Abramsky
Computing Laboratory, Oxford

Dr Iain Couzin
Department of Ecology and
Evolutionary Biology,
Princeton University

Dr Thomas E Downing
Oxford Office,
Stockholm Environment Institute

Dr Mark Fricker
Department of Plant Sciences,
Oxford

Prof Peter Hedström
Nuffield College, Oxford

Prof Sam Howison
Oxford Centre for Applied and
Industrial Mathematics

Prof Neil Johnson
Department of Physics,
University of Miami

Prof Philip Maini
Centre for Mathematical Biology,
Oxford

Dr Felix Reed-Tsochas
Institute for Science, Innovation and
Society, Saïd Business School,
Oxford

Prof Gesine Reinert
Department of Statistics, Oxford

Dr Janet Smart
BT Centre for Major Programme
Management,
Saïd Business School, Oxford

Prof Anne Trefethen
Oxford e-Research Centre

*The Scientific Management Board
met three times in the period 1st
January 2008 – 30th September
2009*

MEMBERS OF THE INTERNATIONAL ADVISORY BOARD

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Northeastern University, USA

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ETH Zürich, Switzerland

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Prof Simon Levin
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Cornell University, USA

Prof Mark Newman
University of Michigan, USA

Prof Frank Schweitzer
ETH Zürich, Switzerland

Dr Guy Theraulaz
Université Paul Sabatier, Toulouse,
France

Prof Brian Uzzi
Northwestern University, USA

Prof Alessandro Vespignani
Indiana University, USA

Prof Duncan Watts
Yahoo Research (New York), USA

Prof Geoffrey West
Santa Fe Institute, USA

Prof Peyton Young
University of Oxford, UK

MEMBERS OF THE INDUSTRIAL ADVISORY BOARD

Dr Robert Ghanea-Hercock
BT

Dr James Martin
Headstrong

Dr Shail Patel
Unilever

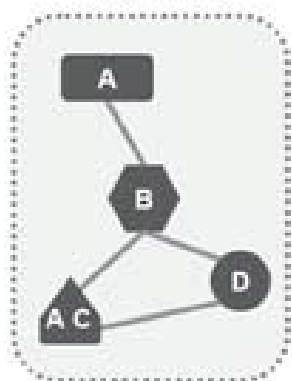
Dr James E West
IBM

RESEARCH ACTIVITIES

RESEARCH PROJECTS SHOWCASE

The following selections of research projects give an introduction to some of the active areas of CABDyN research.

Protein interaction
network



Predicting & Validating Protein Interactions Using Network Structure

Protein interactions play a vital part in the function of a cell. As experimental techniques for detection and validation of protein interactions are time consuming, there is a need for computational methods for this task. Protein interactions appear to form a network with a relatively high degree of local clustering. In this paper we exploit this clustering by suggesting a score based on triplets of observed protein interactions. The score utilises both protein characteristics and network properties. Our score based on triplets is shown to complement existing techniques for predicting protein interactions, outperforming them on data sets which display a high degree of clustering. The predicted interactions score highly against test measures for accuracy. Compared to a similar score derived from pairwise interactions only, the triplet score displays higher sensitivity and specificity. By looking at specific examples, we show how an experimental set of interactions can be enriched and . As part of this work we also examine the effect of different prior databases upon the accuracy of prediction and find that the interactions from the same kingdom give better results than from across kingdoms, suggesting that there may be fundamental differences between the networks. These results all emphasize that network structure is important and helps in the accurate prediction of protein interactions. The protein interaction data set and the program used in our analysis, and a list of predictions and validations, are available at [http://www.stats.ox.ac.uk/bioinfo/resources/Predicting Interactions](http://www.stats.ox.ac.uk/bioinfo/resources/Predicting%20Interactions).

Reference: (2008) PLoS Computational Biology: 4 (7) e1000118

Contact: Gesine Reinert (CABDyN)

Collaborators: Pao-Yang Chen and Charlotte M. Deane



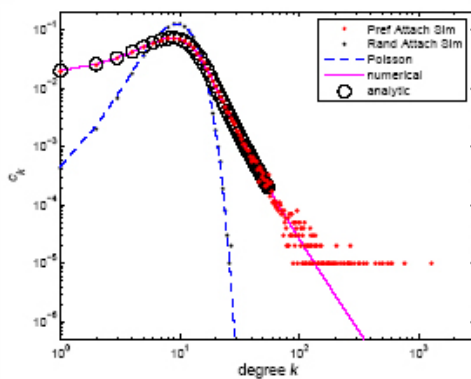
Bias in Epidemiological Studies of Conflict Mortality

Cluster sampling has recently been used to estimate the mortality in various conflicts around the world. A recent study on Iraq employed a new variant of this methodology as far as its microlevel details are concerned by sampling households on "residential streets crossing main streets". This can introduce a substantial bias into the mortality estimates because the residents on residential streets are more likely to be exposed to violence than those living further away.

This type of non-coverage bias is notoriously difficult to assess. We apply a modeling approach to gauge the extent of the bias and provide a sensitivity analysis to help readers tune their own judgements on the extent of the bias.

Contact: Jukka-Pekka Onnela (CABDyN)

Collaborators: Neil F. Johnson (CABDyN), Michael Spagat, Sean Gourley, and Gesine Reinert (CABDyN)



Accelerating Networks

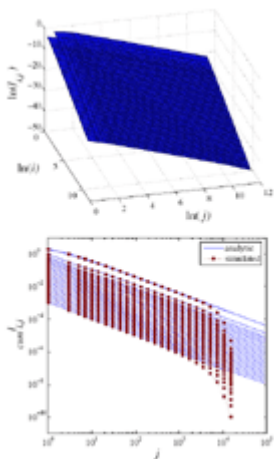
In many real-world, evolving networks, the rate at which links are added to the network is different from the rate at which nodes are added to it, the World WideWeb being one example. This results in the concept of accelerating or decelerating networks. In Accelerating Networks we review existing definitions of network acceleration and, having found them somewhat restrictive, propose a new definition. This might be used to describe a network at any stage of its evolution (whether decaying, growing, or neither), and applies to both directed and undirected networks. We demonstrate its applicability through a simple case study application to the evolution of Wikipedia in three languages.

Existing methods to analyse accelerating networks have used the (somewhat inappropriate) mean-field technique. In ongoing work, we show that it is not only possible, but more accurate to use the master equation technique. This is demonstrated in the graph on the left where the latter is compared to simulated accelerating networks with preferential and random attachment. We demonstrate this process through application to the evolution of the co authorship network in the cond-mat archive.

Reference: *New Journal of Physics* **9** 181

Contact: David Smith (CABDyN)

Collaborators: Neil F. Johnson (CABDyN) and Jukka-Pekka Onnela (CABDyN)



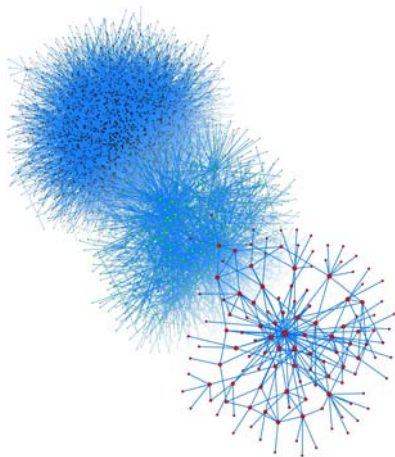
Link-Space Formalism for Network Analysis

We introduce the link-space formalism for analyzing network models with degree-degree correlations. The formalism is based on a statistical description of the fraction of links l_{ij} connecting nodes of degrees i and j . To demonstrate its use, we apply the framework to some pedagogical network models, namely, random attachment, Barabási-Albert preferential attachment, and the classical Erdos and Rényi random graph. For these three models the link-space matrix can be solved analytically. We apply the formalism to a simple one-parameter growing network model whose numerical solution exemplifies the effect of degree-degree correlations for the resulting degree distribution. We also employ the formalism to derive the degree distributions of two very simple network decay models, more specifically, that of random link deletion and random node deletion. The formalism allows detailed analysis of the correlations within networks and we also employ it to derive the form of a perfectly nonassortative network for arbitrary degree distribution.

Reference: Physical Review E. 77 036112.

Contact: David Smith (CABDyN)

Collaborators: Chiu Fan Lee (CABDyN), Jukka-Pekka Onnela (CABDyN), and Neil F Johnson (CABDyN).



Mechanisms for Robust Network Contraction

This project seeks to complement the large body of work on network growth by developing new models which explore how networks may contract without collapsing, and what specific mechanisms can be identified that contribute to the robustness of a contracting network. We therefore need to understand how different combinations of assembly and disassembly processes act on network structures, and under what circumstances the network topology is preserved.

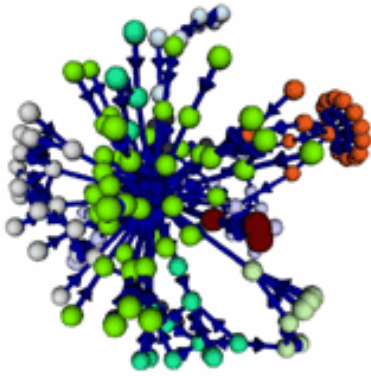
The empirical side of the project is based on an extensive dataset of transactions between firms in the New York garment industry over a period of almost 20 years. In addition to the empirical research, extensive simulations are run to explore different modes of contraction, and to generalize the findings beyond the specific inter-firm network on which the empirical research is based.

Reference: 'Asymmetric disassembly and robustness in declining networks',

Proceedings of the National Academy of Sciences U.S.A . (PNAS) 105, 16466-16471 (2008).

Contact: Felix Reed-Tsochas (CABDyN)

Collaborators: Serguei Saavedra (CABDyN) and Brian Uzzi (Northwestern University)

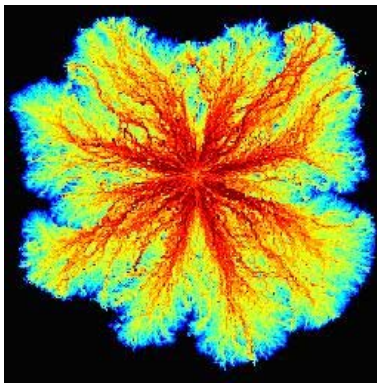


Interaction Patterns in Ecological and Organizational Networks

This project looks at empirical data for a specific class of ecological networks, as well as data from a manufacturer-contractor network, with a view to identifying common features in the interaction patterns for these very different systems and environmental contexts. The similarities that we find are not simply fortuitous, but reflect that in both cases there are analogous constraints on consumer-resource interactions. The empirical analysis is augmented by the aim to develop a stochastic model that can account for the observed structural features in both types of networks.

Contact: Felix Reed-Tsochas (CABDyN)

Collaborators: Serguei Saavedra (CABDyN) and Brian Uzzi (Northwestern University)



Agent-Based Modeling of Resource Canalisation

Mark Fricker, Neil Johnson, David Smith and Chiu-Fan Lee have developed a generic agent-based model which is remarkably simple, yet which yields emergent structural networks that capture the dynamical evolution of canalised nutrient fluxes observed in real fungi. In this model, the nutrients required for growth are translocated through the developing structure by the agents themselves. This is in contrast to agent models based on diffusion-limited aggregation (DLA) or diffusion-limited growth (DLG), and most continuous (PDE) models where growth is controlled by diffusion of nutrients through an external field.

Reference: Smith et al. (2008)

Contact: Mark Fricker (CABDyN)

Collaborators: David Smith (CABDyN), Neil Johnson (CABDyN), Chiu-Fan Lee (CABDyN), Jukka-Pekka Onnela (CABDyN)

WORKING PAPERS

*All working papers can be downloaded from the CABDyN Complexity Centre's website:
http://www.cabdyn.ox.ac.uk/complexity_working.asp*

Title: Imitative Trust Versus Indirect Reciprocity

Author(s): [S. Saavedra](#), [D. Smith](#), and [F. Reed-Tsochas](#)

Paper#. 09-09-010

Title: Communities in Networks

Author(s): [Porter, M. A.](#), [Onnela, J.-P.](#),

[Mucha, P. J.](#)

Paper#: 09-02-009

Title: Effects of Epidemic Threshold Definition on Disease Spread Statistics

Author(s): [Lagorio C.](#), [Migueles, M.V.](#), [Braunstein, L.A.](#), [López, E.](#), [P.A. Macri](#)

Paper#: 08-11-008

Title: Master-Equation Analysis of Accelerating Networks

Author(s): [Smith, D. M. D.](#), [Onnela, J.-P.](#),

[Jones, N.](#)

Paper #: 08-10-007

Title: Sampling Bias in Systems with Structural Heterogeneity and Limited Internal Diffusion

Author(s): [Onnela, J.-P.](#), [Johnson, N. F.](#), [Gourley, S.](#), [Reinert, G.](#), [Spagat, M.](#)

Paper #: 08-10-006

Title: Rapidly Detecting Disorder in Rhythmic Biological Signals: a Spectral Entropy Measure to Identify Cardiac Arrhythmias

Author(s): [Staniczenko, P.P.A.](#), [Lee, C.F.](#), [Jones, N.S.](#)

Paper #: 08-10-005

Title: Community Structure in Online Collegiate Social Networks

Author(s): [Traud, A.L.](#), [Kelsic, E.D.](#), [Mucha, P.J.](#), [Porter, M.A.](#)

Paper #: 08-09-004

Title: Transmission of Errors in Production Networks

Author (s): [S. Saavedra](#), [S.](#), [Smart, J.](#), [Reed-Tsochas, F.](#), [Uzzi, B.](#)

Paper #: 08-03-003

Title: Network Automata and the Functional Dynamic Network Framework

Author (s): [Smith, D.M.D.](#), [Onnela, J.-P.](#), [Lee, C.F.](#), [Fricker, M.D.](#), [Johnson, N.F.](#)

Paper #: 08-03-002

Title: Bias in Epidemiological Studies of Conflict Mortality

Author (s): [Johnson, N.F.](#), [Spagat, M.](#), [Gourley, S.](#), [Onnela, J.-P.](#), [Reinert, G.](#)

Paper #: 08-01-001

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Author(s): Lee, C. F.

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Author(s): Richardson, T., Mucha, P. J., Porter, M. A.

Physical Review E, Volume 80, Number 3, 16 September 2009

doi:10.1103/PhysRevE.80.036111

Title: **Dynamic Communities in Multichannel Data: An Application to the Foreign Exchange Market During the 2007–2008 Credit Crisis**

Author(s): Fenn, D.J., Porter, M.P., McDonald, M., Williams, S., Johnson, N. F., Jones, N. S.

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Author(s): [Hedström, P.](#), [Wittrock, B.](#) (Eds)

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* CABDyN co-authors in "BLUE"

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SEMINARS AND WORKSHOPS

DISSEMINATION EVENTS

Oxford Signals Days

The Oxford Signals Days were designed to bridge research from Oxford's different departments and divisions. The event organised by Nick Jones and Felix Reed-Tsochas of CABDyN; brought together experimentalists, analysts and theorists from across the University's 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 a system through time.

The event consisted of a series of talks given by: Holger Kantz and David MacKay – keynote speakers, Simon Blockley, Joanna Dunkley, Chris Holmes, Patrick McSharry, Bent Nielsen, lead Rezek, Mark Roberts, Steve Roberts, Jan Schnupp, Nathalie Seddon, Neil Shephard, Richard Vaughan -Jones, Mark Woolrich.

23-24.04.2009 Physics Department, University of Oxford

Silicon Valley Comes to Oxford - Networks Masterclass

"Silicon Valley Comes to Oxford" has become an annual event at the Saïd Business School, which brings entrepreneurs and leading technology and financial experts from Silicon Valley to Oxford for a series of debates, discussion panels and masterclasses.

This year Felix Reed-Tsochas and Mark Fricker of CABDyN were joined by Stephen Roberts and Victoria Nash to give a Masterclass for Silicon Valley Guests on the Subject of "Networks".

23.11.2008 Saïd Business School, University of Oxford

Oxford BioNets Day

The Oxford Biological Networks Day was held in the Physics Department of the University of Oxford, and was organised and supported by the Oxford Centre for Integrative Systems - Judith Armitage and CABDyN Complexity Centre - Nick Jones and Felix Reed-Tsochas. The day was designed to bridge research on biological networks from Oxford's different departments and divisions. It brought together experimentalists, analysts and theorists from across the Universities' departments with the goal of increasing contact between researchers studying networked systems in Biological and Medical Science with those in Mathematical and Physical Science. The opening lecture was given by Lord Robert May (Zoology), and the event was focused on the following themes: subcellular networks, networked cells and networked organisms.

03.10.2008 Physics Department, University of Oxford

Complex Systems in a Nutshell

The “**In a Nutshell**” series is a joint venture between the University of Oxford’s Regional Liaison Office and the Oxford Science Enterprise Centre at the Saïd Business School which informs the Oxford business community on interesting and current issues. The series brings together leading academics from the University to discuss, in everyday language, a particular subject and the issues surrounding it. The aim of the event was to give a broad professional audience an introduction to the field of Complexity Science and the ways in which the study of Complex Systems provides insights into the design of more effective business networks and systems. The evening consisted of a series of talks given by Felix Reed-Tsochas, Mark Fricker and Jukka-Pekka Onnela.

08.07.2008 Saïd Business School, University of Oxford

MMCOMNET Final Workshop

The Measuring and Modelling Complex Networks Across Domains (**MMCOMNET**) project set out to measure and model complex networks from different domains, with the goal of understanding their structure, function and behaviours.

CABDyN hosted the fifth and final **MMCOMNET** project workshop. A number of CABDyN members presented their results from this EU funded three-year project alongside project partners from Germany: Technische Universität, Dresden, Poland: Politechnika Warszawska, France: INSEAD Business School, Switzerland: Swiss Federal Institute of Technology Zurich, Sweden: Stockholm University. The UK Fungal Network (UKFN) also participated in this event by giving a series of talks on biological networks which share common features with other complex networks, in terms of their overall structure and dynamics.

16-18.04.2008 Saïd Business School, University of Oxford

SEMINAR SERIES

Hilary Term 2008

“Pink Noise and Sensory Adaptation”

Dr Nick Jones, Physics Department and Oxford Centre for Integrative Systems Biology, University of Oxford
January 22, 2008

“Fluctuation Scaling: Taylor’s Law and Beyond”

Dr Zoltan Eisler, Equity Arbitrage Capital Fund Management, Paris
February 5, 2008

“Markets Come to Bits: Evolution, Computation, and Markomata in Economic Science”

Prof Philip Mirowski, Department of Economics and Policy Studies, University of Notre Dame
February 12, 2008

“Emergence of Communities in Social Networks”

Dr Jukka-Pekka Onnela, Department of Physics and Saïd Business School, University of Oxford
February 19, 2008

“Patterns of Cooperation in Ecological and Organizational Networks”

Serguei Saavedra Sanchez, Department of Engineering Science, University of Oxford
February 26, 2008

“Neutral Degree Distributions in Complex Food Webs”

Dr Rich Williams, European Science Initiative, Microsoft Research Ltd
March 4, 2008

“Cognition vs Time as Constraints in the Structuring of Human Social Networks”

Prof Robin Dunbar, Institute of Cognitive & Evolutionary Anthropology, University of Oxford
March 11, 2008

Trinity Term 2008

“Collective Motion: Models and Experiments”

Prof Tamás Vicsek, Department of Biological Physics Eötvös Loránd University (ELTE), Budapest
April 22, 2008

“Limited Path Percolation in Complex Networks”

Dr Eduardo Lopez, Saïd Business School, University of Oxford
April 29, 2008

“Systems Modelling Approaches for Making and Exploring Decisions”

Prof Julian Hunt, Department of Space and Climate Physics, University College London
May 20, 2008

“Tempo and Mode in Language Evolution”

Dr Quentin Atkinson, Institute of Cognitive and Evolutionary Anthropology, University of Oxford.

June 3, 2008

“Physics and Complexity”

Prof David Sherrington, Rudolf Peierls Centre for Theoretical Physics, University of Oxford

June 10, 2008

Michaelmas Term 2008

“A Model of Cooperation for Bipartite Networks”

Dr Felix Reed-Tsochas, Institute for Science, Innovation and Society, Saïd Business School, University of Oxford

October 14, 2008

“The Tangled Nature Model of Biological Emergence: How far Can One Go by Using a Minimalist Model of Co-Evolution?”

Prof Henrik Jeldtoft Jensen, Institute for Mathematical Sciences, Imperial College London

October 21, 2008

“Stability, Complexity and Diversity in Random Replicator Models of Ecology and Evolutionary Game Theory”

Dr Tobias Galla, Theoretical Physics Group, University of Manchester

October 28, 2008

“Voting Together: How Social Networks Affect the Emergent Norm of Voter Turnout”

Dr Meredith Rolfe, Oxford University Centre for Corporate Reputation, Saïd Business School, University of Oxford

November 4, 2008

“Modelling4All – A ‘Flickr’ for Computer Modelling”

Dr Ken Kahn, Oxford University Computing Services

November 11, 2008

“The Business Value of Understanding Networks of Conversations.”

Mark Rogers, CEO Market Sentinel

November 18, 2008

“An Understanding of Food-Web Persistence from Local to Global Scales”

Dr Daniel Stouffer, Integrative Ecology Group, Estación Biológica de Doñana, Spain

November 25, 2008

Hilary Term 2009

“Statistical Physics and Complex Networks”

Prof Shlomo Havlin, Department of Physics, Bar-Ilan University, Israel

January 27, 2009

“Some Offbeat Approaches to Epidemics on Networks”

Dr Peter Dodd, Division of Epidemiology, Public Health and Primary Care, Imperial College, London

February 10, 2009

“Microdynamics in Stationary Networks: Empirical Results and Modelling”

Dr Marc Barthelemy, Commissariat à l'Énergie Atomique – Département de Physique, France

February 17, 2009

“Schumpeter Meeting Keynes: A Policy – Friendly Model of Endogenous Growth and Business Cycles”

Prof Giovanni Dosi, Sant'Anna School of Advanced Studies, Pisa Italy

February 25, 2009

“Do the Rich Really Take It All?”

Dr Vittoria Colizza, Complex Systems Lagrange Lab, ISI Foundation, Turin, Italy

March 18, 2009

Trinity Term 2009

“Robust Networks”

Prof Sanjeev Goyal, Faculty of Economics, Cambridge University

April 28, 2009

“Quantitative Foodwebs as Tools for Ecologists”

Dr Owen Lewis, Department of Zoology, University of Oxford

May 12, 2009

“Are Networks Real?”

Prof Alan Baker, Department of Philosophy, Swarthmore College, CABDyN Complexity Centre, Saïd Business School, University of Oxford

May 19, 2009

“Size Matters: Growth, Innovation, Economies of Scale and the Pace of Life from Cells to Cities and Corporations”

Prof Geoffrey West, Santa Fe Institute

May 26, 2009

“Runaway Growth in the Coagulation Equation Revisited”

Dr Colm Connaughton, Mathematics Institute and Warwick Centre for Complexity Science, University of Warwick

June 2, 2009

“Dynamics of Political Polarization”

Dr Delia Baldassarri, Princeton University

June 9, 2009

CABDyN Summer Workshops

“Giving Character to Particles and Nodes”

Prof Neil Johnson, Department of Physics, University of Miami
July 10, 2009

“Lost in Parameter Space: Biologically Inspired Agent Models”

Dr Mark Fricker, Department of Plant Sciences, University of Oxford
July 24, 2009

“The Mixed Value of Protein Interaction Network Data”

Dr Nick Jones, Department of Physics, University of Oxford
August 14, 2009

“Predicting Inter-Domain Contact Sites Using Local Network Information”

Qiang Lou, Department of Statistics, University of Oxford
September 4, 2009

“Shortest Paths in Bipartite Networks”

Prof Gesine Reinert, Department of Statistics,
University of Oxford
September 17, 2009

PROJECT FUNDING

Active Grants

Junior Research Fellowship in Computational Complex Systems and Networks 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 is held by Dr Jukka-Pekka Onnela, who is affiliated with the Physics Department and the Saïd Business School.

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.

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 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).

Scaling in Complex Systems [1 May 2009 – 31 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 future of cities. The project will allow us to strengthen existing links with the Santa Fe Institute, and develop new links with Imperial College London.

“Coevolution, Interconnections and Communities of Social and Political Networks in the United States Congress” [October 2009- September 2013] \$420k grant has been awarded to CABDyN’s Mason Alexander Porter. Mason is the Principal Investigator with J.H. Fowler as a co – investigator on this research award which falls within the James S. McDonnell Foundation’s programmes area of “Studying Complex Systems”.

CABDyN Seminar Series [August 2008 – July 2011] £13k grant is funded by The Institute for Science, Innovation and Society.

MMCOMNET – “Measuring and Modelling Complex Networks Across Domains” [February 2005 – May 2008] €1.5m (University of Oxford – €541k) Specific Targeted Research Project for which Oxford (PI: Felix Reed-Tsochas) was the scientific coordinator. Project was carried out with 5 other European Partners; ETH Zurich, INSEAD, Technical University Dresden, Warsaw University of Technology, University of Stockholm.

GIACS – “General Integration of the Applications of Complexity in Science” [July 2005 – January 2009] €1.4m (University of Oxford – €6k) Coordination Action under European Commission NEST Pathfinder Initiative “Tackling Complexity in Science”.

ONCE-CS – “Open Network of Centres of Excellence in Complex Systems” [July 2005 – March 2008] €1m (University of Oxford – €123k) project was funded as part of the FET initiative of the IST (Information Society Technology) programme of the European Commission under priority Framework 6. The purpose of ONCE-CS was to strengthen European research in complex systems, and to assist people in business and public services to use the new science effectively.

“Modeling the Effect of Status and Reputation in a Large Interfirm Network” [July 2008 – January 2009] £23k Oxford University Corporate Reputation Centre funded a short term post-doc position.

Future Grants

“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 led 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.

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 Said 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’

COMMUNICATION

WEBSITE

The CABDyN website was set up in 2003 to help coordinate and publicise the activities of CABDyN. In its present form it is used to make available a wide range of information and resources. These include publications, working papers, seminar talks, profiles of CABDyN members, news items, press coverage, a showcase for selected research projects, and information on research programmes. Types of resources include text documents, images, video clips, and software. 2009/10 will see the next major revision of the website.

www.cabdyn.ox.ac.uk

PRESS COVERAGE

“On my mind: Network Dynamics in a Shrinking World – The Universe in 2009.”

Felix Reed - Tsochas

SEED Magazine, February 1, 2009

“On my mind: Collective Intelligence and Decision Making – The Universe in 2009.”

Iain Couzin

SEED Magazine, February 1, 2009

“Project Networking.”

Janet Smart

Project Magazine, January 1, 2009

“Article of the Year 2008.”

Journal of Peace Research, December 15, 2008

“Hives of Industry.”

SAID Internet News, December 11, 2008

“Staying Connected.”

SAID Internet News, October 21, 2008

“The Hunger, the Horror.”

Sally Palmer

New Scientist Feature Article, May 30, 2008

“Selbstmord durch Ansteckung (Social Contagion).”

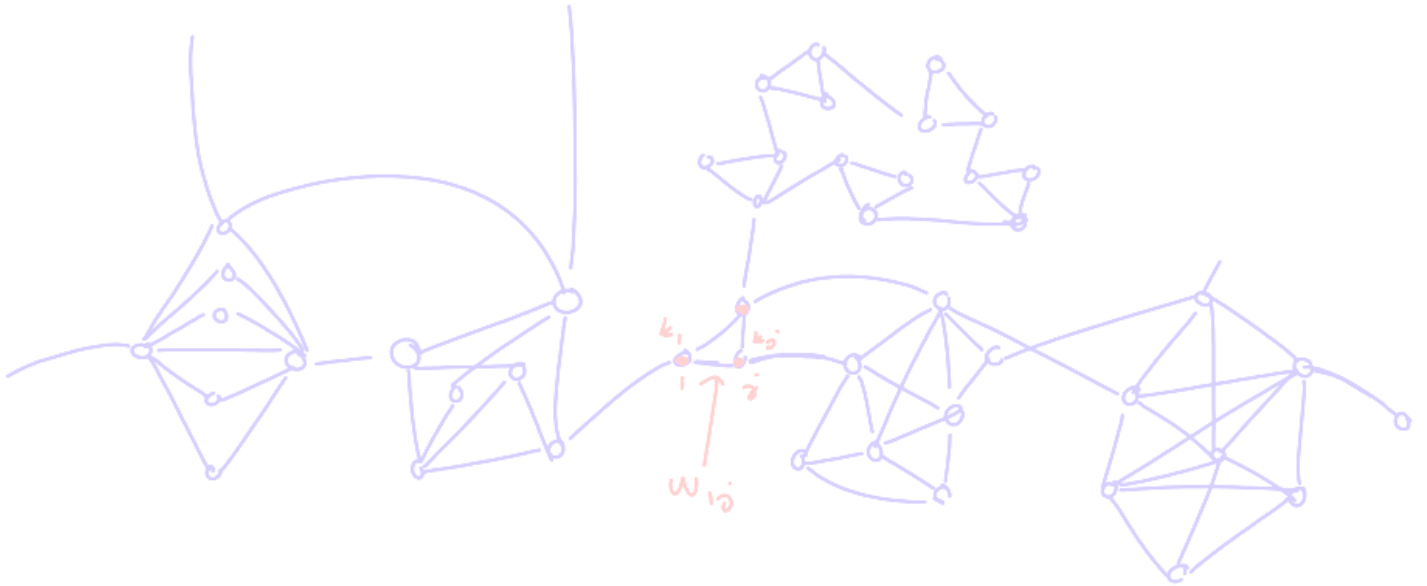
Peter Hedström

Der Spiegel, May 1, 2008

“Business Benefits from a More Disciplined Approach.”

Stuart Crainer

The Times Online, January 23, 2008



CABDyN Complexity Centre
University of Oxford
Saïd Business School
Park End Street
Oxford
OX1 1HP

Tel: +44 (0)1865 288785
www.cabdyn.ox.ac.uk