MSc projects at BT Research

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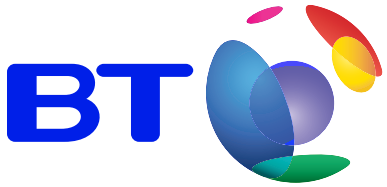


University of York MSc talk 2007 Jan 31 1330

TYPESET 2007 JANUARY 26 10:33 IN PDFLATEX ON A LINUX SYSTEM

Adastral Park, Martlesham, Suffolk

- Cambridge-Ipswich high-tech corridor
- 2000 technologists
- 15 companies
- UCL, Univ of Essex

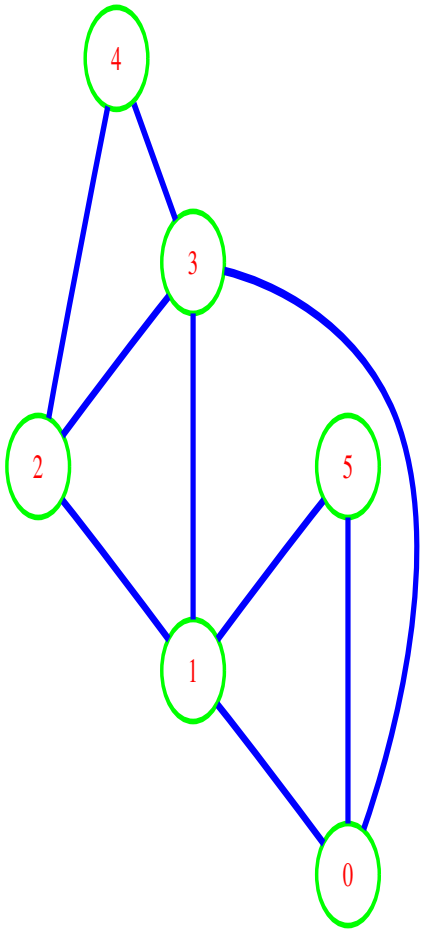
BT Research centres

- Broadband centre
- Foresight centre
- IT futures research centre
- Intelligent systems centre
- Mobility centre
- Networks centre
- Pervasive ICT centre
- Security centre
- Asian Research centre
- Disruptive lab at MIT

MSc projects supervised by Keith Briggs

- Semidefinite programming and graph theory
- Monte Carlo Markov chain simulation of exponential random graph models
- Markov models of wireless protocols
- other projects might be possible by negotiation . . .

Graph concepts



- *clique* - a complete subgraph
- *clique number* ω - the number of nodes in a largest clique
- *colouring* - an assignment of colours to nodes in which no neighbours have the same colour
- *chromatic number* χ - the number of colours in a colouring with a minimal number of colours
- *edge colouring* - an assignment of colours to edges in which no edges with a common endpoint have the same colour
- *edge chromatic number* χ' - the number of colours in an edge colouring with a minimal number of colours

Semidefinite programming and graph theory

Semidefinite programming (SDP) is a kind of generalized linear programming. Many practical optimization problems can be formulated as SDPs. There has been rapid progress in the last 20 years on understanding the theory of SDP, but the development of SDP software that is convenient to use has lagged behind. Good software is now available. This project would use sdpsol for small test problems, and then move to DSDP for large problems. The aim of the project is to see what performance one can achieve on real graph theory problems of the types that come up in network modelling. Such problems include the Lovasz theta number (a lower bound for the chromatic number), the maximal stable set problem, and the maximum cut problem. An important outcome of the project would be a determination of how the computation time scales with problem size. Geometric optimization problems could also be studied.

Semidefinite programming and graph theory

- Hard (i.e. slow to solve) problems can sometimes be approximately solved by fast methods
- Even better is if the fast method provides bounds to the true solution
- This is the case for some problems in graph theory

Typical results

graph	n	p or m	α	ω	χ_f	θ	χ	
g1	10	0.5	4	4	4	4	4	medium
g2	10	0.9	3	7	7	7	7	dense
g3	10	0.1	9	2	2	2	2	sparse
g4	50	5	45	2	2	2	2	sparse, big
g5	50	100	23	3	3	3	3	medium density, big
g6	50	1000	4	14	16.5	15.36	17	high density, big

- theorem: we always have $\omega \leqslant \omega_\mathsf{f} \leqslant \chi_\mathsf{f} \leqslant \chi$
- recall $\omega \leqslant \theta \leqslant \chi$

Exponential random graphs

- this is a class of random graphs proposed as models for social networks and now being applied to communication networks
- they are constructed with a very close analogy to statistical mechanical models in physics, so that one may talk of the temperature, free energy, entropy etc. of a graph!
- in this project we would write software to simulate this graph process, and study the problem of parameter estimation and fitting to observed graphs

Exponential random graphs

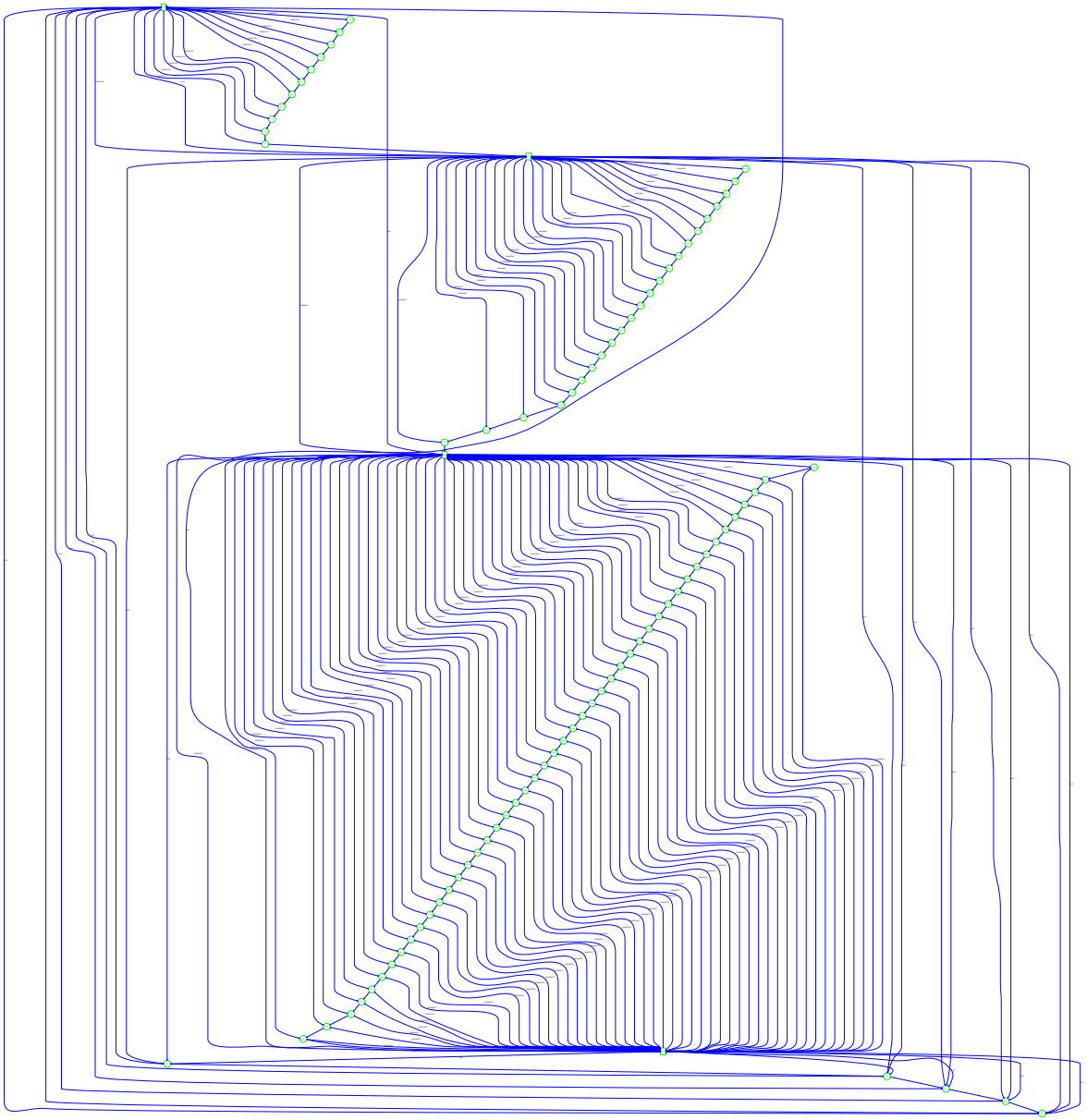
This project would build on the exponential random graph project from 2005. Please see Alan Terry's report for background information.

The sampling techniques for ensembles of random graphs used in this form of network modelling depend on Monte Carlo Markov chain techniques. These, however, often converge slowly and need therefore to run as fast as possible. This depends on very efficient low-level representations of graphs. Adjacency matrices can be packed into bit strings, thus exploiting the CPU cache optimally. This project would compare the speed of various representations of graphs. Most work would be done in C, but this project would ideally suit a student who would like to explore assembler coding as well.

Markov models of wireless protocols

Mobile wireless systems transmit data with protocols similar to TCP, but different in several respects. The performance of such systems can be modelled with Markov chains. At the last Bath Study Group we developed methods for handling the large sparse matrices arising in this problem. Part of the project would be to implement these methods. Additionally, simulations are useful. This project would develop software for such a simulation, especially for a varying number of users of a wireless access point, and compare the results with analytical predictions.

Markov models of wireless protocols



Markov models of wireless protocols

- I have a large set of methods worked out in theory in great detail
- The project would implement some of these in software