Mathematics for Operations Research (applied probability, network modelling)

People

- Frank Kelly *(Random processes, networks and optimization, especially applications to the design and control of communication networks)*

- Yuri Suhov *(Statistical mechanics, communication theory, queueing systems, networks including neural networks)*

- Richard Weber *(Mathematics for operational research and systems; models in telecommunications and operations management; control of queues, stochastic networks, on-line bin packing, ergodicity of Markov processes, optimal search, stochastic scheduling, dynamic resource allocation, financial mathematics)*

- Peter Whittle *(Sequential optimisation problems, stochastic processes, neural networks)*

- Damon Wischik *(Stochastic networks, large deviations, internet traffic modelling)*

visiting fellows: Ayalvadi Ganesh, Peter Key

ten research students

Overview

- An aim is to understand large scale networks:

  - networks we have constructed (e.g. telephone, communication networks), or natural networks (e.g. neural networks)

  - the relationship between microscopic rules and macroscopic behaviour

- Close links with other disciplines

 - especially computer science, economics, management studies, engineering

Highlights

- J.B. Martin and Y.M. Suhov. Fast Jackson networks Annals of Applied Probability 9, 1999, 854-870.

- I. Kurkova and Y.M. Suhov. Malyshev's theory and JS-queues (to appear Annals of Applied Probability, 2003/4)

- (differential equations as asymptotic limits; analytic criteria for recurrence of random walks)

Highlights

– Perfect Packing Theorems and the Average Case Behavior of Optimal and Online Bin Packing, E. G. Coffman, Jr., C. Courcoubetis, M. R. Garey, D. S. Johnson, P. W. Shor, R. R. Weber, and M. Yannakakis, SIAM Review 44 (2002), 95-108.

– This paper was published in SIAM Review 2002 as a "best paper of the year". It uses novel ideas regarding positive recurrence of multidimensional Markov chains, computer proof and strong law of large numbers to evaluate the performances of several bin packing algorithms.
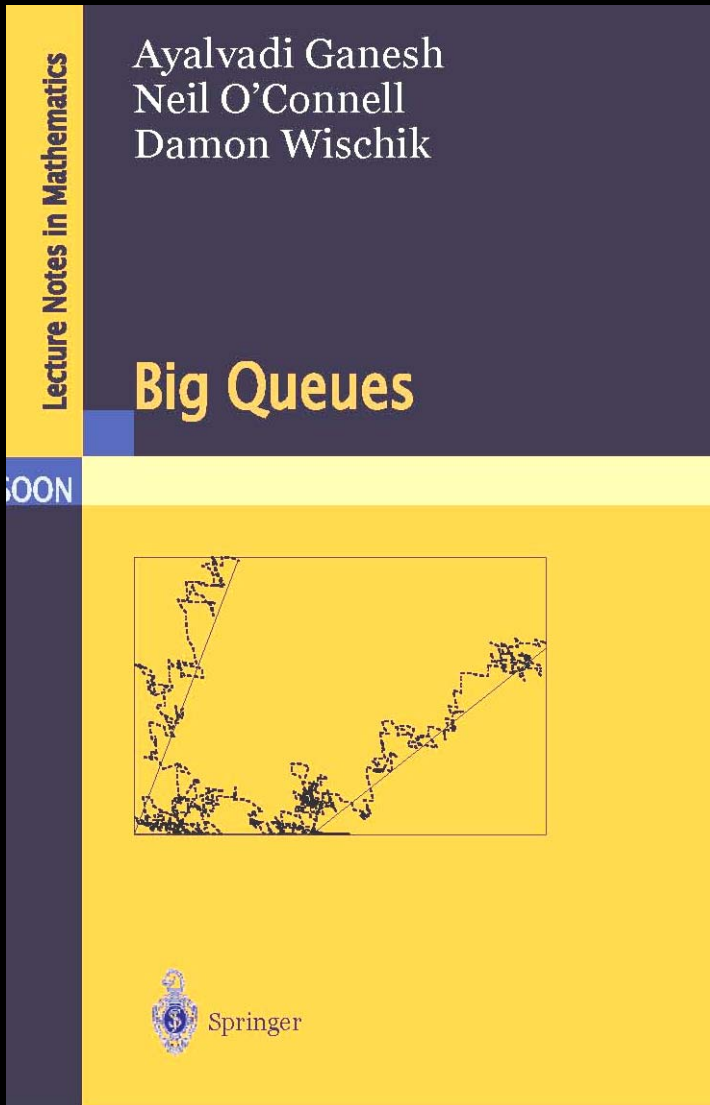
Highlights
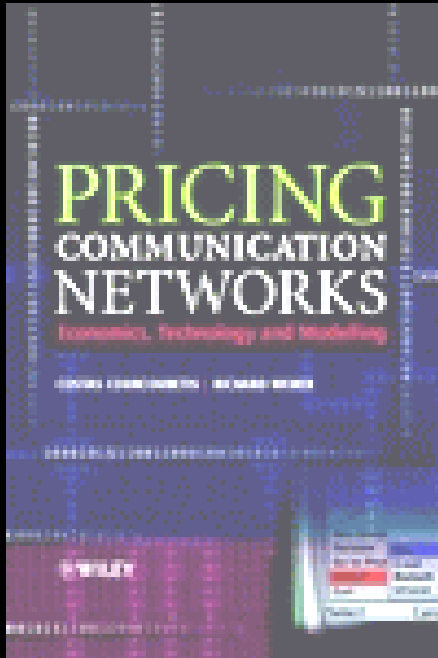
C. Courcoubetis and R. Weber
Pricing Communication Networks,
Wiley 2003

A framework of mathematical models for pricing contracts for network services

(challenges: statistical description of traffic, network flow and game aspects)

Highlights

Large deviations theory provides powerful results and general techniques for studying rare events: it applies to queueing problems under a variety of limiting regimes

Lecture Notes in Mathematics

Ayalvadi Ganesh
Neil O'Connell
Damon Wischik
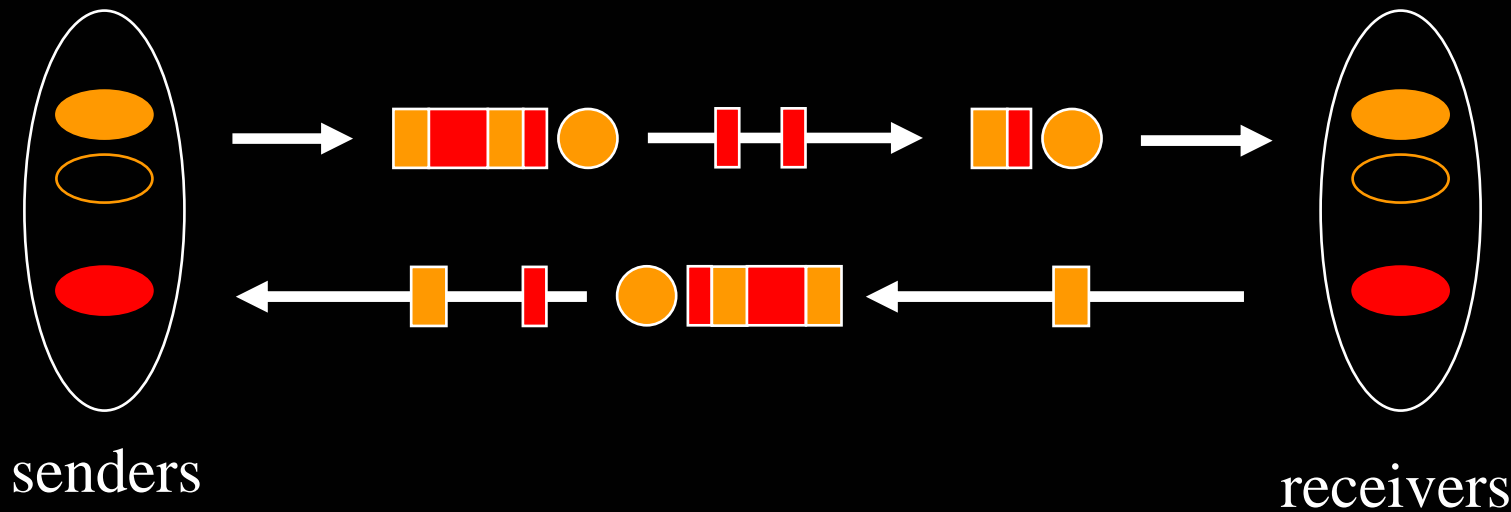
Big Queues

SOON

Springer

Highlights

- F.P. Kelly Fairness and stability of end-to-end congestion control. European Journal of Control 9 (2003) 159-176.
- F.P. Kelly and R.J. Williams Fluid model for a network operating under a fair bandwidth-sharing policy, to appear Annals of Applied Probability
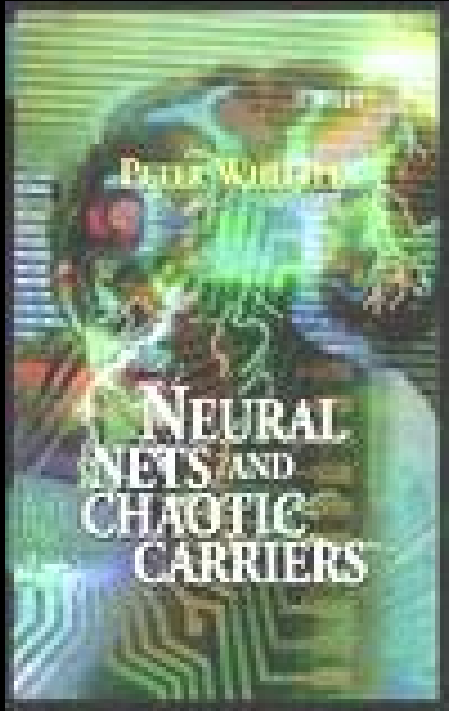
Source: CAIDA,
Young Hyun
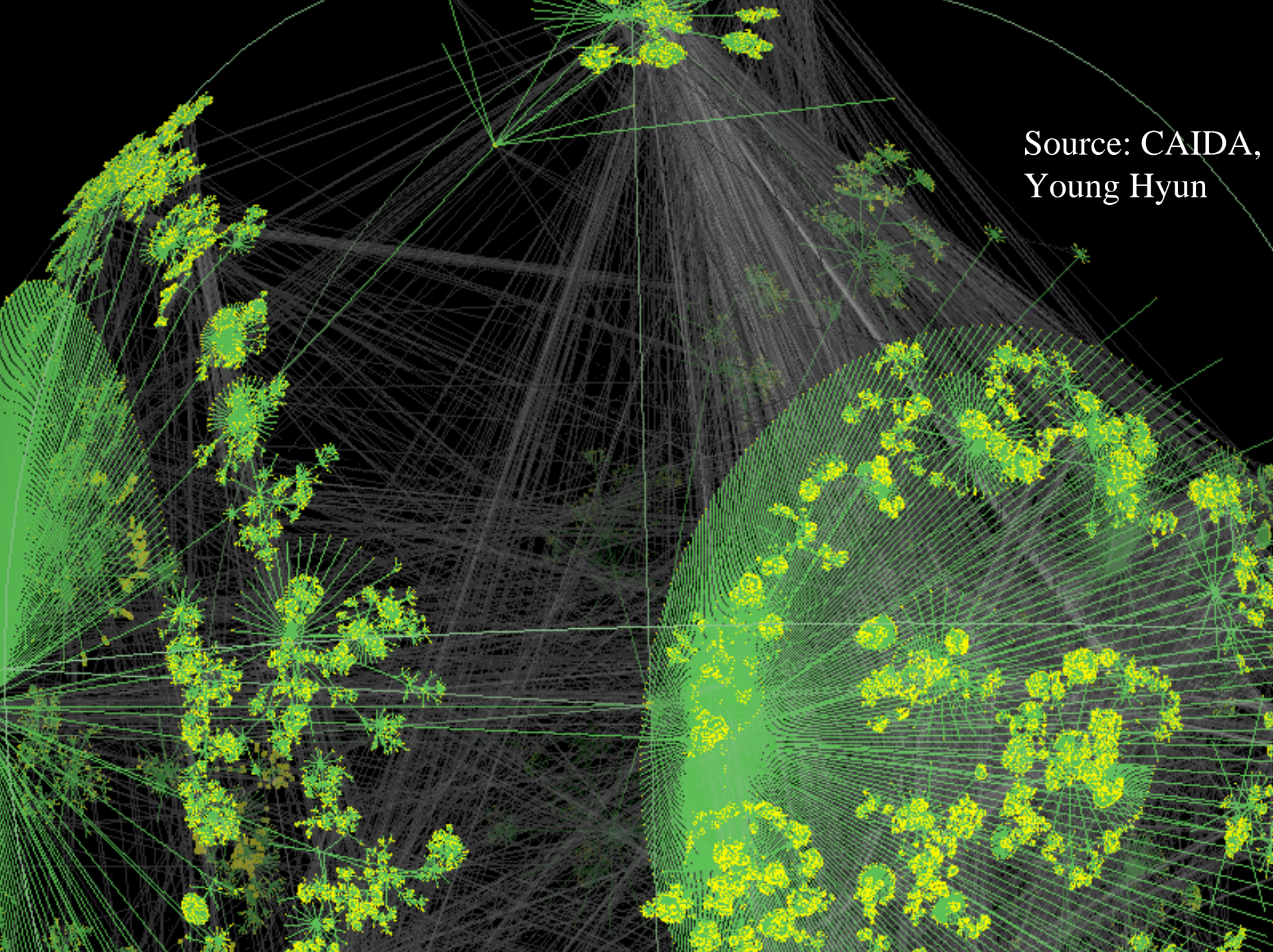
End-to-end congestion control

senders   receivers

Senders learn (through feedback from receivers) of congestion at queue, and slow down or speed up accordingly. Understanding aided by models of queues, network flow and feedback control: techniques include optimization, limit theorems, control theory)

Highlights

Peter Whittle,
Neural Networks and Chaotic Carriers

An associative memory must be able to cope with 'fading data', i.e. to form an inference from data even as its memory of that data degrades. The resultant net shows striking biological parallels, suggesting testable anatomical predictions

P. Whittle Applied Probability in Great Britain Operations Research 50(2002), 227-239.

Links with other disciplines, industry

- European projects
  - CA$hMAN (Charging and Accounting Schemes in Multiservice ATM Networks)
  - M3I (Market Managed Multiservice Internet)
  - MMAPPS (Market Management of Peer to Peer Services)
- Computer Laboratory, Applied Economics, Engineering Department, BT, Microsoft Research, France Telecom, Intel Research (Crowcroft, Gibbens, Massoulie, McAuley, Roberts, Vinnicombe)

International involvement

- EURANDOM (Stochastic Networks – research project)
- Institute for Pure and Applied Mathematics, UCLA
  (Large Scale Communication Networks, Spring 2002)
- Institute for Mathematics and its Applications, Minnesota (Control and Pricing in Communication and Power Networks, Winter 2004)
- Centres de Recherches Mathematiques Montreal (Conference on Stochastic Networks, July 2004)
- INFORMS: council member of Applied Probability section, chair and member of prize committees, two holders of Lanchester prize
- Editorships, member of conseil scientifique de France Telecom, etc

Final remark

- The Mathematics Faculty at Cambridge has been an excellent base for the Mathematics of Operations Research:
  - academically gifted students
  - pursuit of excellence taken for granted
  - expert and helpful colleagues in the full range of mathematical sub-disciplines
  - ease of collaboration with other disciplines and industry