Stochastics in Applications, Göteborg, Nov 16, 2001

Stochastics in Telecommunications

Ingemar Kaj
ikaj@math.uu.se
Department of Mathematics
Uppsala University

UPPSALA
UNIVERSITET

Outline

- Background
- New proposed SSF research program

- Everything is about the Internet
- What do we have to learn from the engineers?
- What we can offer to them?
- Central topics
- Measuring, Modeling, Making disruptive prototypes
- The 'Day in the Life of the Internet' Challenge

ASN: Stochastics in telecommunications, 1997-2001

- PhD funding
  - 1997: 1, 1998-2001: 5
  - Plus 5 with projects close to the program themes
- Results
  - Approx 8 Lic + 1 PhD (by Jan 02)
  - Several projects include collaboration with industry: Ericsson Radio Systems AB, Ericsson Utvecklings AB, Ericsson Mobile Platforms AB, Telia Research AB, SICS AB.
  - International workshops, national graduate courses, conference visits and presentations, publications

Proposed new research program

Stochastic methods in telecommunication

Specific goals

- To carry out research on stochastic methods for applications in communications technology with particular emphasis on developing mathematical techniques relevant in telecommunications for mobile users and for the mobile Internet.
- To maintain a PhD program in mathematical statistics with focus on stochastic methods in telecommunications where new scientists get a broad knowledge and training in basic methodology as well as special competencies of potential top-priority interest for the Swedish telecommunications industry.
- To deepen collaboration with researchers in other academic areas and with the telecommunications industry.

Research directions

- **Data traffic modeling**
- **TCP modeling and TCP congestion control in packet networks**
- **Noise reduction and interference cancellation**
- **Simulation and complex queuing systems**
- **Spatial models for mobile telecommunications**
- **Stochastic methods for Internet telephony and radio based access networks**
- **Resource allocation on data networks**

Note: Senior research + PhD program

Probability of funding ?

SSF Applied Mathematics, 80 Mkr

- 67 applications, September 19, 2001
- Approx 20(?) projects will be selected for 2nd round of evaluations, Dec 20, 2001
- Total of 5 stochastic projects

SSF plan to finance 5-8 projects, starting April 2002

Stochastic methods in telecommunications is:

- Nothing new
  - Erlang: The most successful theory in the history of applied mathematics;
  - Conny Palm: Combined in a rare way practical experiments using equipment made with his own hands and deep mathematical analysis and modeling of observed measurements;
- Good for us

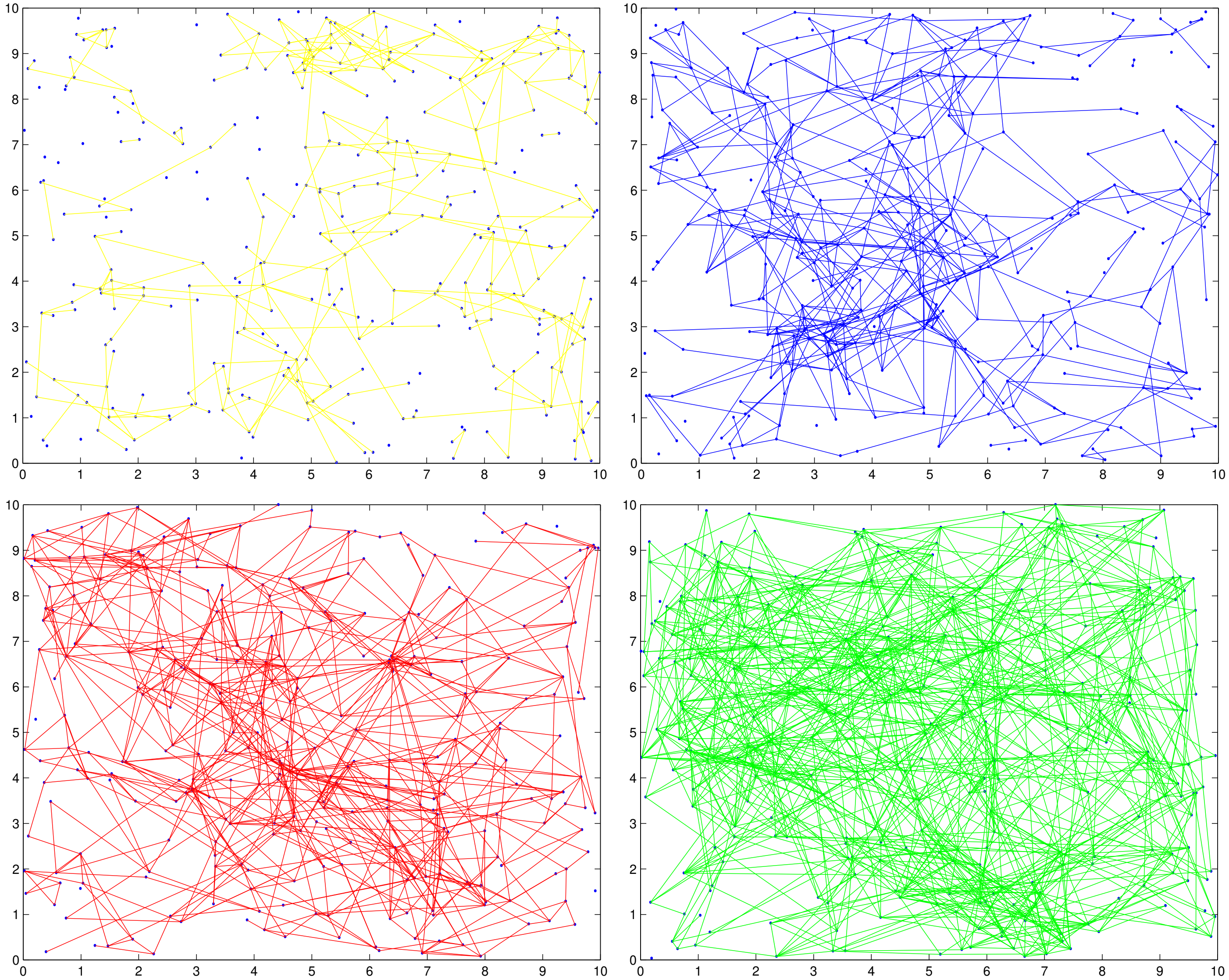
  The future of mathematical statistics is determined by

  1. Inner scientific quality;
  2. Our ability to attract students on all levels;
  3. **Our ability to interact and develop together with our 'scientific neighbors'**;
- Good for them
  - The language of stochastics is exceptionally powerful, fundamental for applied mathematics;
  - We are *eclectic* (can do something new of what other people discuss);

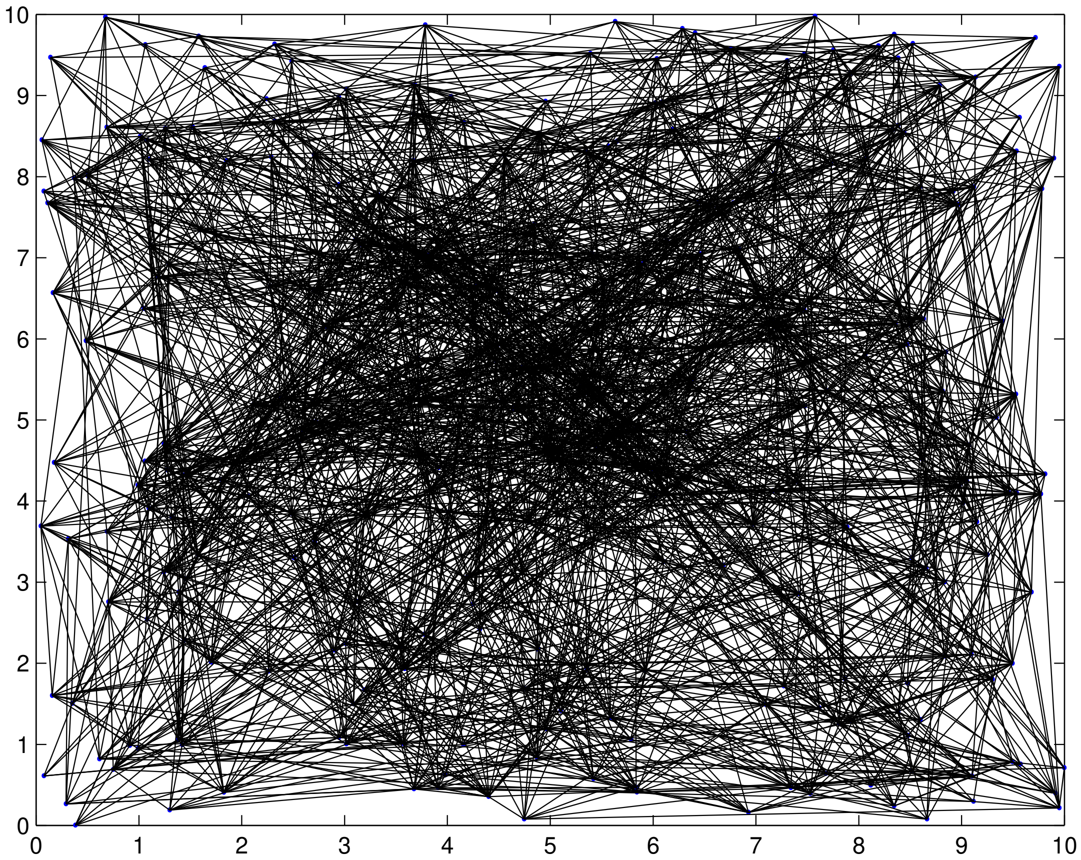
Everything has to do with the Internet;
the key concept is Quality of Service

- Transparency
  - Time integrity (no delay)
  - Semantic integrity (no loss)
- Accessibility
  - Admission; Currently no admission control in the Internet
  - Blocking probability; Key parameter for dimensioning telephone networks
- Realized throughput
  - Main QoS measure for document transfer, Web page download, etc
  - How much capacity? How to distribute capacity among flows?

The Internet grows



The future Internet ?



Some key issues

- A structured Internet ?
  - Expedite forwarding; Priority traffic
  - Assured forwarding; Transmission guaranteed, up to blocking probability
  - Best effort traffic; Today's Internet, currently no admission control
- Scalability
- Traffic aggregation
- Towards a self-regulating Internet ? (Network experts + control theory, stochastics ?)

Traffic classes

- **Stream traffic**
  - Telephone traffic; Talkspurts/silence (on/off)
  - Videoconferencing; More complex rate variations, multiple timescales
  - Prerecorded video (?)

  Mean duration? Mean rate? Heavy tails? stationary/non-stationary?

- **Elastic traffic**
  - Data files, text, images, video for storage, etc
  - E-mail; Varying flow rate acceptable
  - Web downloads; Some real-time constraints

  File sizes: Heavy tails? Mice/Elephant phenomenon!

The nature of network traffic, some questions

- Poisson, still useful?
- Heavy tails, self-similarity, long-range dependence ($\sim$ 1994); Is this nonsense, after all ?
  - Yes; (exact) self-similarity is
  - No; Mice/Elephant phenomenon is real, everyone agrees
- Fractional Brownian motion, Stable processes; Are these useful approximations of network traffic?
- **Microscopic/macroscopic behavior** Interaction, meanfield-approximation, algorithms, ...

What else ?

- Spatial models, mobility
- Internet Telephony
- Radio access to the Internet, the mobile Internet

  This makes things even more random, our competence even more useful...
- Wireless access; revival of Aloha ?
- The Internet has developed in a cooperative academic enviroment, is it reasonable to expect cooperative behavior from commercial competitors? Game theory, ...
-
-

What do the networking people think about the future, about statistics?

Workshop report conclusions: "Looking over the fence at networks" (NRC, Jan 2001)

- Measuring: Understanding the Internet Artifact
- Modeling: New Theory for Networking
- Making disruptive prototypes: Another Approach to Stimulating Research

Measuring: Understanding the Internet Artifact

- Collect and archive data in anticipation of future use;
- Develop and deploy the technology to make it possible to record a day in the life of the Internet;
- Take such a snapshot;

Modeling: New Theory for Networking

- Understanding scaling and dynamics requires the use of new modeling methodologies
- Concerns of manageability, reliability, robustness, and evolvability are of critical importance and require the development of new basic understanding and theory
- Even traditional areas, such as routing, must be addressed in a new context light of how the global Internet has evolved

Making disruptive prototypes: Another Approach to Stimulating Research

- Very successful, widely adopted technologies are subject to ossification, which makes it hard ... to replace it with something better
- Develop alternative visions
- Document the failures

Vision/Conclusion

The proposal is in the spirit of Conny Palm's work in promoting both the fundamental methodology of stochastics and the investigating experimentalist's approach. We expect the program to have substantial national impact and the graduates and their future work to be of strategic importance for the Swedish telecommunications industry.