



# Teletraffic Research at Networking Laboratory TKK Helsinki University of Technology

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<http://www.netlab.tkk.fi/tutkimus/>



# Networking Laboratory

- Focus on layer 3 and beyond
- Teaching: networking technology, teletraffic theory, networking protocols and services, networking business/network economics
- Big educational unit: 40-50 M.Sc. theses per year, 1-2 PhD's per year (3 in 2006)
- 4 professors (5th one to be nominated in 2007), total staff 60

## Research Areas

- Heikki Hämmäinen: **Network Economics**
- Raimo Kantola: **Autonomic Communications  
Mobile Peer-to-peer**
- Jörg Ott: **Disruption Tolerant Networking  
(S)IP-based Multimedia**
- Jorma Virtamo: **Teletraffic Theory  
Performance Analysis**

## Teletraffic Theory Group: People

- J. Virtamo, professor
- S. Aalto, PhD, teaching researcher
- P. Lassila, D.Sc., teaching researcher
- A. Penttinen, D.Sc., researcher
- I. Juva, D.Sc. Student
- J. Leino, D.Sc. Student
- T. Tirronen, D.Sc. Student
- J. Nousiainen, M.Sc. Student
- I. Kudjoi, M.Sc. Student
  
- Recent graduated doctors: E. Nyberg-Oksanen, H. Koskinen, R. Susitaival
- Esa Hyytiä (D.Sc., 2004) is currently a post doc at FTW, Austria, and is still collaborating closely with us as an "external member".

## Teletraffic Theory Group: Projects

- ABI (Algorithms for Broadband Infrastructure)
  - Tekes strategic project, 3+2 years, 2006-2008 (2010)
  - Joint project with VTT (Ilkka Norros) and Helsinki University (Kimmo Raatikainen)
  
- FANCY (Flow-Aware Networking: Applications and Analysis)
  - Academy of Finland, 3 years, 2005-2007
  
- CLOWN (Cross-Layer Optimization of Wireless Networks)
  - Tekes project, 2 years, 2006-2008
  
- Recently finished projects:
  - NAPS, Academy of Finland, jointly with P. Orponen and P. Floréen
  - AHRAS, Finnish Defence Forces

# Teletraffic Theory Group: Research Topics I

## Wireless networks

- Analysis of RWP mobility model
  - P. Lassila, J. Virtamo, E. Hyttiä
- Connectivity and coverage problems of ad hoc networks
  - H. Koskinen
- Additional node problem
  - O. Apilo, J. Karvo, H. Koskinen
- Dimensioning of wireless mesh networks with QoS requirements
  - P. Lassila, A. Penttinen, J. Virtamo
- Optimal forwarding / MAC methods in large / dense ad hoc networks
  - O. Apilo, E. Hyttiä, P. Lassila , J. Virtamo
- Geometric routing in large networks
  - E. Hyttiä, J. Virtamo
- Flow-level analysis of a 2 BS system
  - J. Leino, A. Penttinen, J. Virtamo
- Inter-cell coordination for interference avoidance
  - S. Liu, J. Virtamo

# Teletraffic Theory Group: Research Topics II

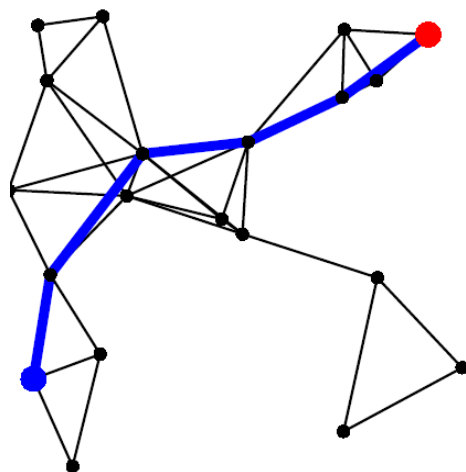
## Performance analysis research

- Size-based scheduling
  - S. Aalto, E. Nyberg-Oksanen
- P2P networks
  - S. Aalto, R. Susitaival, J. Virtamo
- Balanced fairness studies
  - J. Leino, A. Penttinen, J. Virtamo
- Traffic engineering, load balancing
  - S. Aalto, R. Susitaival, J. Virtamo
- Value extrapolation method
  - J. Leino, J. Virtamo
- Traffic matrix estimation
  - I. Juva, J. Virtamo
- Degree distrib. for fountain codes
  - E. Hyytiä, T. Tirronen, J. Virtamo
- Traffic measurements and analysis
  - S. Aalto, I. Juva, M. Peuhkuri, R. Susitaival

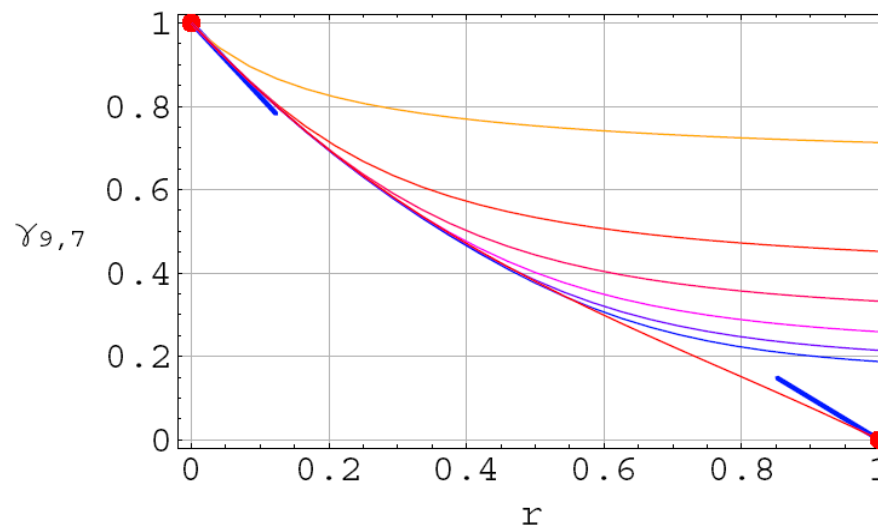
# Teletraffic theory group: research examples

- **Balanced fairness (BF) studies**
  - novel bandwidth sharing scheme proposed by Bonald and Proutière in 2003
  - significantly facilitates flow-level analysis in the dynamic setting
- **Our group has significantly contributed to the theory**
  - new algorithms, approximation methods and extensions of BF to new application areas

Network example



Per-class throughput

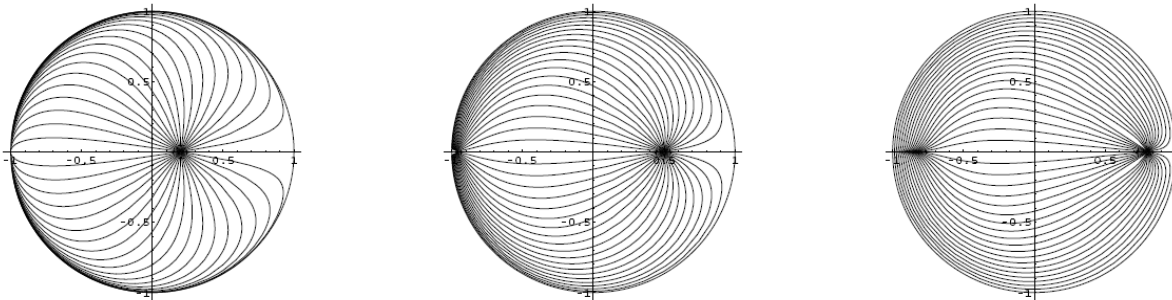




# Teletraffic theory group: research examples

- Load balancing in dense wireless multihop networks
  - dense network = large network, typical hop distances are long
  - given the traffic matrix, load balancing tries to minimize the maximum load
- New problem formulation for infinitely dense networks
  - complex problem of calculus of variations
  - several results for approximating the global optimum
  - new insights into the fundamental properties of routing (single- vs. multipath)

## Examples of the flow fields



## “The best“ load distribution (so far!)

