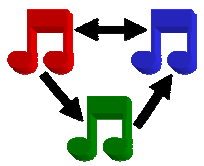




Incentives for Sharing in Peer to Peer Networks

Philippe Golle
Kevin Leyton-Brown
Ilya Mironov

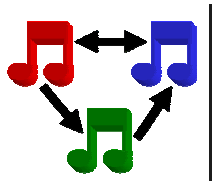
Computer Science, Stanford University



Motivation: Napster System

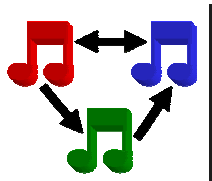
(May 1999 – July 2001)

- Dominant strategy for non-altruistic agents to share nothing and download as much as possible
 - free-rider problem
 - study of Gnutella: 70% of users shared nothing
- Why does anyone share?
 - client requires users to opt out of sharing
 - service free, fosters sense of community
- Why isn't this enough?
 - advent of for-profit systems
 - service with more shared files is more competitive



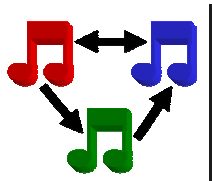
Outline

- Unlike talk on Monday, no discussion of fair exchange, escrow, watermarking issues
- Model:
 - a very simple game-theoretic model of a P2P file sharing system, free-rider problem
- Theory:
 - pros and cons of three payment schemes that give rise to strict equilibria in which free-riding does not occur
- Experiments:
 - robust convergence to the same equilibria in an enriched model; also some interesting behaviors



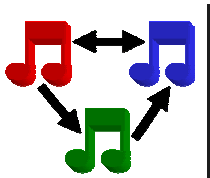
Model

- Single-shot game in which agents choose a level of sharing, level of downloading
- Utility depends on:
 - amount downloaded
 - variety of the network
 - disk space used
 - bandwidth used
 - altruism
 - financial transfer



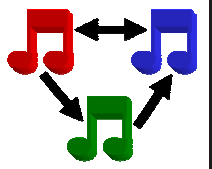
Micro-Payments

- Scheme:
 - charge users for downloads, reward them for uploads
 - overall, the system breaks even
- Advantage:
 - unique, strict equilibrium for all agents to both share and download maximally
- Disadvantages:
 - equilibrium doesn't hold for risk-averse agents: they don't directly control their number of uploads
 - users can make a profit
 - users dislike micro-payments



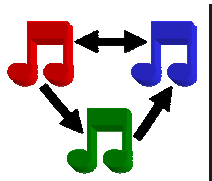
Quantized Micro-Payments

- Scheme:
 - charge a fixed price for each block of b files
 - reward uploads as before
- Advantages:
 - may be preferable to users
 - unique, strict equilibrium as before
- Disadvantage:
 - collusion: agents can direct their zero-marginal-cost downloads to others



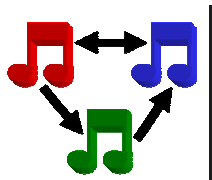
Points, Rewarding Sharing

- Scheme:
 - “points” currency: points can be bought but not sold
 - pay agents for size of material shared
- Advantage:
 - no agent makes a profit
 - maximal sharing, downloading is a strict equilibrium
- Disadvantages:
 - no sharing, maximal downloading is also strict equilibrium
 - agents don't want their shared files to be downloaded
 - share at off-peak times, share unpopular files
 - agent could stop sharing as soon as a file is requested

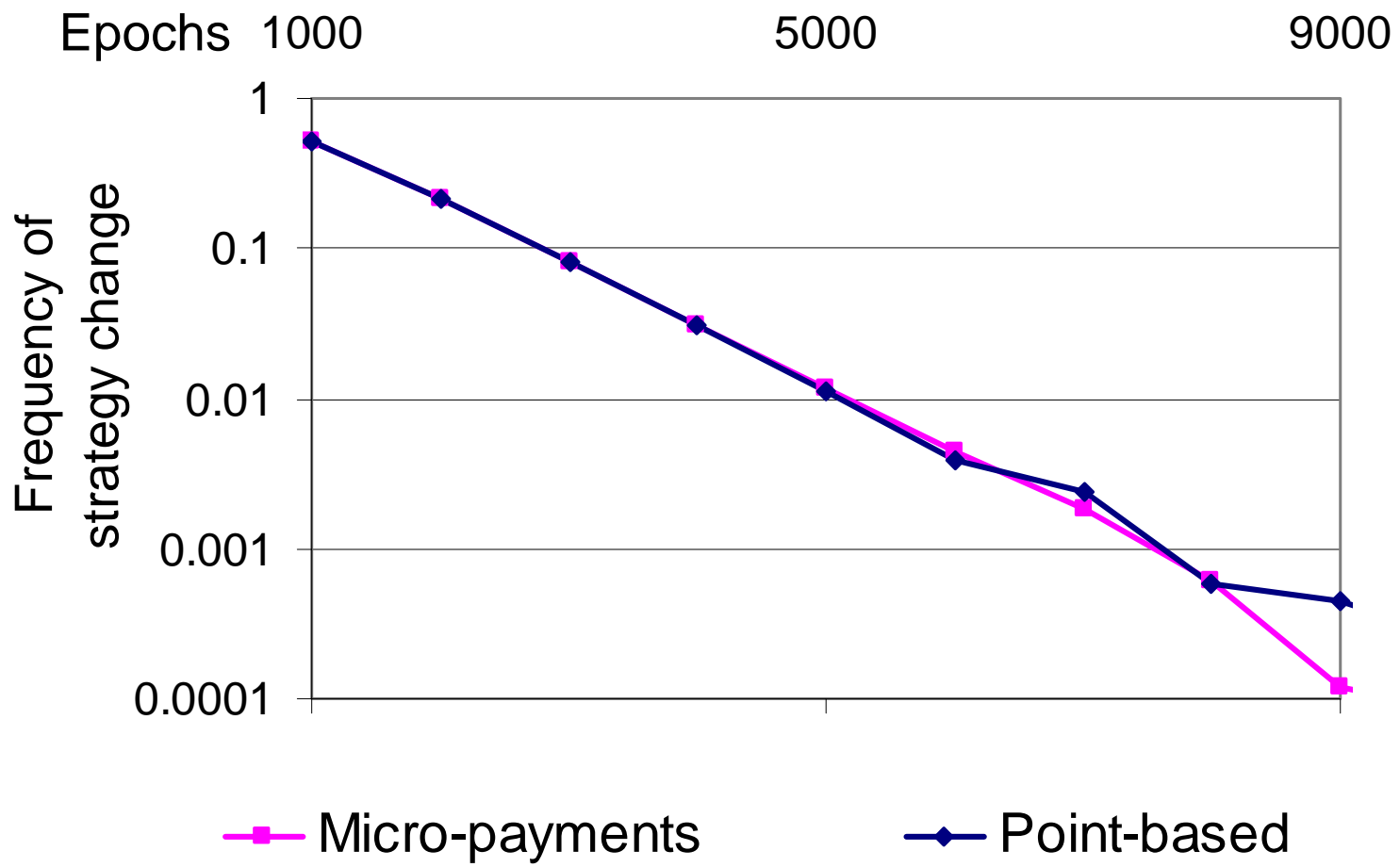


Experimental Results

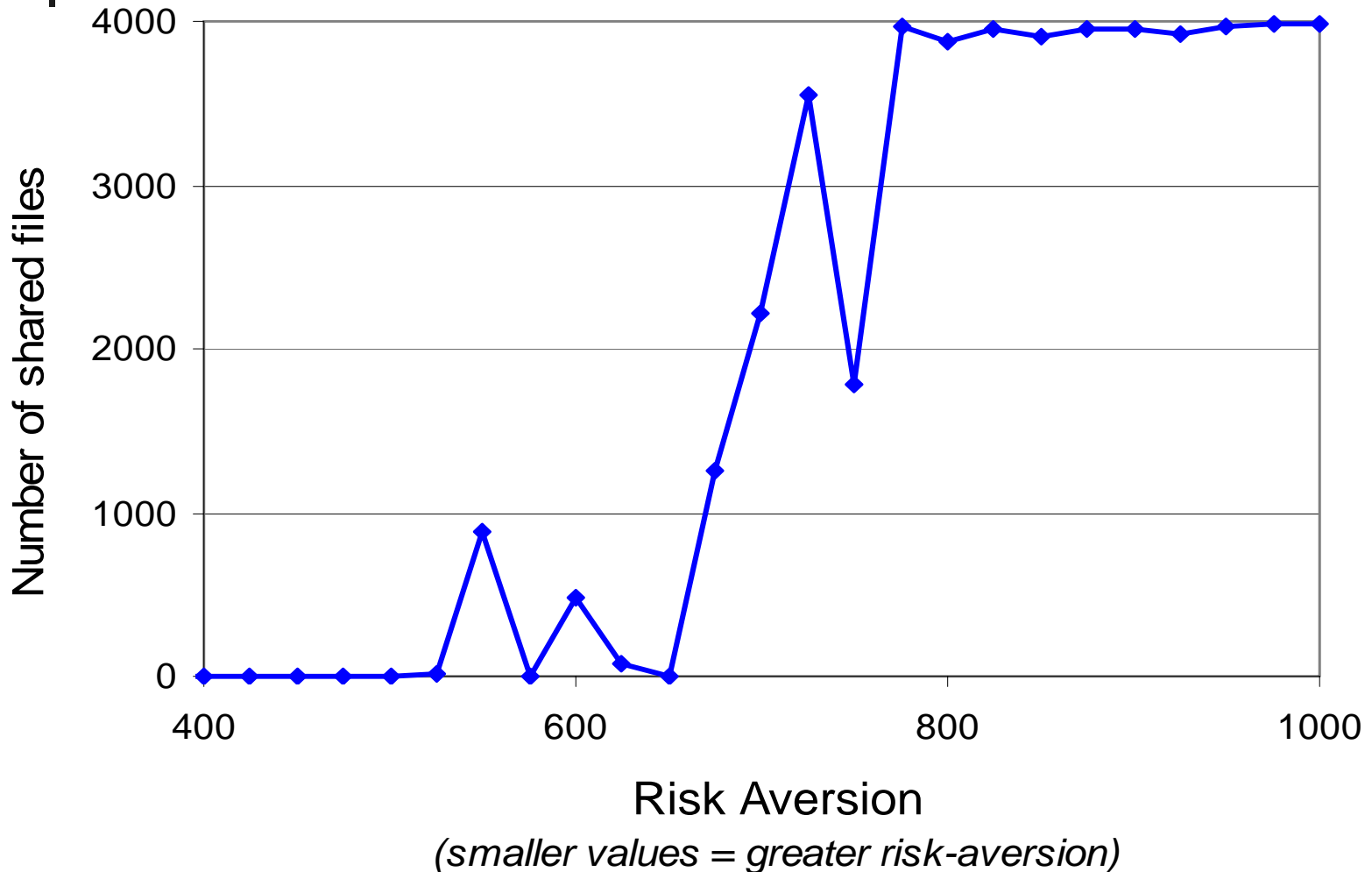
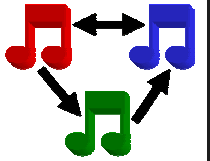
- Experiments using TD Q-learning
- Validate and enrich our theoretical model:
 - levels of risk-aversion
 - utility functions
 - different types of files and agents
- Experiments:
 - strategy convergence in this richer setting
 - interesting effects

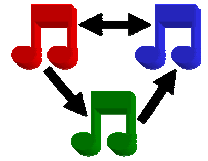


Strategy Convergence

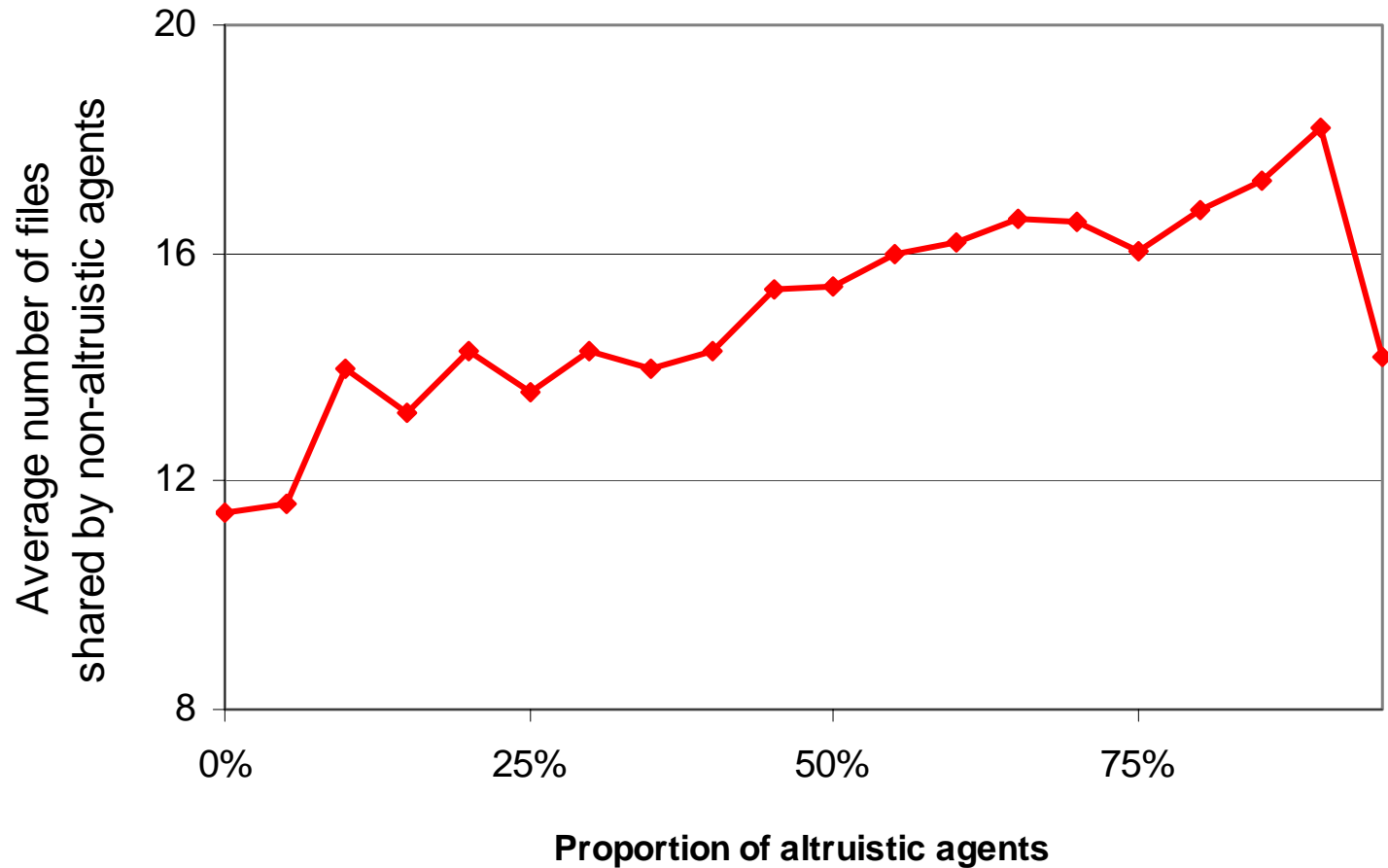


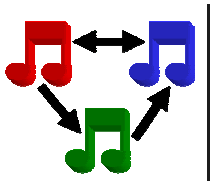
Micro-Payments: Effect of Risk Aversion on Sharing





Points: Effect of Altruism on Sharing





Conclusion

- Model:
 - a very simple game-theoretic model of a P2P file sharing system, free-rider problem
- Theory:
 - discussed three payment schemes that give rise to equilibria in which free-riding does not occur, pros & cons
- Experiments:
 - showed convergence to the same equilibria in an enriched model; also some non-trivial behaviors
- Full version at WELCOM'01, online at <http://robotics.stanford.edu/~kevinlb>