Economics of P2P Systems

IS296A: Economics-Informed Network Design
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Diversity of P2P Systems

- Distributed storage, search, and retrieval
  - File-sharing: Napster, Gnutella, kaZaA, Overnet, BitTorrent, ...
  - Anonymity/Persistence: Eternity, Freehaven, FreeNet, Publius, ...
  - DHTs: Chord, CAN, Pastry, Tapestry, OpenDHT, ...

- Distributed computation
  - Globus (grid), Entropia, SETI@Home, etc.

- Communications
  - Connectivity: mobile wireless ad-hoc networks, “rooftop” networks
  - Redundancy: resilient overlay networks
  - Anonymity: onion-routing, MIX-net, Crowds
  - Distributed multimedia: Skype (VoIP), ESM/Narada, Splitstream (live streaming), PROMISE (on-demand streaming)
P2P System Characteristics

What do P2P systems have in common?

- No infrastructure or service provider: rely on contributions by individual peers
- Hidden action: difficult to monitor or enforce cooperation
- Ad-hoc communities: highly dynamic memberships; interactions with strangers
The P2P Dilemma

- P2P systems rely on grassroots contribution of resources
- Contributions can be costly
  - e.g., incoming link utilization degrades by 20-80% when simultaneously uploading due to TCP Data/Ack contention
- Fundamental tension between individual rationality and collective welfare

[Feldman et al., 2003]
Evolution of P2P Cooperation

- 1999: Adar and Huberman, Freeriding on Gnutella
  - Freeriding: 66% FR

- 2000: Cohen, Incentives Build Robustness in BitTorrent (p2pecon'03)
  - "Give and ye shall receive!"

- 2001: Golle et al., Incentives for Sharing in P2P networks

- 2002: Andrade et al., Influences on Cooperation in BitTorrent Communities (p2pecon'05)
  - Freeriding: 5-6% FR

- 2003: Hughes et al., Freeriding in Gnutella Revisited: The Bell Tolls?
  - Freeriding: 85% FR

- 2004

- 2005: Cohen, Incentives Build Robustness in BitTorrent (p2pecon’03)
  - "Give and ye shall receive!"

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What can we do?

- Rely on altruism
  - No intervention necessary if societal generosity sufficiently high [Feldman04b]
  - Warm-glow theory: altruistic action may be part of rational behavior [Andreoni90]
- Enforcement
  - Obedient vs. malicious peers
  - Often circumvented by determined hackers
- Incentives
  - Rational users respond to reward and/or punishment
  - Security requirements still remain
Incentives for P2P Cooperation

- Barter
  - BitTorrent (tit-for-tat; direct reciprocity)
  - End System Multicast (taxation)

- Reputation (indirect reciprocity)
  - KaZaA, Eigentrust, CONFIDANT, ...
  - EBay: 3 billion feedback comments

- Currency
  - Tokens, stamps, claims, mojos, karma, nuglets, ...