In Search of *Homo Swappus* : Evolution of Cooperation in Peer-to-Peer Systems

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Exhibit A. Homo Swappus

A REMINDER FROM Gnutella, Freenet 🔗 Geeks Everywhere

http://www.modernhumorist.com/

Exhibit B. Homo Swappusnot?

Outline

- Evolution of cooperation: from murderous apes to P2P file-swappers
- The evolution continues: white-washers, roving vagabonds, liars and shirkers
- Beyond *homo economicus* : BitTorrent and rationality revisited

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 <u>individual rationality</u> and <u>collective welfare</u>

The P2P Dilemma

- Rational users (a.k.a. homo economicus) choose to <u>free-ride</u>
 - Consume but not contribute
 - May lead to system collapse ("Tragedy of the Commons")
- How to encourage cooperation among strangers?
 - Challenges: large, dynamic groups with anonymity, hidden action, hidden information, and asymmetries of interest

Evolution of Human Cooperation



Adapted from: http://pharyngula.org/images/lay_evo_obesity.jpg

Kin selection: survival and propagation of genes

- Altruism towards genetic relatives
- Hostility, murder of non-related males

Evolution of Human Cooperation



Formation of hunter-gatherer groups beyond family ties:

- Economies of scale
- Specialization
- Risk management



Evolution of Human Cooperation



Reciprocity

Reputation and Trust

Money and Markets

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, ...







Evolution of P2P Cooperation



Outline

- Evolution of cooperation: from murderous apes to P2P file-swappers
- The evolution (arms-race?) continues: whitewashers, roving vagabonds, liars and shirkers
- Beyond *homo economicus* : BitTorrent and rationality revisited

Whitewashers

- Cheap (or free) pseudonyms
 - Sybil attack, sock puppetry (collusion)
 - Whitewashing attack
- Whitewash: always defect, and continuously change identity
 - Whitewashers indistinguishable from legitimate newcomers
 - Tit-for-tat (TFT) no longer evolutionary stable in the presence of whitewashers [Feldman and Chuang, 2005]
 - TFT always cooperates with stranger
 - Reputation-based mechanisms circumvented
- Response 1: increase cost of acquiring new identities
- Response 2: punish all newcomers
 - Social cost of cheap pseudonyms (Friedman & Resnick, 1998)
 - Stranger-adaptive strategy (Feldman et al., 2004)



Roving Vagabonds

- Real Estate Lesson #1: Location! Location! Location!
- Structured DHT topologies: excluding object popularity, some locations route <u>100x to 1000x</u> more traffic than others



- Rational node response: strategic churning
 - repeatedly exit and re-enter P2P network in hopes of finding better location in the network

Liars and Shirkers

- Two types of information asymmetries:
- Hidden information
 - Players possess private information (e.g., transit costs in routing [Feigenbaum et al., 2003])
- Hidden action
 - Players' actions unobservable to others (e.g., multi-hop routing [Feldman et al., 2004])





- Mechanism design and agency theory
 - Use of incentives to induce truth revelation or good behavior
 - Recent advances (e.g., distributed algorithmic MD) considers algorithmic complexity and communications complexity of mechanisms

Outline

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BitTorrent Revisited

- Andrade et al. (p2pecon 2005) found free-riding as low as 5-6% in some BitTorrent communities (*etree* and *easytree*)
- Is the tit-for-tat mechanism in BitTorrent really responsible for reduced free-riding?
 - BitTorrent mechanism not strategy-proof
 - Shneidman et al. (PINS 2004) identify multiple "rational manipulation points"
 - Hales and Patarin (2005): subvert with multiple fake IDs
 - Jun and Ahamad (p2pecon 2005) show free-rider obtained same download completion time
- Andrade et al. also found 27-52% of peers (across four communities) act as seeders

Alternate Explanations?

- Near rationality (e.g., ε–equilibrium)
 - Switching cost: not costless to modify client code or default configuration
- Tribe formation and evolutionary group selection
 - Due to lack of meta-search capabilities [Hales & Patarin]
- MPAA hasn't filed any lawsuits yet
- Social norm: "When complete, keep your window open to contribute bandwidth"
 - Contingent cooperation: contribute only if prevailing contribution level is perceived to be high
- Modus operandi:
 - Initiate movie download before bedtime
 - Broadcatching: automatic download via RSS + regex

Beyond Homo Economicus (Rationality Revisited)

- Altruism
 - Information gift economies
 - e.g., linux, creative commons, wikipedia, ...
 - Warm-glow (Andreoni, 1990)
 - "Digital Robin Hoods"
- Strong reciprocity
 - Reciprocate (reward cooperators and/or punish defectors) even if action reduces own utility
 - Ultimatum, Dictator, and Public Goods games: ~50-60% of subjects exhibit reciprocal behavior, ~20% exhibit selfish behavior
 - Considerations of fairness and social norms
- Even selfish individuals may not be *perfectly* selfish
 - bounded rationality or near rationality vs. hyper rationality
 - Imperfect knowledge; imperfect execution (e.g., trembling hand)



Implications/Open Questions

- How to design P2P systems when population is a mixture of altruists, reciprocators, and selfish rascals?
 - Now throw in faulty peers and malicious attackers
 - Now consider peers with imperfect information, and possibly trembling hands?
- May not need 100% cooperation, but how much is optimal or sufficient?
- Might explicit incentives crowd out voluntary good behavior?
 - e.g., incentives gone awry at Haifa daycare centers

In Search of Homo Swappus...

- P2P systems as virtual microcosm of physical world
 - Rational peers respond to incentives ...
 - ... but not all peers are rational
- P2P systems mediate interactions in/with physical world
 - E.g., P2P as underlay to "layer 8" social networks



http://fusion.sims.berkeley.edu/GarageCinema/images/MMM1.gif



http://www.wired.com/news/images/full/campus_strength_f.jpg

■ Homo swappus → homo sapiens in a P2P world

Thank you!

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