The notes for **Incentives for Sharing in Peer-to-Peer Networks**

What is P2P

In a Peer-to-Peer network, end users share resources via direct exchange between computers

A pure peer to peer system is a distributed system without any centralized control, where the software running at each node is equivalent in functionality

Free-rider problem

The phenomenon of selfish individuals who opt out of a voluntary contribution to a group's common welfare

Problem Definition

- n agents participate in the system: $A1, \ldots, An$.
- Each agent Ai's strategy: $Si = (\sigma, \delta)$
  - Sharing: σ 0(none), σ 1(moderate) or σ 2(heavy)
  - Downloading: δ 0(none), δ 1(moderate) or δ 2(heavy)

Agent Utility

- **Amount Downloaded (AD):** Agents get happier the more they download
- **Network Variety (NV):** Agents prefer to have more options
- **Altruism (AL):** Satisfaction of contributing to the network
- **Disk Space Used (DS):** A cost of allocating disk space to be used
- **Bandwidth Used (BW):** A cost of uploading files to network
- **Financial Transfer (FT):** Agents may ends up paying money or getting paid for usage of the network

- The equation for agent Ai's utility function:

  Ui = [fiAD(AD) + fiNV(NV) + fiAL(AL) - [fiDS(DS) + fiBW(BW)] –FT

Two assumptions about agents' relative preferences for different outcomes:

$$fAD(k) > k\beta$$
$$fDS(k) + fBW(k) < k\beta$$

(1) The monetary equivalent of the utility agents gain from downloading files at level k is more than $k\beta$, for some constant β

(2) The monetary cost to agents of sharing files at level k and uploading them at level k is less than $k\beta$

Micro-Payment Mechanisms

To charge users for every download and to reward then for every upload.

- If agent Ai chooses the action (σ s, δ d), its expected payment to the system:

$$E[FT] = \beta \left(d - \delta^{-i} \frac{s}{\frac{n-2}{n-1}\sigma^{-i} + s} \right).$$

- β : the cost/reward per file
- σ -i be the total number of units shared by agents other than Ai
- δ -i be the total number of units downloaded by agents other than Ai.

Rewards for Sharing

$$E[v_i] = \delta^{-i} \frac{s}{\frac{n-2}{n-1}\sigma^{-i} + s}.$$

- Σ = {(σ 2, δ 2), … , (σ 2, δ 2)} is a strict equilibrium
- Σ = {(σ 0, δ 2), … , (σ 0, δ 2)} is a strict equilibrium
  n-1 agents playing the strategy S=(σ 0, δ 2)
  Agent Ai will follow strategy S.
  Since no files to download
  Ai will be made to serve files for all other agents' download requests, bringing him negative utility

Learning Algorithm

- Q(a,s) ←(1−α)Q (a, s)
  + α (P (a, s) + c*maxa' Q(a', s'))
  - a is the action that the agent took
  - s is the current state, s' is the new state
  - P(a,s) is the payoff of the current round
  - The decay 0< α <1 and the future income discount 0<c<1 are fixed

Conclusion

- Free-rider problem is a real issue for P2P systems
- Free-rider become even more important in commercial systems
- A simple game theoretic model of agent behavior is proposed