TEPP
Techno Economics & Policy Program

Agent-based Modeling for P2P Systems with Learning

Focused on Reputation Eigenvector based System with Ownership Eigenvalue

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Table of Contents

Introduction

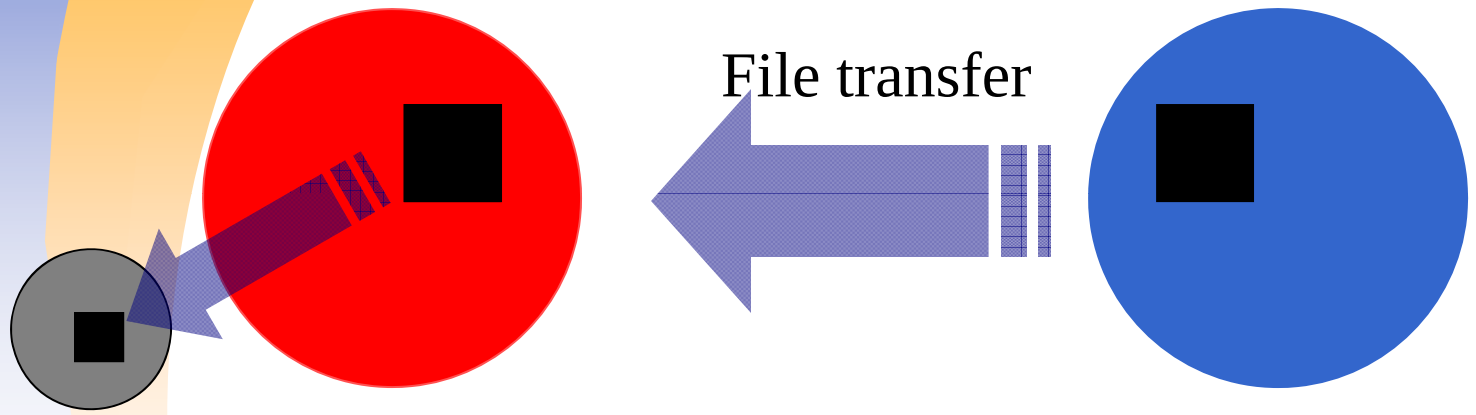
- Our Contribution -

- Reform of former P2P system simulation
  - More realistic reflection about human behavior
    - Possible usage strategy deviations are considered
      - Creation, falsification of ownership info, etc.
    - Adaptive Strategy choices of agents are enabled
      - Replicator dynamics
  - Reflection of measurement study results about P2P systems
    - User fetches an abject at-most-once
    - Newly popular objects tend to be recently born

Eigenvector based System (1) - Simulated System -

- Contributing agents are promoted by access priority based on reputation Eigenvalue
  - Kung's paper of inaugural p2pecon workshop
- Contribution includes sharing & creation
- Without incentive mechanism for creators, the system will be starved out
- Objects including digital right can realize ownership reputation

Eigenvector based System (2) - Simulated System -



Reputation Value =

A – Usage repu + Uploading repu

Reputation Value =

B + Service repu + Ownership repu

■ : Object, owned by objective agent

Service reputation = Uploading + Ownership

Eigenvector based System (3) - Simulated System -

- All the agents have their own reputation rankings calculated by service and usage
  - Service reputation of *agent i*
    - Uploading reputation: Uploaded quantity of objects by *agent i*
    - Ownership reputation: Other agents' downloading quantity for the objects created by *agent i*
  - Usage reputation of *agent i*
    - Downloaded quantity of objects by *agent i*
- All the agents are designed to have obligations of complying with the request of other agents, having higher reputation values

Agent's Payoff

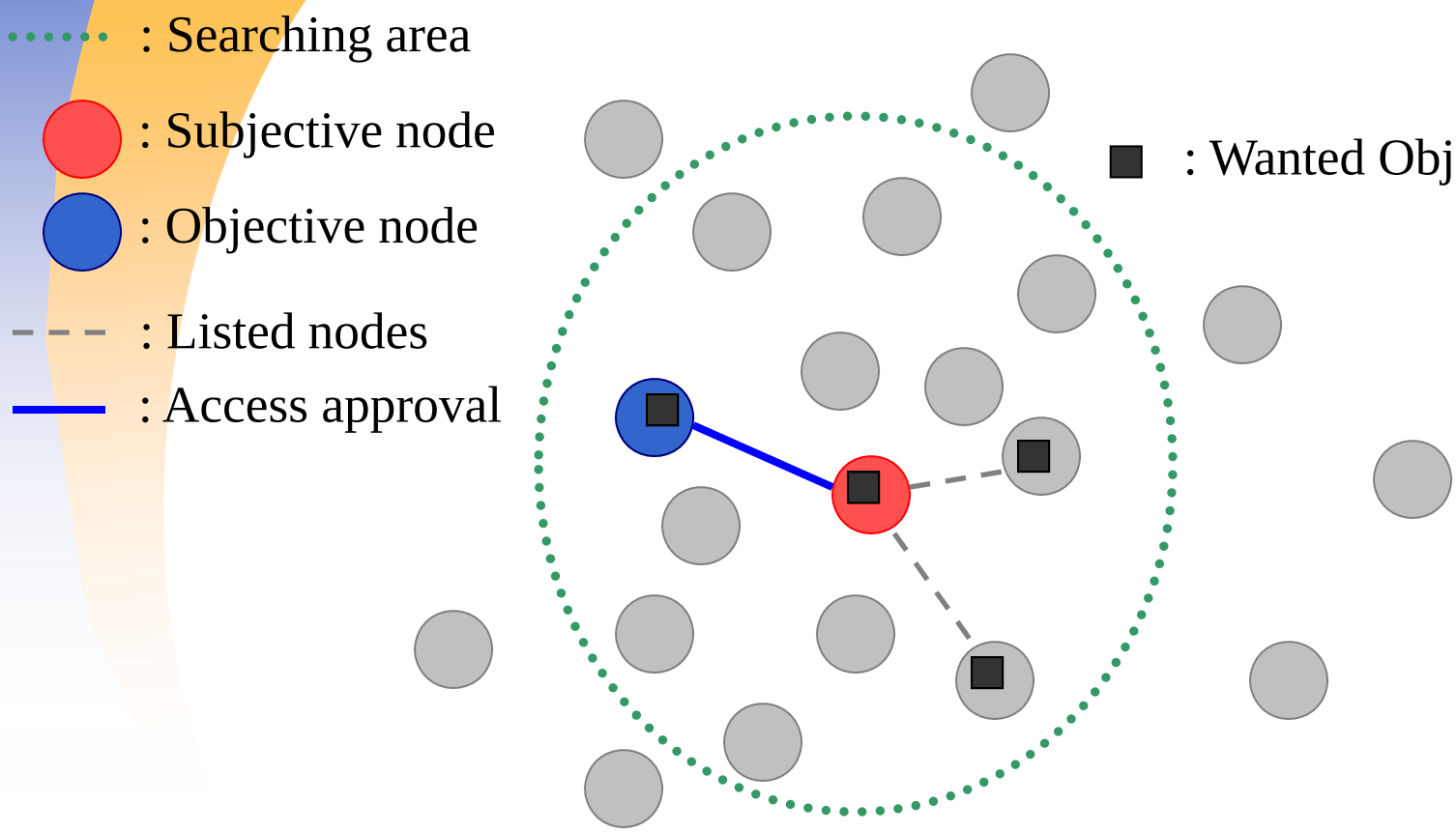
- Basic Assumptions -

- Agent's Payoff is determined by Benefit & Cost elements
  - Benefit element : Downloaded Objects

$$Benefit_i = \sum_j f(request\ order(j,i))$$

    - i = identity of an agent, j = identity of an downloaded object
    - f is designed to be decreasing function to the increasing request order
    - The order of requesting opportunity of agents is randomly distributed
    - Popularity (Frequency of requests) of objects follows the Zipf distribution
  - Cost element : Bandwidth
    - Marginal cost of bandwidth increases as the quantity of used bandwidth raises
  - Usage capacity of each agent's bandwidth is limited at the same amount

Behavioral Strategy (1) -Basic Assumptions -



- Each agent's behavioral strategy is designed to maximize myopic payoff within given system rules

Behavioral Strategy (2) -Basic Assumptions -

- Each agent's behavioral strategy is designed to maximize myopic payoff within given system rules

① Decide the object, which will be requested on the basis of popularity distribution, except preoccupied objects (In repeated operation, exclude formerly requested objects which is determined as unavailable)

② Calculate additive payoff of downloading
   a. If <0, break

③ Make the list(L) of connected agents who have the requesting object in searched area
   b. If L is null, go to ①

④ Confirm the objective agent in L if the constraints for access priority and bandwidth capacity is satisfied
   c. If ④ is not fulfilled, go to ①

⑤ Complete requesting opportunity after transferring is activated

Usage Strategy Set

- Agent's Strategy -

Four species of agents in modeled system

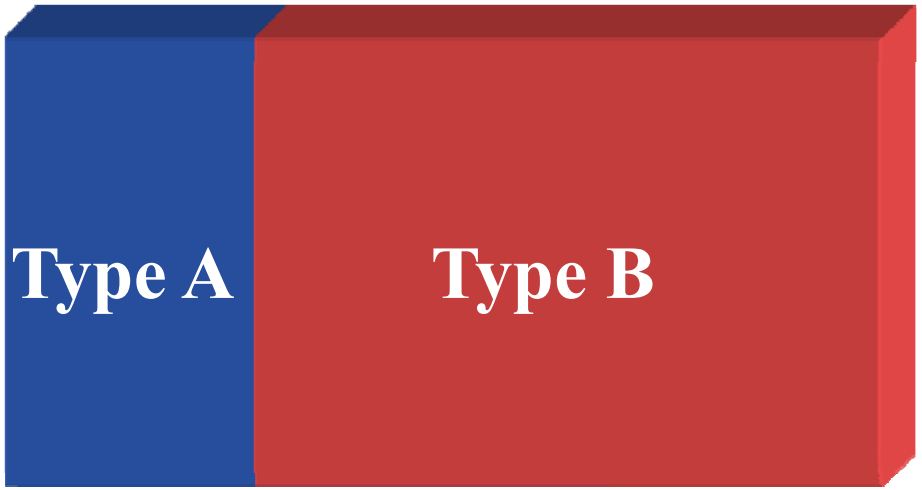
	Creators	Fair Sharers	Passive Hackers	Active Hackers
Creating	○	X	X	X
Ownership Counterfeiting	X	X	○	○
Strategic Gathering	X	X	X	○
Sharing	○	○	○	○

- Simulation considered the adaptation of each agent's strategy about choosing one's species and also advertising amount
- The strategy set related with advertisement is categorized as following three - increasing one unit, decreasing one unit and holding the present quantity

Evolutionary Strategy Choice - Agent's Learning-

Replicator Dynamics

$$\Delta x_i = x_i((Ax)_i - x^T Ax)$$



Evolutionary Strategy Choice - Agent's Learning-

- Replicator Dynamics

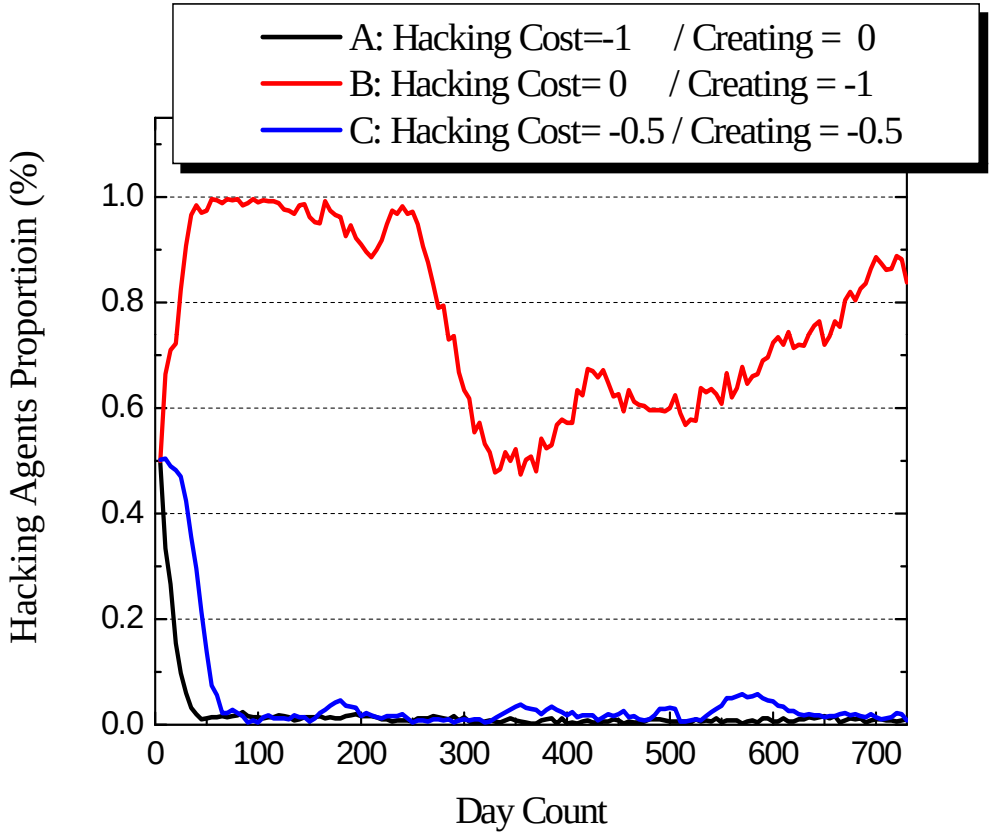
$$\triangle x_i = x_i((Ax)_i - x^T Ax)$$

  - x_i : Proportion of agents with characteristic i
  - A : Matrix which contains the payoff information of the species with each characteristic
- Random perturbation in agents' strategy choices
  - 5% of whole population choose their stratgies randomly
- Heterogeneous propensity about strategy change
  - Agents have heterogeneous sensitivity to payoff amount

Hacking vs. Creating

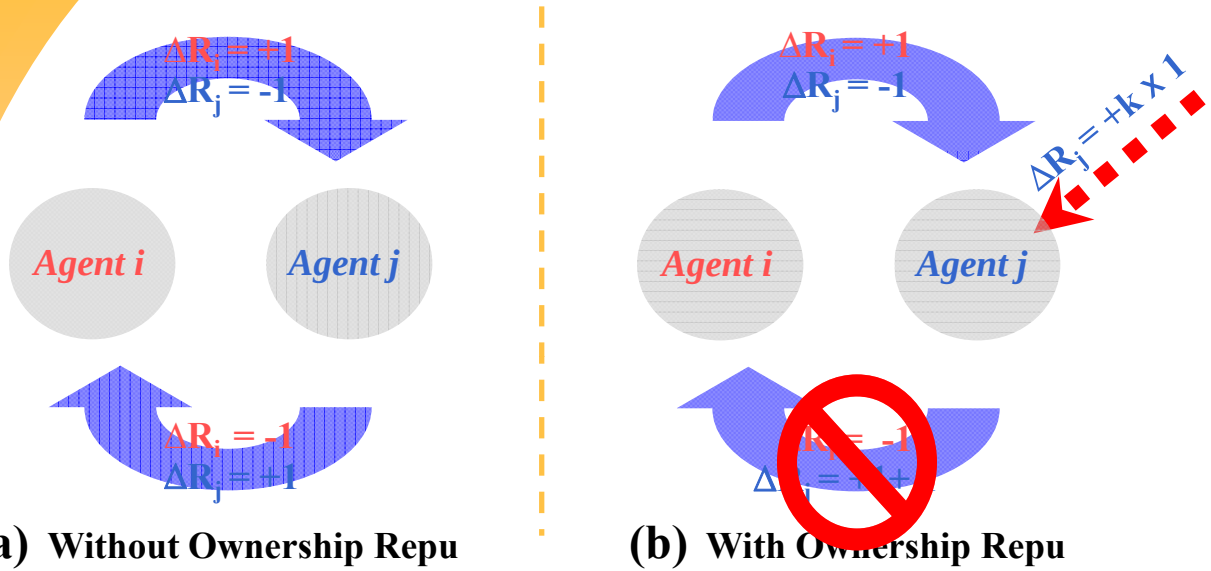
-Simulation Results -

- Equal size of objects
- Uniform distribution of the number of initially stored objects and given bandwidth capacity
- Total object quantity
  - A:44935, B:1900
- Total accumulated transaction amount
  - A : 91426, B : 155190
  - **Opposite trend to the number of produced object numbers**



'Creators' dominate other species in A case
'Fair sharers' dominate in C case

Effects of Ownership Reputation - Result Analysis -



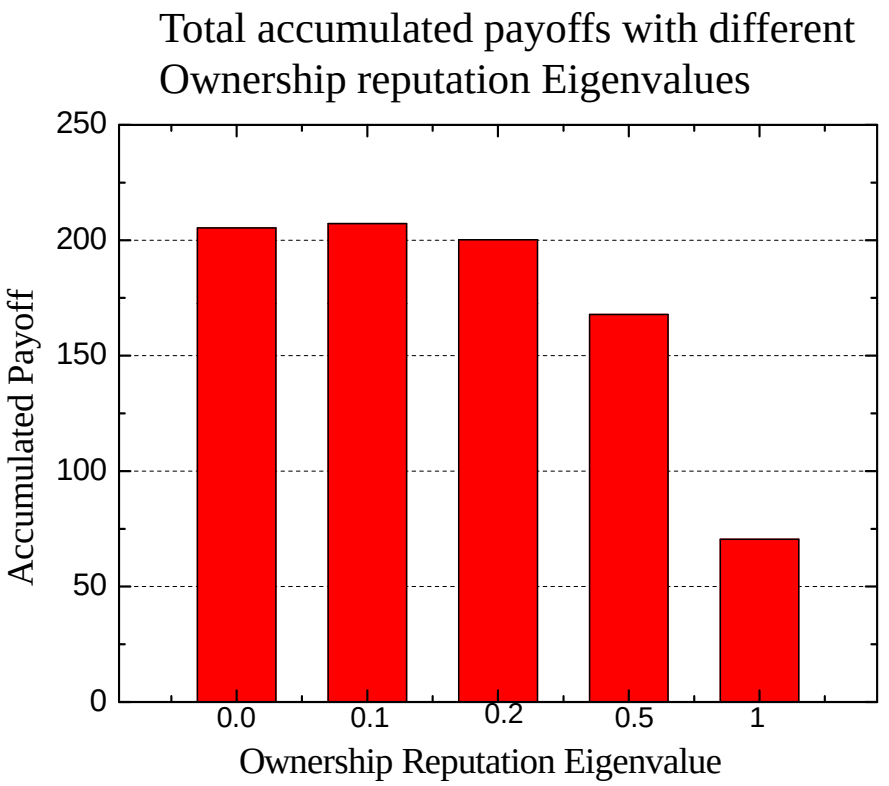
(a) Without Ownership Repu **(b) With Ownership Repu**

Sequentially alternating requests from one agent to the opposite with the same initial reputation scores

- In case (b), **reputation condensation** is Occurred
  - Requests of *agent i* will not be satisfied until the reputation difference from ownership(*kx1*) is diminished by asymmetric transfer (*agent i*'s uploads and *agent j*'s downloads)

Ownership Eigenvector(1) -Simulation Results -

- In Ideal Situation
  - Hacking cost = -1
  - Creating cost = 0
- Accumulated payoff and object quantity per an agent decreases definitely as ownership Eigenvalue increases
- This hindrance effect can be removed by choosing relatively small Ownership Eigenvalue in ideal situation



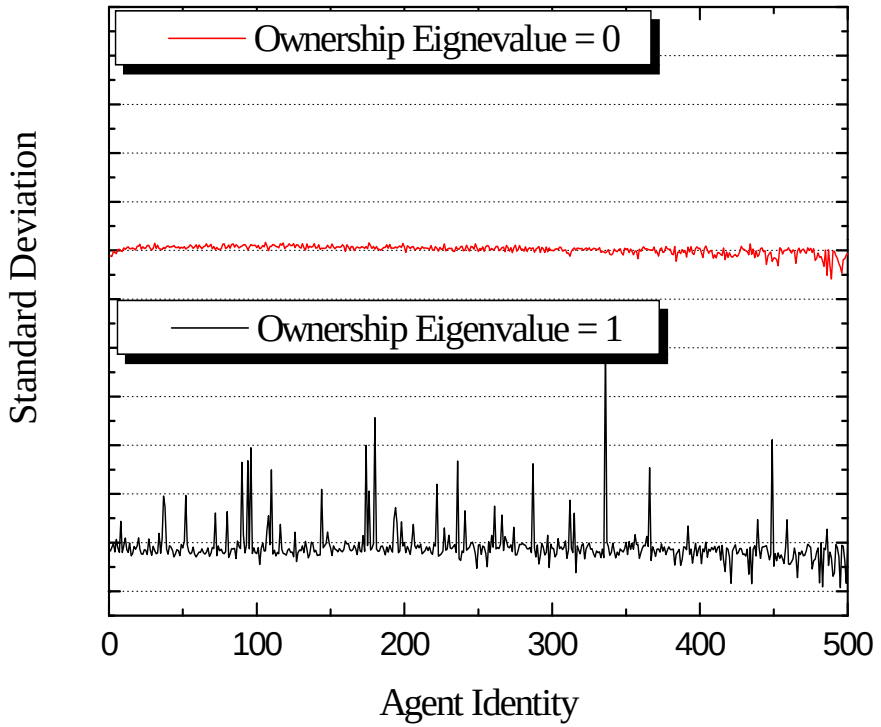
Transaction hindrance effect increases with larger reputation Eigenvalue

Ownership Eigenvector(2) -Simulation Results -

- The changes of additive reputation values with heterogeneous speeds and directions generate condensation of reputation

- Ownership reputation
  - Incentives to 'Creators' through access priorities
  - Obstacles to transactions by hindering request accomplishments

Standard deviations of time series about each agent's additive reputation.

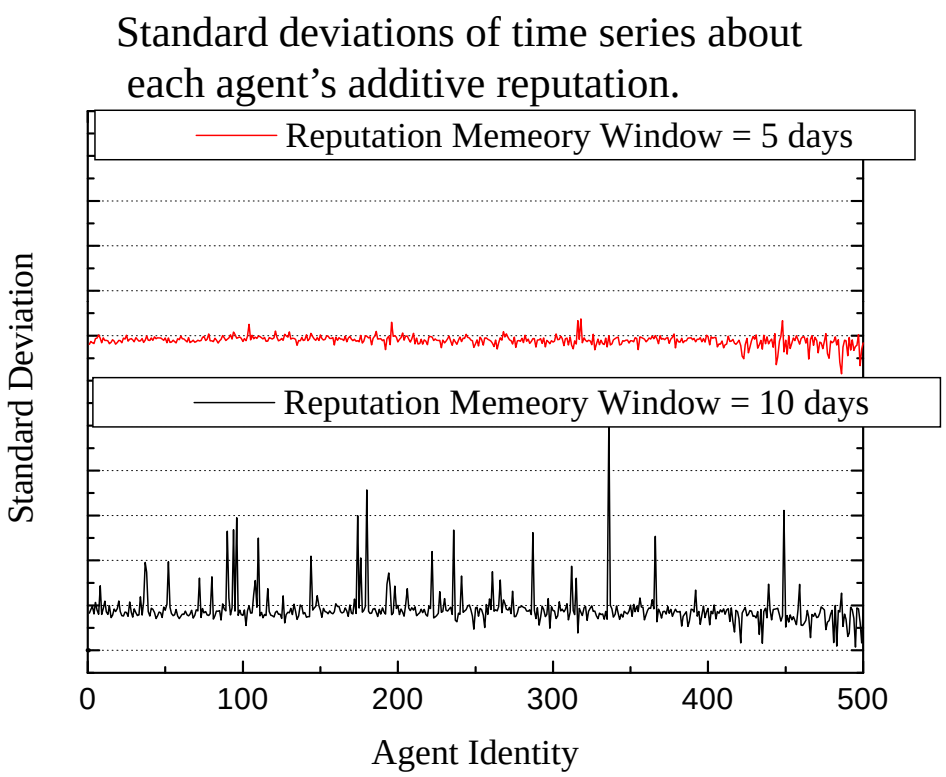


Larger ownership reputation Eigenvalue generates more inequality in reputation earning

Reputation Memory Window

-Simulation Results -

- Reputation Memory Window
  - Accumulating period for reputation
- 10 days ➔ 5days
  - Total accumulated payoff of whole population increases more than twice
- Reduction of memory window size discounts the time share that condensation matters worse.



Smaller reputation memory window diminishes inequality in reputation earning

Discussion

- Reputation value should be considered carefully
  - Particularly, the system, which uses reputation score as currency for transaction, can suffer from similar reputation condensation problem
  - Realization of reputation management systems, which reward for creators, have possibility of decreasing social welfare even if the productivity of the systems increase
- Earned reputation cannot be used for investments or savings
  - Condensed reputation is similar with the money which is kept in one's basement
  - Huge business contraction will occur in real economy case
  - In reputation case, the consumption of reputation is constrained to the capacity of bandwidth. Accordingly, much time should elapse before resolving the condensation

Concluding Remarks

- If hacking cost is low enough, ownership reputation can support unfair falsification
  - Mechanisms like Monitoring & imposing penalty or technical supports like DRM should be implemented in advance for utilizing ownership reputation
- Rewards for creators using reputation should be careful
  - Trade-off between providing incentive for creators and easing transaction
- The methods suggested in this paper can promote the transaction by smoothing each user's reputation value, but these adjustments will decrease the incentives for gaining reputation, and weaken the penalty for free riding
- Permission of reputation property transaction can be one of the solutions

Thank you