A Decentralized Review System for Data Marketplaces

Game Theoretic Analysis of Incentive-based Mechanism

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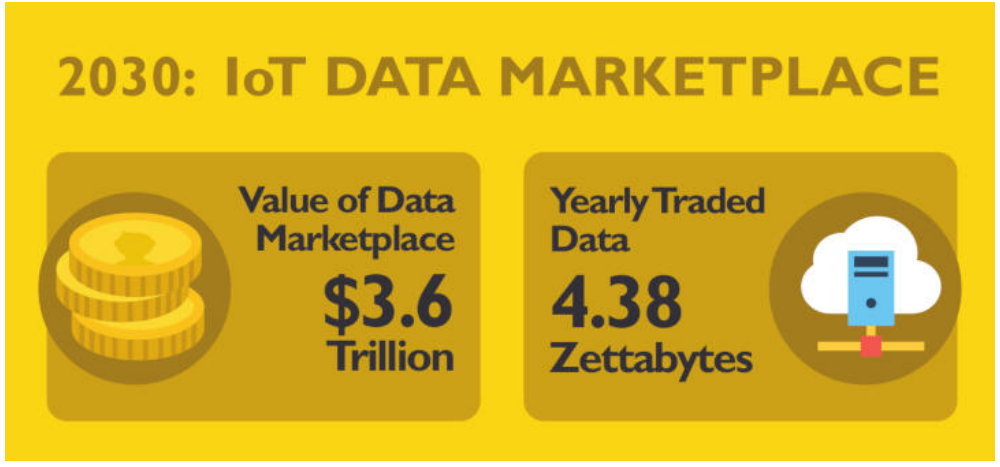
May 3-5, 2021, ICBC Conference

IoT Data Marketplace

Motivation



MARKETPLACES

Data Marketplaces with Blockchain Superpowers

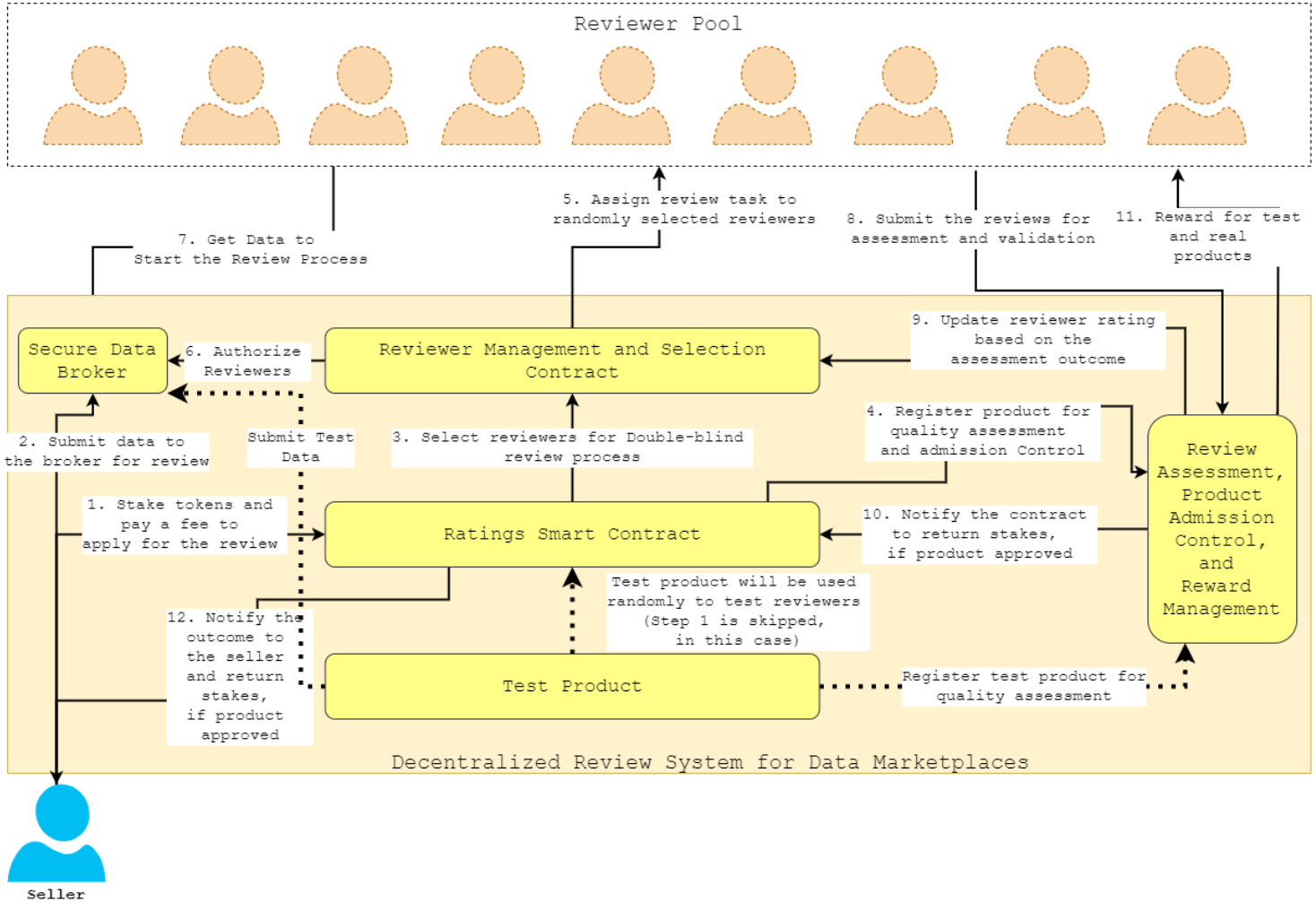
Use Ocean Market to publish data, stake on data (curate), and buy data. Earn by selling, staking, or running your own fork of Ocean Market. Data has automatic price discovery. Data is published as interoperable ERC20 datatokens. Compute-to-data enables private data to be bought & sold. It's a decentralized exchange (DEX), tuned for data.

https://www.accenture.com/us-en/insights/high-tech/dawn-of-data-marketplace,
https://oceanprotocol.com/technology/marketplaces,

Contributions

- Novel incentive-based decentralized review system for data marketplaces
- Game-theoretic modeling of the incentives of review process and identifying conditions under which reviewers behaving honestly is the unique Nash equilibrium
- Simulations to find which incentives are effective
- Code and data used are made publicly accessible at https://github.com/ANRGUSC/DecentralizedReviewSystem

Architechture for Decentralized Review System



Game-Theoretic Model for Reviewer Strategies

Payoff Matrix for Reviewer's Game

Objective: Find conditions where dominant Nash strategy is to review

Parameters

W : Reward for review of test product
R : Reward for matching majority decision

p_T : Prob. of Test product

$p_L * C$: Cost of reviewing when lazy

p_Q : Prob. of high quality review

Reviewer has two strategies 1.Review OR 2. Guess

Payoff for Reviewer 1 and Reviewer 2

	Guess	Review
Guess	$[\alpha = \frac{(1-p_T)R}{2} + \frac{p_T W}{2}, \quad \alpha]$	$[\alpha, \quad \beta = \frac{(1-p_T)R}{2} + p_T p_Q W + \frac{p_T(1-p_Q)W}{2} - p_L C]$
Review	$[\beta, \quad \alpha]$	$[\gamma = (1-p_T)(p_Q^2 R + p_Q(1-p_Q)R + \frac{(1-p_Q)^2 R}{2}) + p_T p_Q W + \frac{p_T(1-p_Q)W}{2} - p_L C, \gamma]$

TABLE I
PAYOFF MATRIX FOR REVIEWER GAME

Desired Equilibrium: (Review, Review) is the only Nash Equilibrium

$\beta > \alpha$ and $\gamma > \alpha$

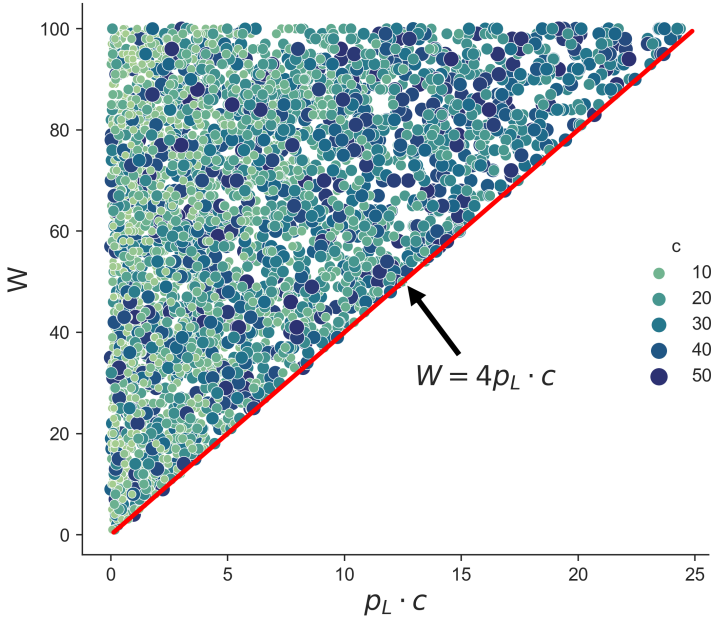
Assuming $p_Q = 1$,

$$W > \frac{2p_L C}{p_T}$$

Simulation Results

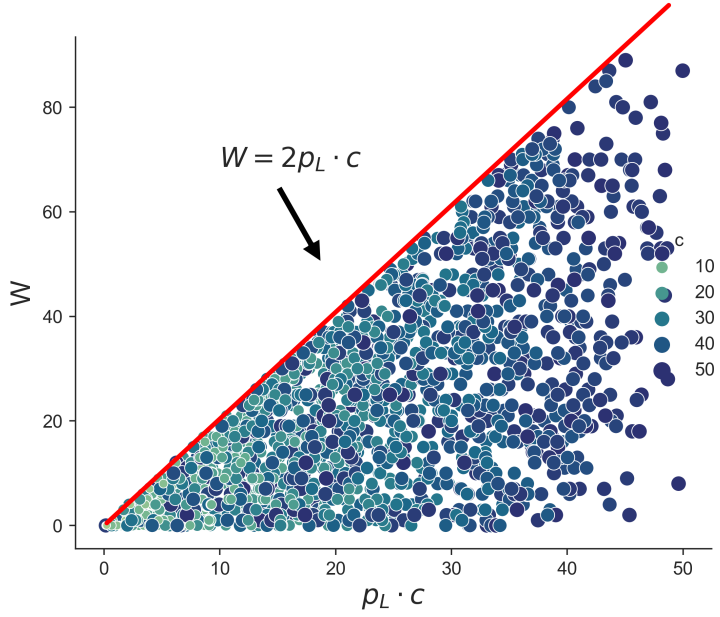
Which incentive works for ensuring review as the dominant strategy?

Review Strategy



pT=0.5

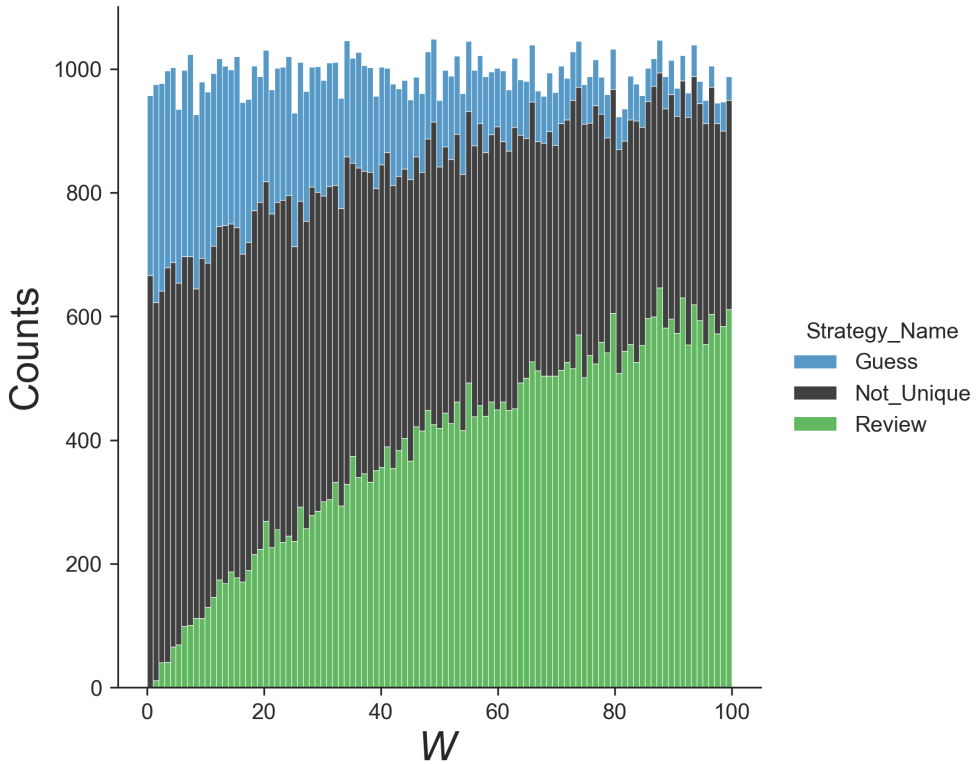
Guess Strategy



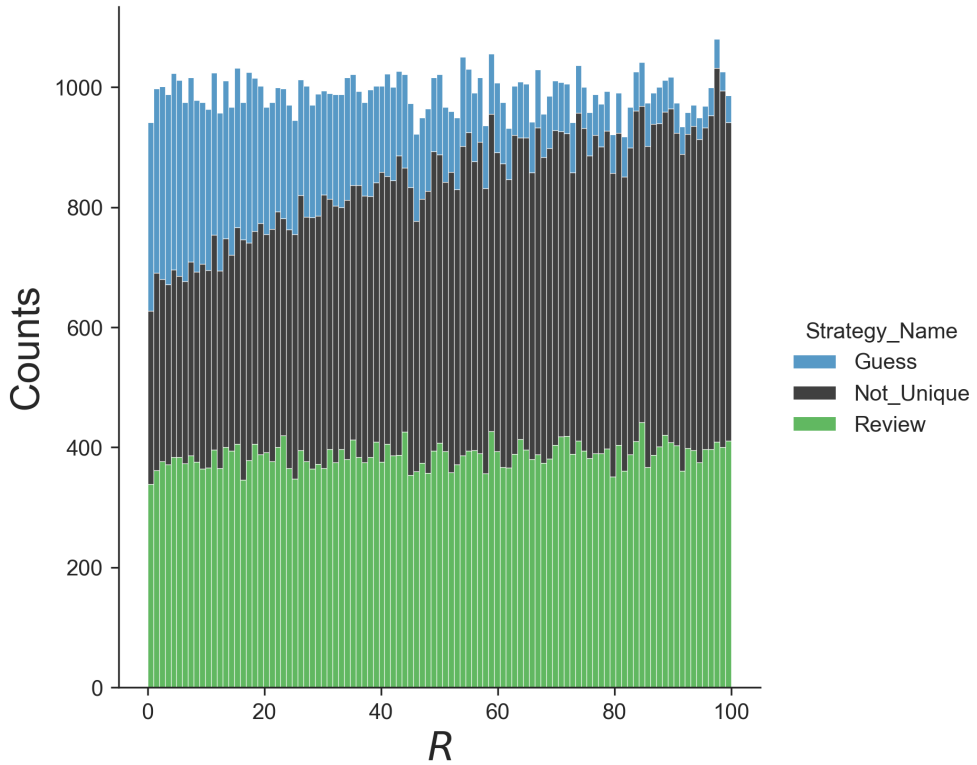
pT=0.5

W vs R for Unique Nash equilibrium

W: Reward for Assessing Test Product

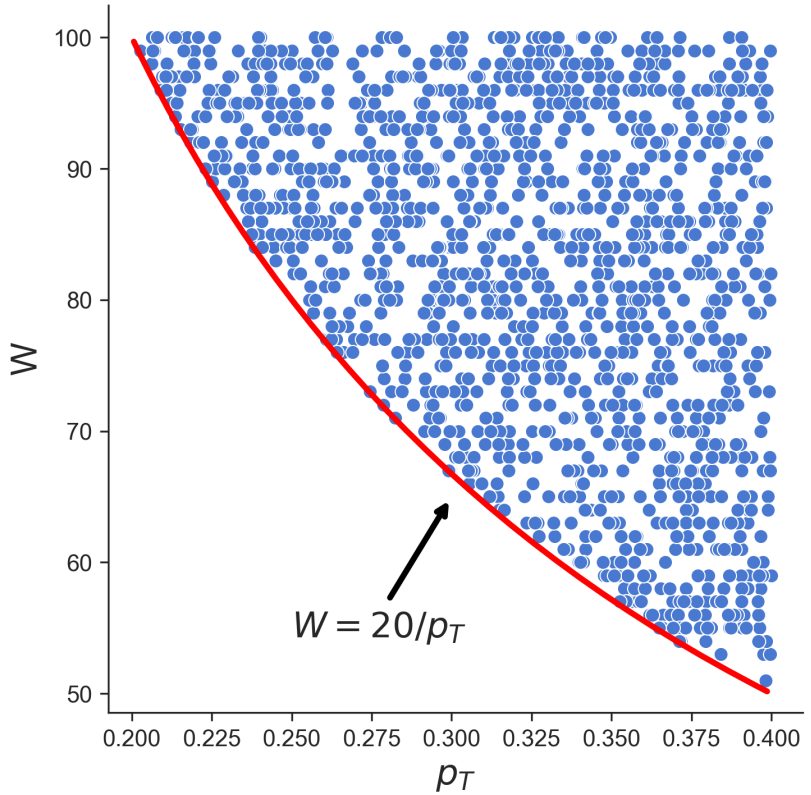


R: Reward for Matching Majority Decision



Relation between pT and W: Review Strategy

keeping $p_L \cdot C$ constant and varying p_T from 0.1 to 0.4



Higher Reward for Test Product as `$p_T$` increases

Seller’s game

Parameters:

$P_{A,H}$, $P_{R,L}$:Prob. of accepting a high/low quality product

M_H, M_L:Expected Profit from a high/low quality product

F_{apply}:Application fee for getting a product reviewed

F_{stake}:Staking fee risked by the Seller

$U^{seller}_{\text{apply,H}}$, $U^{seller}_{\text{apply,L}}$:Seller's utility for a

- Utility from posting a high quality product will increase as the probability of getting an accept increases
- Utility for posting a low quality product will decrease as probability of losing the staking fees increases
- Probability of a high quality of review increases the quality of products in the data market

Conclusions

Decentralized Incentive-mechanism

Conditions for honest review process

Simulations for game-theoretic analysis

- Proposed and analyzed a novel comprehensive incentive-based decentralized review system for data marketplaces
- Unique Nash equilibrium of reviewing which encourages the reviewers to do an honest review and ensure high quality of data marketplace
- Simulations for a game-theoretic model that finds W to be more effective than R

Future Work

Platform Design

- Selection of Reviewers
- Test Generation
- Review Frequency
- Scalability
- Blockchain

Trust

- Malicious users
- Counterfeiting
- Incorrect reviews
- Confidentiality

Prototype for implementing the proposed mechanism for an open data marketplace.

Questions?