"Kevin will be giving my report on outsourcing."

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Incentivizing Outsourced Computation

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Scenario
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Marge
(Boss): trusted

Vacuum clean the house
(Job): algorithm + input

Simpsons
(Contractors): untrusted

honest

lazy

rational

malicious

Aug 16, 2008
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Scenario

Marge (Boss): trusted

Vacuum clean the house (Job): algorithm + input

Goal: Make sure the house is cleaned thoroughly

Simpsons (Contractors): untrusted

honest

lazy

rational

malicious

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Model

Contractors won't be employed unless they can pay the fine

Contractors would like to earn the reward!
Why do the job at all?

Cost of vacuuming the house: $\text{cost}(1)$

Utility of an honest contractor:

$$\text{util}(1) = \text{reward} - \text{cost}(1) > 0$$

Participation constraint.
Why perform the job correctly?

- Lazy contractors (Homer) can use \textit{broom} instead of \textit{vacuum}
- Broom does the job correctly with probability $q < 1$
  - But has lower cost
  - $0 \leq \text{cost}(q) < \text{cost}(1)$
Guaranteed Accuracy

Ideally, everyone should use vacuum instead of broom

Solution: Require hash of intermediate steps (will be different for broom and vacuum) (e.g., plug into electricity)
Employ Multiple Contractors

- Marge needs to make sure the house is really clean, and ready for Christmas
- Give the same job to multiple people
- Marge double-checks the result only when the contractors return different results.
Problem: Two Equilibria

All lazy
\[ \text{util}(q) = \text{reward} - \text{cost}(q) \]

All honest
\[ \text{util}(1) = \text{reward} - \text{cost}(1) \]

Clearly \[ \text{util}(q) > \text{util}(1) \]
Method 1: Using Honest Contractors to Incentivize Rational Contractors

• If some fraction of contractors are honest
• Set fine/reward using
  • $\Pr[\text{honest contractor exists in group}]$
• Then all rational contractors will behave honestly
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Method 2: Using Bounties to Incentivize Rational Contractors

- Offer extra reward (bounty) to whoever catches a cheater
- If cheating gives advantage $\text{adv}$ then set $\text{bounty} \geq \text{reward} \cdot \text{adv}$
- Then all rational contractors will act honestly

utility when you catch a cheater
$\text{util}(1) = \text{reward} - \text{cost}(1) + \text{bounty}$
Method 2: Using Bounties to Incentivize Rational Contractors

- Offer extra reward (bounty) to whoever catches a cheater
- If cheating gives advantage adv then set bounty ≥ reward · adv
- Then all rational contractors will act honestly

utility when you catch a cheater
util(1) = reward – cost(1) + bounty
Malicious Contractors

• Malicious contractors are irrational
  • Bart will break the vases while cleaning

• Bart wants to
  • reduce accuracy of the job
  • waste Marge's time
Malicious Contractors

• Malicious contractors are **irrational**
  • Bart will break the vases while cleaning
• Bart wants to
  • reduce accuracy of the job
  • waste Marge's time
• **Needs to keep non-negative balance**
  • needs to stay in the system
  • will not be employed if cannot pay the fine
Limited Damage by Malicious Contractors

- We show the accuracy loss and wasted work caused by malicious contractors are very limited.
- Bart needs to clean the house many times so that he can pay the fine when he breaks the vase.
Conclusion

• Ways for Marge to employ untrusted family members to thoroughly clean the house using a vacuum
• Limit damage caused by malicious Bart, and force him to clean the house most of the time.
• Best of all, at Brown University, our Brownie group rewards its members who clean after the meetings with
Incentivizing Outsourced Computation

Full presentation this Friday @ Seattle
NetEcon 08
cs.brown.edu/research/brownie

THANKS!

cs.brown.edu/research/brownie