Brief Announcement: Algorithmic Mechanisms for Internet-based Computing under Unreliable Communication

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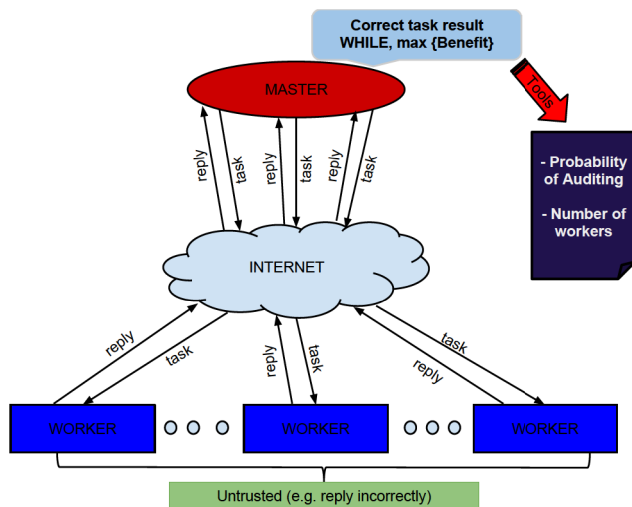
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Motivation

- Internet emerges as a viable platform for supercomputing
  - @home systems, volunteering computing (e.g., SETI@home [Korpela et al 01])
  - P2P and Grid computing [Foster, Iamnitchi 03]

- **Problem:** Great potentials of Internet-based computing limited by untrustworthy platforms components

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Motivation

Prior Work

In Fernandez, Georgiou and Mosteiro 10 an Internet-based master-worker framework was considered

- Types of workers:
  - malicious: always report incorrect result
  - altruistic: always compute and report correct result
  - rational: selfishly (in a game-theoretic sense) choose to be honest or cheat

- Game-theoretic approach
  - Enforce a desired unique NE between rational workers
  - Design the game that provides the appropriate incentives i.e. reward/punish

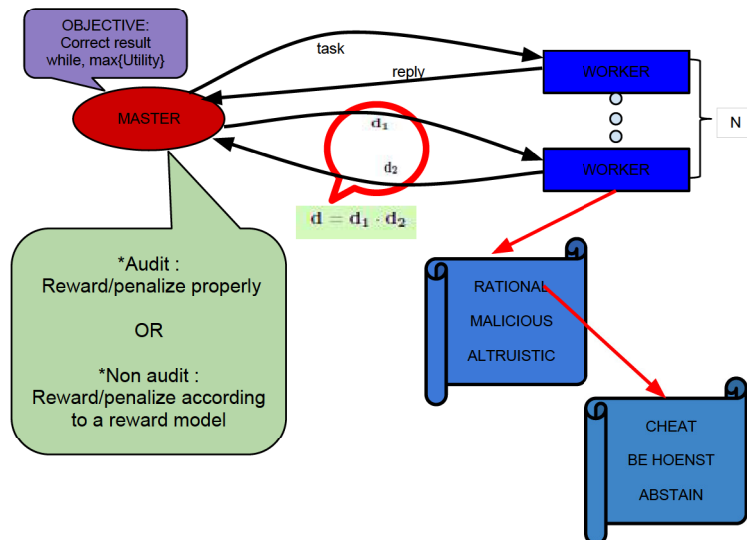- A reliable network was considered

Slide 5 — Problem Statement

Problem Statement

- Communication uncertainty
  - Messages exchanged may get lost or arrive late

- Possibility of workers not replying
  - Around 5% of the workers are available more than 80% of the time Half of the workers are available less than 40% of the time [Heien, Anderson and Hagihara 09]
  - Long computational length is incur by a task [Kondo et al. 07]

- **Master's challenges**
  - **Provide incentives for workers to reply and reply truthfully**
  - **Ensure the above in the presence of low network reliability**

Slide 6 — Contributions

Contributions

- Develop and analyze two realistic game-theoretic mechanisms
  - Time-based mechanism
  - Reply-based mechanism

- Mechanisms provide the necessary incentives for rational workers to truthfully compute and return the task result, despite:
  - Malicious workers actions
  - Network unreliability

- Apply the mechanisms to two realistic settings:
  - SETI-like volunteer computing applications
 - Contractor-based applications (e.g. Amazons mechanical turk)

Slide 7 — Framework

Framework

OBJECTIVE: Correct result while, max{Utility}

MASTER

task

reply

WORKER

N

d_1

d_2

$\mathbf{d} = \mathbf{d_1} \cdot \mathbf{d_2}$

*Audit : Reward/penalize properly

OR

*Non audit : Reward/penalize according to a reward model

RATIONAL

MALICIOUS

ALTRUISTIC

CHEAT

BE HOENST

ABSTAIN

Slide 8 — Algorithms

Algorithms

- Time-based protocol
  - Master fixes a time T, once it is reached gathers all received replies
  - Ties are broken at random

- Reply-based protocol
  - Master fixes k, minimum estimated number of replies, by choosing n
  - If at least k replies are received, audit with $p_{\mathcal{A}}$
  - Else it does nothing, and incurs penalty $MC_{\mathcal{S}}$

Time-based
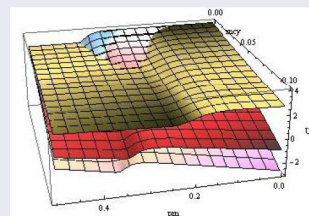
Reply-based
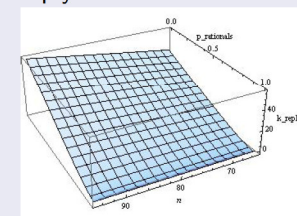
Mechanism Design
Master protocol to chose $p_{\mathcal{A}}$

- Free rationals (master does not rely on rational workers)
  - Case 1: probability of malicious workers p_μ very large, high $p_{\mathcal{A}}$

$$p_{\mathcal{A}} \leftarrow 1 - \varepsilon / \sum_{i=k}^{n} r_i c_i$$

  - Case 2: probability of altruistic workers p_α big

$$p_{\mathcal{A}} \leftarrow 0$$

  - Case 3: rationals probability of being honest $p_{\mathcal{H}}$ is 1, even if $p_{\mathcal{A}} = 0$

$$p_{\mathcal{A}} \leftarrow 0$$

- Guided rationals(force the behavior of rational workers)
  - Rationals enforced to reply correctly ($p_{\mathcal{C}} = 0$ and $p_{\mathcal{N}} = 0$)
  - $p_{\mathcal{A}}$ is set according to worker's equilibria conditions depending on the reward model

Conclusions and Future Work

- We present mechanisms for reliable computation
- Different types of workers
- Unreliable network
- **Future work :** We plan to explore systems with a continuous flow of tasks

Thank you

Presentation available at:
http://www.cs.ucy.ac.cy/ric/dissemination.html

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