Collaboration Models

Lingjie Duan, Takeshi Kubo, Kohei Sugiyama, Jianwei Huang,
Teruyuki Hasegawa, Jean Walrand

Singapore SUTD, KDDI, CHUK, UC Berkeley

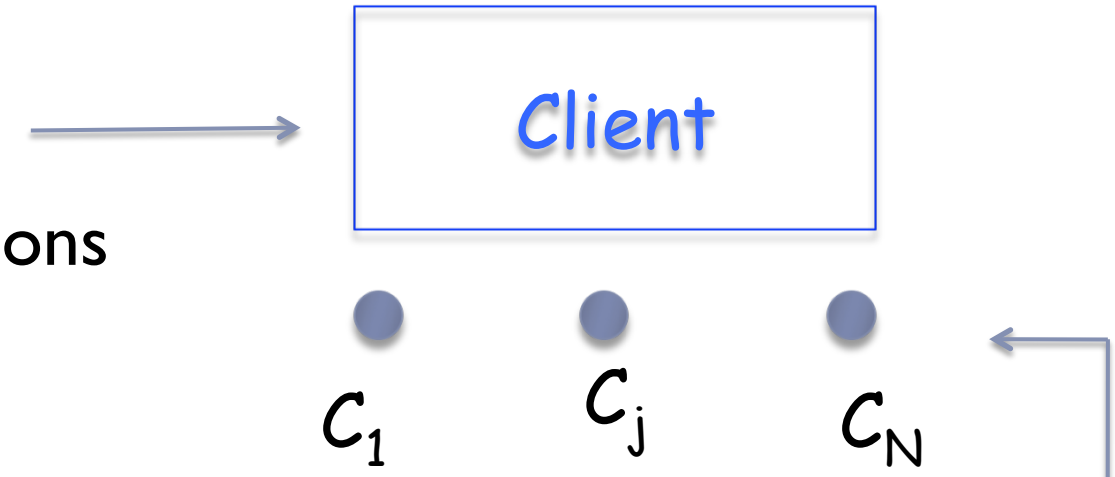
DIMACS Workshop on the Economic Aspects of information Sharing – 2/7/13

Overview

- Data collection & cooperation on tasks
- Incentives for collaboration?
- We model cooperation in two situations:
- Model 1:
  "Data Collection Game" : share reward if successful
- Model 2:
  "Task collaboration": contract

Model 1

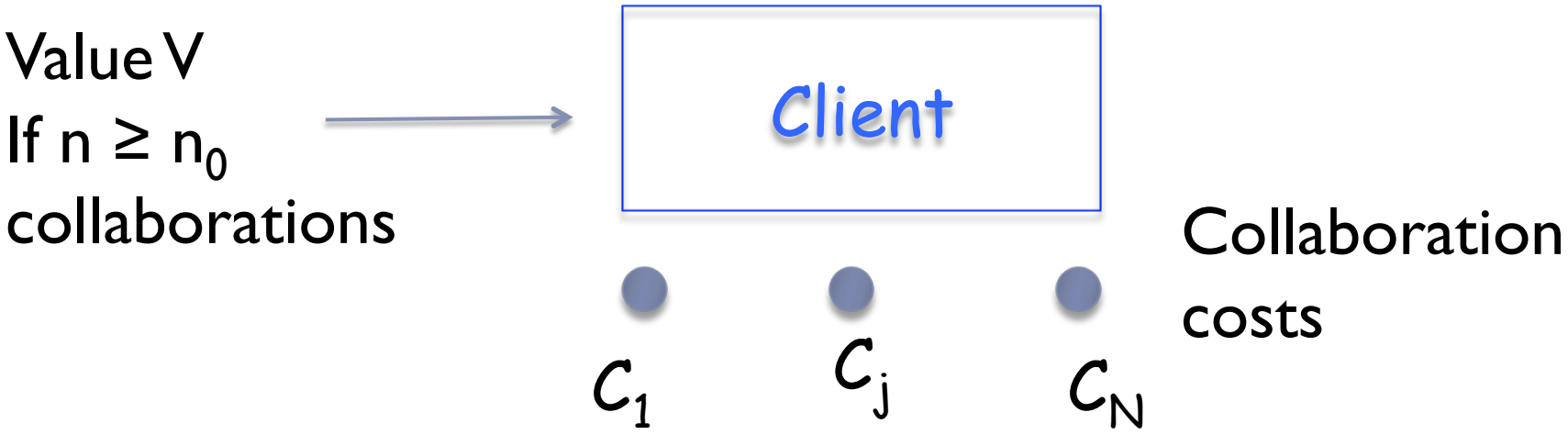
Value V
If $n \geq n_0$
collaborations



Collaboration costs: iid, F(.) known

N known

Model 1



Scheme: Client proposes a reward R

R is divided among collaborators, if $n \geq n_0$

Questions: Whether to collaborate?

How to choose R?

Model 1

Scheme: Client proposes a reward R
R is divided among collaborators

Value V
If $n \geq n_0$
collaborations

Collaboration costs

c_1 c_j c_N

Nash equilibrium: Collaborate if $C_i \leq \gamma$

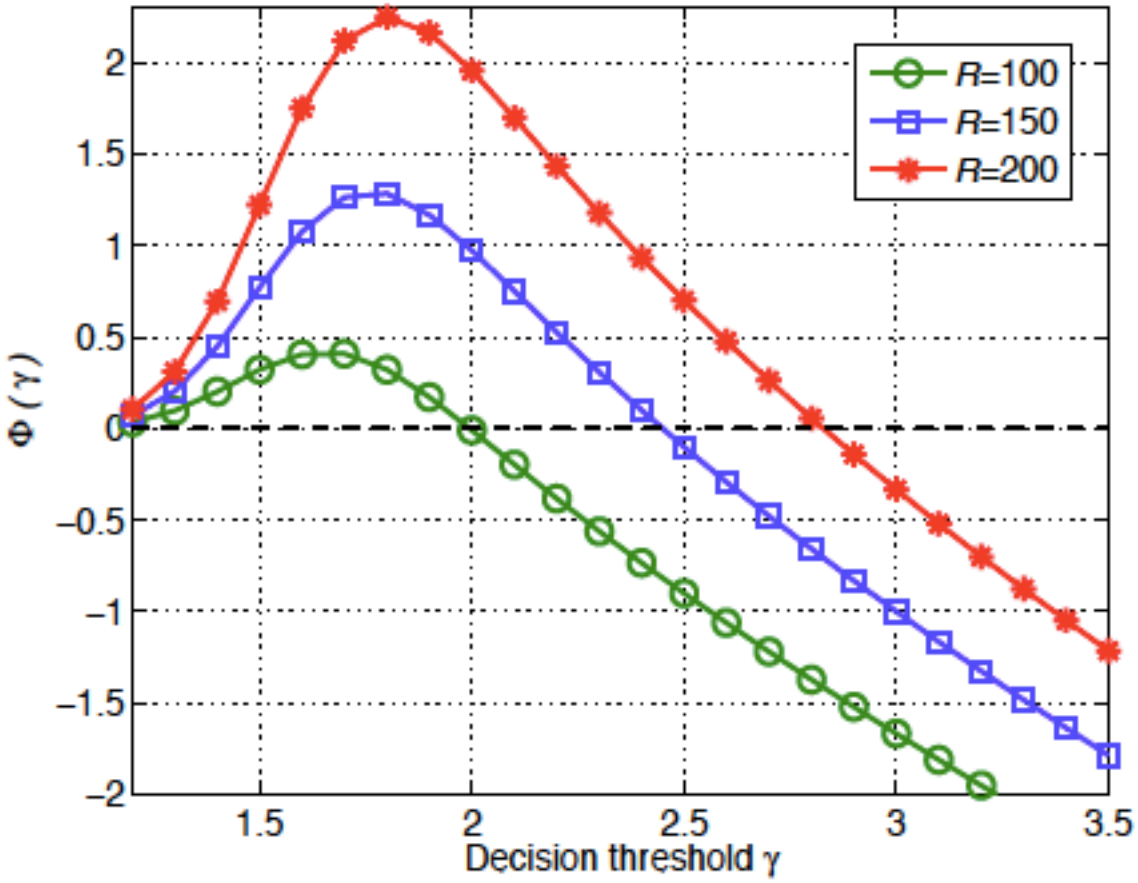
γ = unique solution of

$$\Phi(\gamma) := \mathbb{E}_m \left(\left[\frac{R}{m+1} - \gamma \right] \mathbf{1}_{\{m+1 \geq n_0\}} \right) = 0$$

$$\text{where } m = B(N, F(\gamma))$$

Model 1

Scheme: Client proposes a reward R
R is divided among collaborators



N = 100
n_0 = 40
C_i = U[0, 4]

E.g., R = 100
$\rightarrow \gamma$ = 2
note that E[n] = 50

Model 1

Scheme: Client proposes a reward R
R is divided among collaborators

Choosing R:

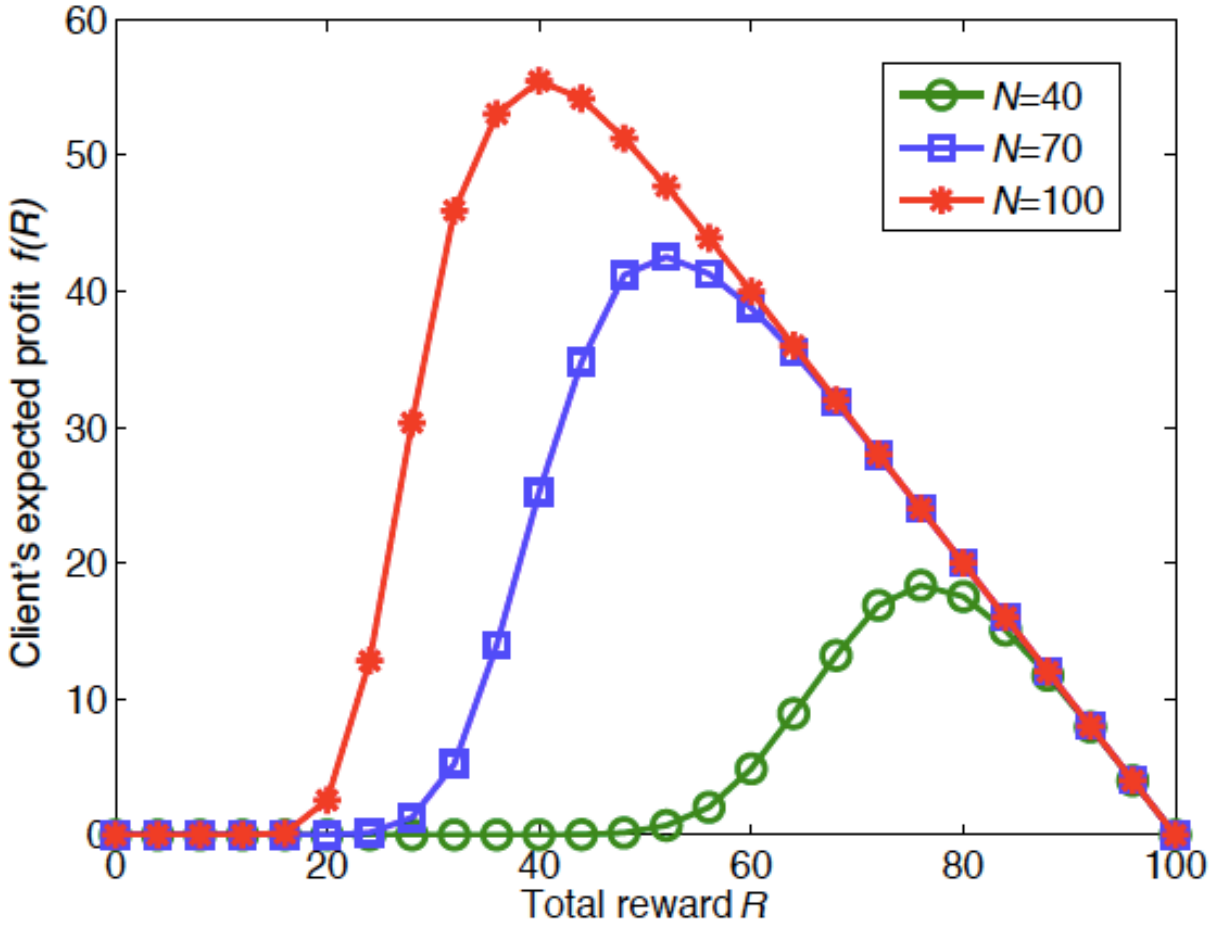
$$\max_R f(R) = \mathbb{E}_n\left([V - R]\mathbf{1}_{\{n \geq n_0\}}\right)$$

$$\text{where } n = B(N, F(\gamma^*(R)))$$

Model 1

Scheme: Client proposes a reward R
R is divided among collaborators

Choosing R:

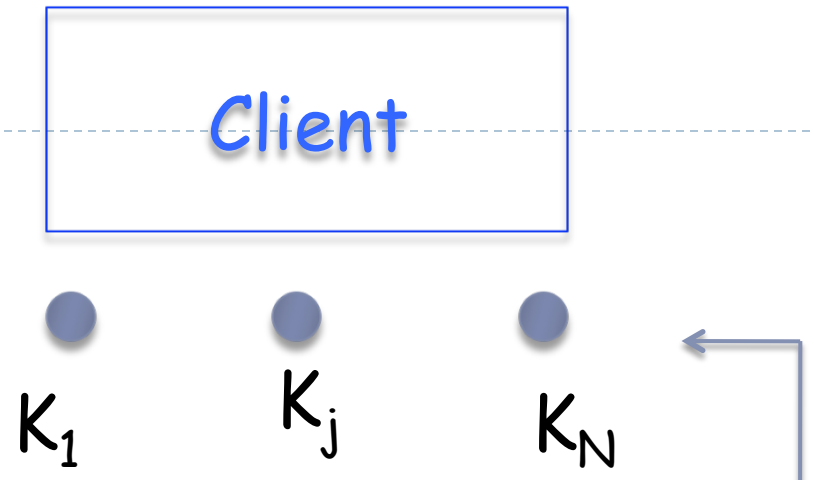


$V = 100$

$n_0 = 30$

$C_i = U[0, 3]$

Model 2



Type i:

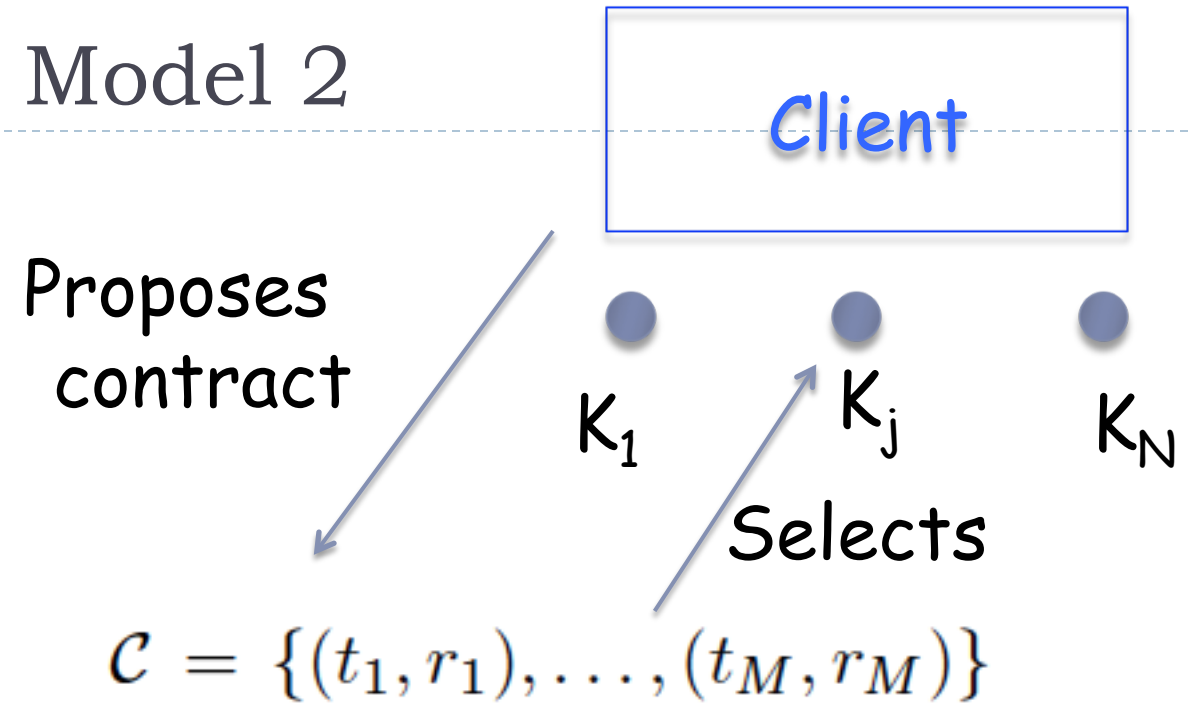
$$u_i(r,t) = r - K_i t, \text{ for } 0 \le t \le \bar{t}_i.$$

Reward r
Effort t

Client's utility:

$$\pi(\{(r_i,t_i)\}_{i\in\mathcal{I}}) = \sum_{i\in\mathcal{I}} (\theta_i \log(1+N_i t_i) - N_i r_i)$$

Model 2



j : I will produce t_m units of effort for reward r_m

Model 2

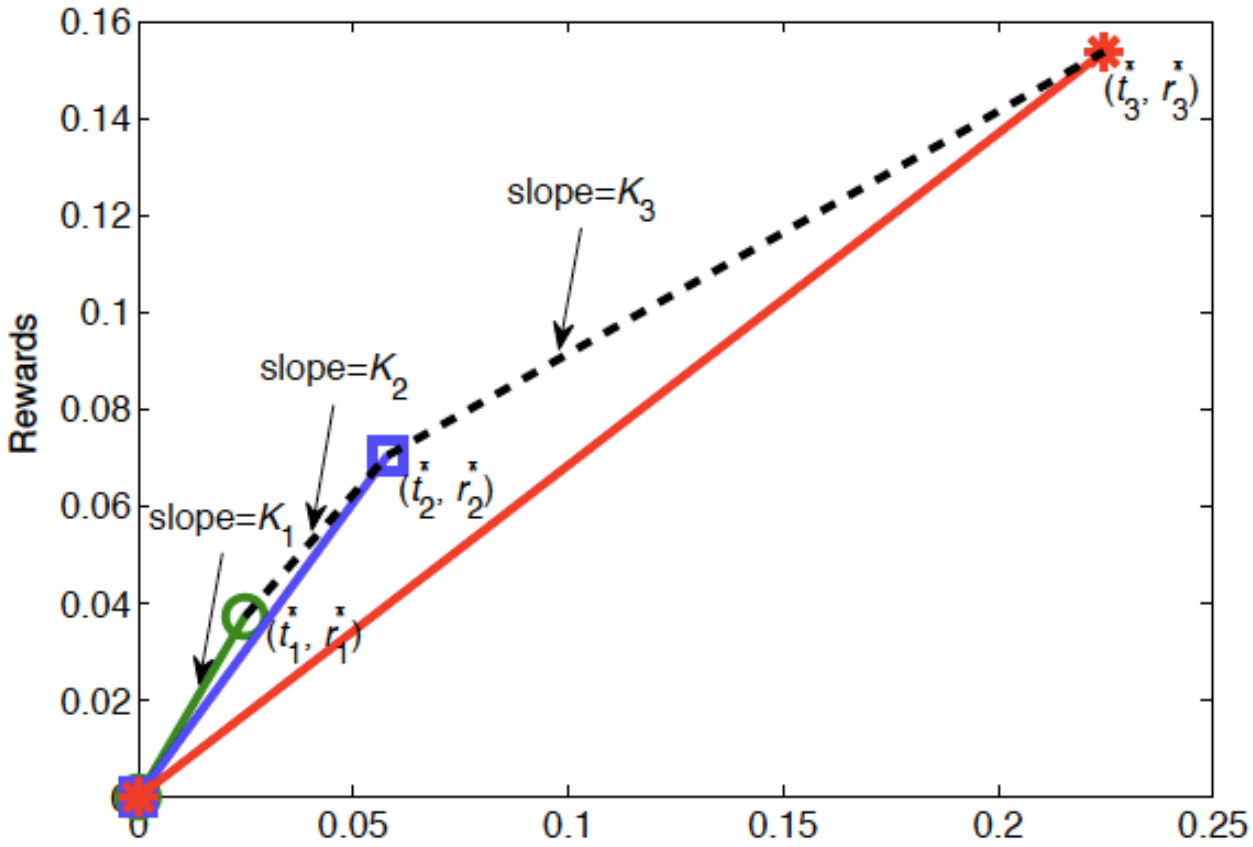
Client

$$\mathcal{C} = \{(t_1, r_1), \ldots, (t_M, r_M)\}$$

N users, each user has type i w.p. q_i

Algorithm for optimal design of contract

Model 2



N = 120

3 types

$q_i = 1/3$

$\theta_i = 5$

$$\pi(\{(r_i, t_i)\}_{i\in\mathcal{I}}) = \sum_{i\in\mathcal{I}} (\theta_i \log(1 + N_i t_i) - N_i r_i)$$

Summary

Design of collaborations

1) "Data Collection" Share R if $n \geq n_0$ → V for client

Collaborate if cost ≤ γ^*

Calculate optimal R

2) "Collaboration on task" User of type i w.p. q_i

Design of optimal contract

This presentation is based on the following paper:

Lingjie Duan, Takeshi Kubo, Kohei Sugiyama, Jianwei Huang, Teruyuki Hasegawa, Jean Walrand, "Incentive Mechanisms for Smartphone Collaboration in Data Acquisition and Distributed Computing," *INFOCOM 2012*.