Network based Mechanisms for Competitive Crowdsourcing

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Overview

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Conclusion and Challenges
Crowdsourcing is the combination of crowd and outsourcing. The term “crowdsourcing” was proposed by Jeff Howe and Mark Robinson in June 2006.

**Definition**

Crowdsourcing is an online distributed problem-solving process where a group of workers solve a problem.

In this work, we are basically focusing on the competitive crowdsourcing platform where decomposable tasks are solved by the crowd workers.

Workers submit their bids corresponding to subtasks and the winner is selected based on the minimum bid values.
Lakhani analyzed a competitive crowdsourcing environment that involves specialized people as the crowd workers.

Maximum platforms follow the mechanism where non-decomposable tasks are solved by the workers.

The success of solving smaller tasks or micro tasks is inspiring to the workers for solving the large decomposable tasks.

We consider systems where anyone can participate as a crowd worker.

We create some mechanisms for the competitive crowdsourcing markets where large decomposable task can be solved by crowd workers.

The requesters (who post the task) and the crowd workers (who solve the task) are both financially benefited from the mechanism.
Related Work

- Gagan et al. designed a mechanism for auction based platforms where heterogeneous tasks can be solved within a limited budget [1].

- Mittal et al. designed an auction based mechanism where a worker is selected who solved the maximum number of tasks within the minimum bidding cost [2].

- Kulkarni et al. proposed a model where larger tasks are broken into multiple smaller steps and distributed among different workers in the collaborative crowdsourcing environment [6].

- Morris et al. described how to solve the subcontracting microtask by the categorized workers (Primary and Secondary) [7].
We consider that a set of requesters \( R = \{r_1, r_2, \ldots, r_n\} \) post a set of integral or decomposable tasks.

All the crowd workers \( W = \{w_1, w_2, \ldots, w_m\} \) decompose the task as much as they can and solve the subtasks and post the solutions with costs.

The winner(s) is (are) selected based on the minimizing the cost of solution.
Basic Definitions

Posted cost
Posted cost is the expenditure declared by a worker for completing a specific task.

Minimum posted cost
Minimum posted cost is the minimum cost of all the posted costs for a particular task.

Boundary cost
Boundary cost is the maximum allowed posted cost for the workers.

Winner
Winner is the worker(s) whose posted cost is(are) selected as the best (minimum) one for a given task.
Basic Definitions

Remuneration
Remuneration is the price money that is given to the winner(s).

Reward
Reward is the amount which is deducted from one co-winner and added to the other co-winner when they become joint winners. Note that, the reward is a flexible component of remuneration.

Budget
Budget is the total estimated cost that a requester can afford for competing a task.
2-decomposable Task Model

Figure: Example of competitive bidding with 2-decomposable tasks.
Four workers (namely $w_1$, $w_2$, $w_3$ and $w_4$) participate in the task and post the costs independently.

With no collaboration, $w_4$ will be selected as the winner.

The solution might not be the best one for the requester.

The solution could further be improved by allowing the workers $w_2$ or $w_4$ and $w_3$ to collaborate and post the joint solution.

For non-decomposable tasks, if we select a worker as the winner who posts the best cost, then the output (cost) may not be good for requesters. Therefore, if we choose joint winners who have collectively posted the best cost, which might be better than the costs posted by the individual workers.
2-decomposable Task Model

Figure: Example of 2 player Envelope game.

Envelope game is a type of cooperation game where every player maximize their profit by opening his envelope.
Figure: Payoff tree representing the reward distribution between the pair of collaborating workers in the envelope game.
2-decomposable Task Model

Change of the minimum posted cost (Above) and corresponding remuneration (Below) are observed over the iterations by varying the probability of joining a pair of workers between 0.01 to 0.08, incremented by 0.01.

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Now we consider the task is $n$ decomposable ($n > 2$). So, a single worker never gets the best solution for the decomposable task. Collaboration between two workers never guarantee that the workers divide the task equal position so envelope game not suitable for $n$ decomposable task. So propose a way that helps out from this problem.
(a) Each worker independently divides the task into sub-tasks and posts the cost for each sub-task. (b) Directed and weighted graph formulation based on the workers’ cost of solution.
$n$-decomposable Task Model

- $i^{th}$ worker divides a task ($T$) into a set of sub-tasks represented by $s_i = \{(s_{i1}^i, s_{i2}^i), (s_{i2}^i, s_{i3}^i), \ldots, (s_{i(k_i-1)}^i, s_{ik_i}^i)\}$, where $k_i \geq 2$ and $s_j^i$ ($\forall i: j \in \{2, 3, \ldots, k_i-1\}$) is a break point of the task, and posts the corresponding cost $c_i = \{c(s_{i1}^i, s_{i2}^i), c(s_{i2}^i, s_{i3}^i), \ldots, c(s_{i(k_i-1)}^i, s_{ik_i}^i)\}$.
- $k_i$’s are not necessarily the same.
- Here, $(s_{i1}^1, s_{i2}^1)$ is basically the first sub-task of the given task which is solved by the worker $w_1$ and $c(s_{i1}^1, s_{i2}^1)$ is the corresponding cost of the solution.
- It is not necessary for a worker to post the solution of all the sub-tasks. A worker may wish to solve a portion of the total task and post its cost, thereby incurring the constraint $s_i \subseteq T$.
- If the worker does not solve the sub-tasks within the deadline, then the solutions are not accepted by the requester.
- The submitted task by the $i^{th}$ worker is $\bigcup_{j=1}^{k_i-1} (s_j^i, s_{j+1}^i)$ where $s_j^i$ is the $j^{th}$ break point.
If we find a shortest path from the network then, the edges of the shortest path are the solution of the decomposable task and total cost is the cost of the shortest path.
The n-decomposable Task Model

- A network $\mathcal{G}$ where order of the network $O = \sum_{i=1}^{k_i} k_i + 2$, size $Z = \sum_{i=1}^{k_i} (k_i - 1) + 2m + \sum_{\forall i, j, x, y} I(s^i_x = s^i_y)$, and the number of components is $m$.
- We map all the tasks into a network model where the set of vertices is $V = \bigcup_{i=1}^{m} \bigcup_{j=1}^{k_i} s^i_j$.
- The set of edges is $E = \bigcup_{i=1}^{m} \bigcup_{j=1}^{k_i-1} (s^i_j, s^i_{j+1})$.
- The cost function is defined as $C^i_{j, j+1} : C(s^i_j, s^i_{j+1}) \rightarrow \mathcal{R}^+$. 

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We consider the shortest path between $s_0$ and $s_p$ as $P_{0p} = \min_p C(P_{0p})$

$$= \min \sum_{(j,j+1) \in V \times V} (s_j^i, s_{j+1}^i) \times X_{j,j+1}$$

subject to

$$X_{j,j+1} - X_{j+1,j} = \begin{cases} 
1, & \text{if } j \in s_0 \\
0, & \text{if } j \notin s_0 \neq s_p \\
-1, & \text{if } j \in s_p 
\end{cases}$$

Here, $X_{j,j+1}$ is an indicator function and the value of

$$X_{j,j+1} = \begin{cases} 
1, & \text{if } j \in P_{0p} \\
0, & \text{if } j \notin P_{0p} 
\end{cases}$$
Figure: Comparative costs of solution of sub-tasks posted by individual workers, combination of workers, and the best one.

We consider a decomposable task is posted with initial budget 10,000. Task is decomposed (arbitrary) into at most 20 sub-tasks and minimum cost of each sub-task is 50 (arbitrary) by 1000 workers.
We have proposed an envelope game based novel mechanism for 2-decomposable task and network based mechanism for n-decomposable task for different competitive crowdsourcing markets.

Our mechanism guarantees that if the workers can solve a task in a collaborative nature within a competitive system than the outcome will be better for the requesters.

Diverse skills are required.

Better strategic interaction between the crowd workers that ensures the aim of the crowdsourcing models.

Appropriate model that encourage the workers to collaborate.
References


Thank you