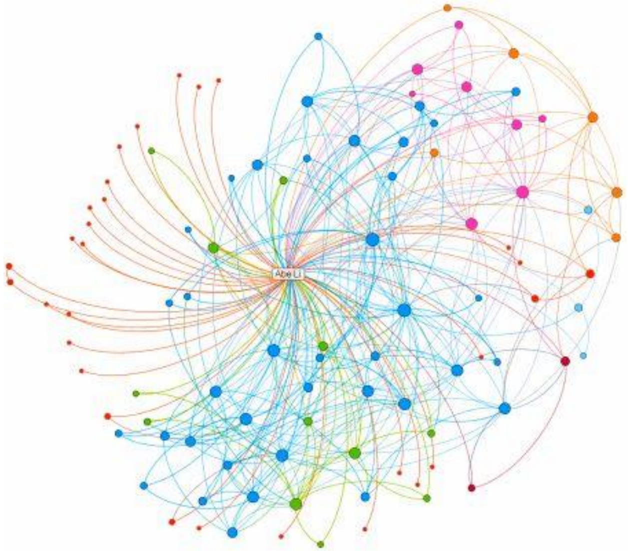
2018 15th IEEE International Conference on Sensing, Communication and Networking

Online Incentive Mechanism for Mobile Crowdsourcing based on Two-tiered Social Crowdsourcing Architecture



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Crowdsourcing with Mobile Phone

Accelerometer

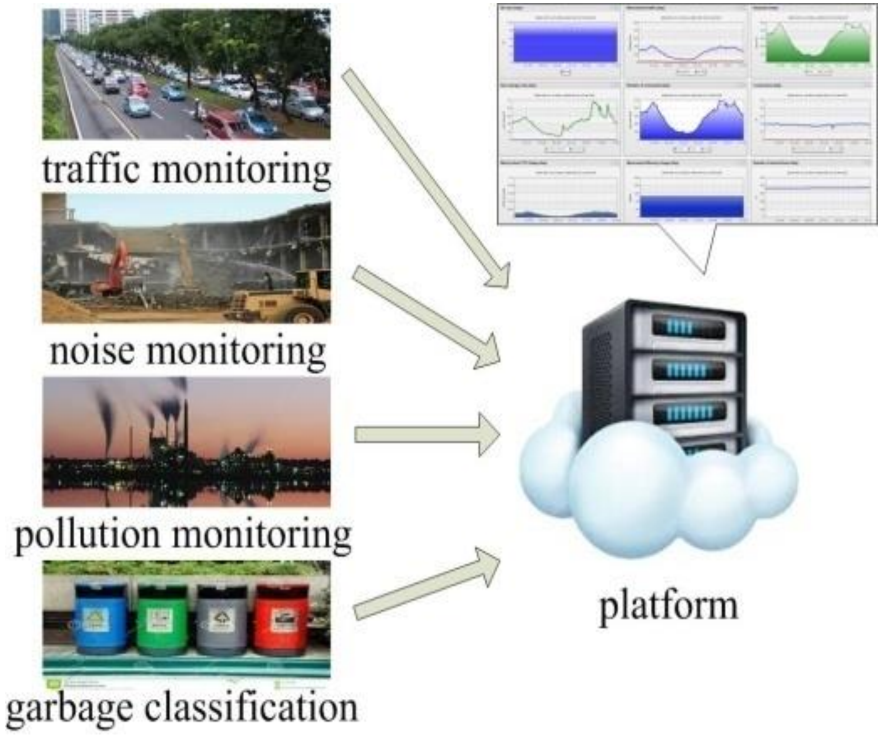
light sensor

Digital Compass

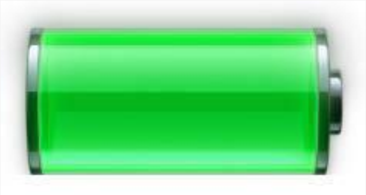
Microphone Camera

GPS

proximity sensor



Incentive Mechanisms for Mobile Crowdsourcing



Power

Memory

Computing ability

TIME

Privacy

compensate users' cost

help to achieve good service quality

Insufficient Participants

6.02%

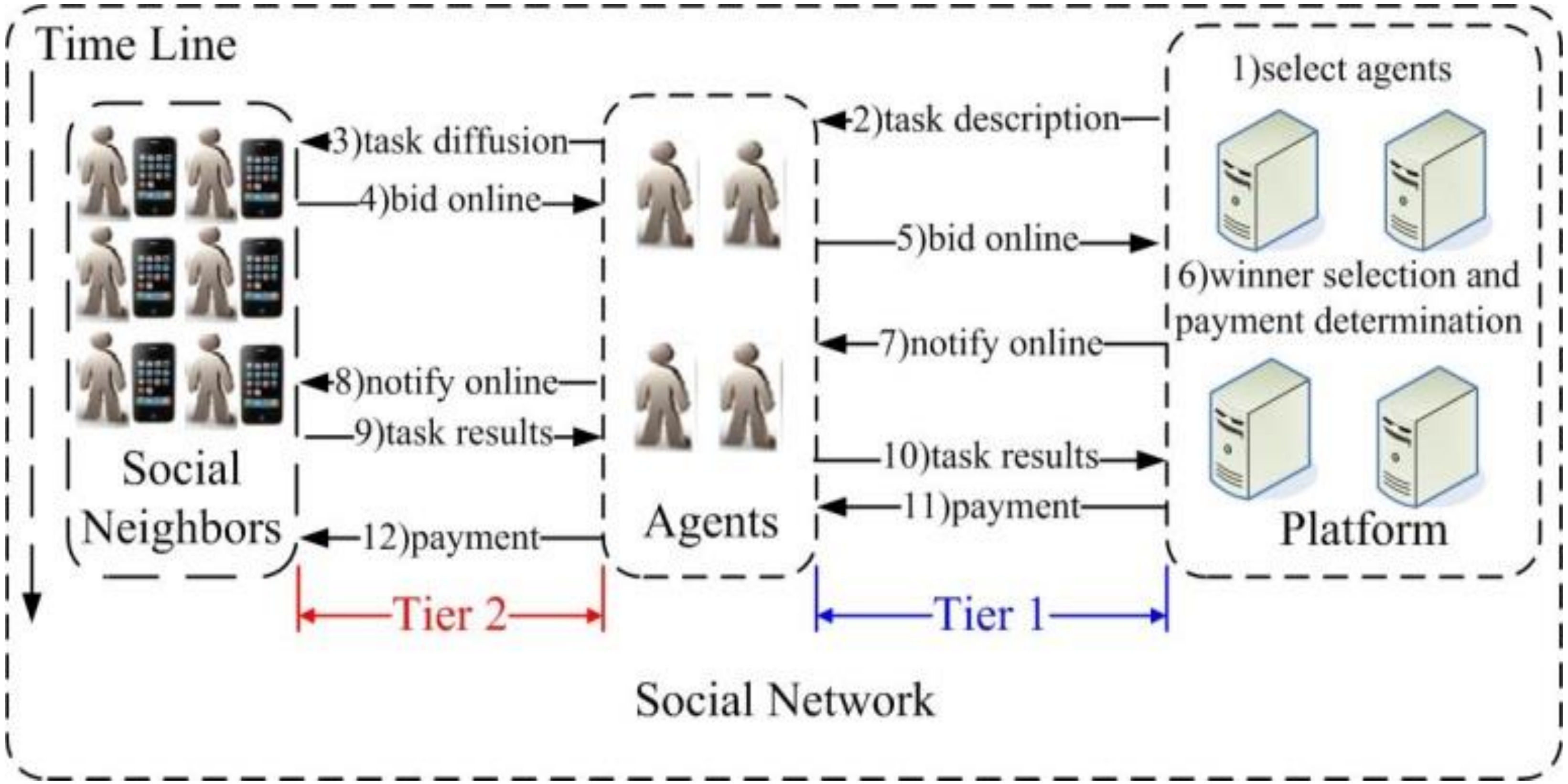
3.83%

618.65

Basic Idea

Spread the sensing tasks to the social network to attract more smartphone users.

Two-tiered Social Crowdsourcing Architecture



Objective

Designing truthful incentive mechanisms to maximize the total value for platform under the budget constraint online setting

Challenges

Practical system model for the two-tiered social crowdsourcing system

Make decision before users depart

How to select the agents? online durations or influence?

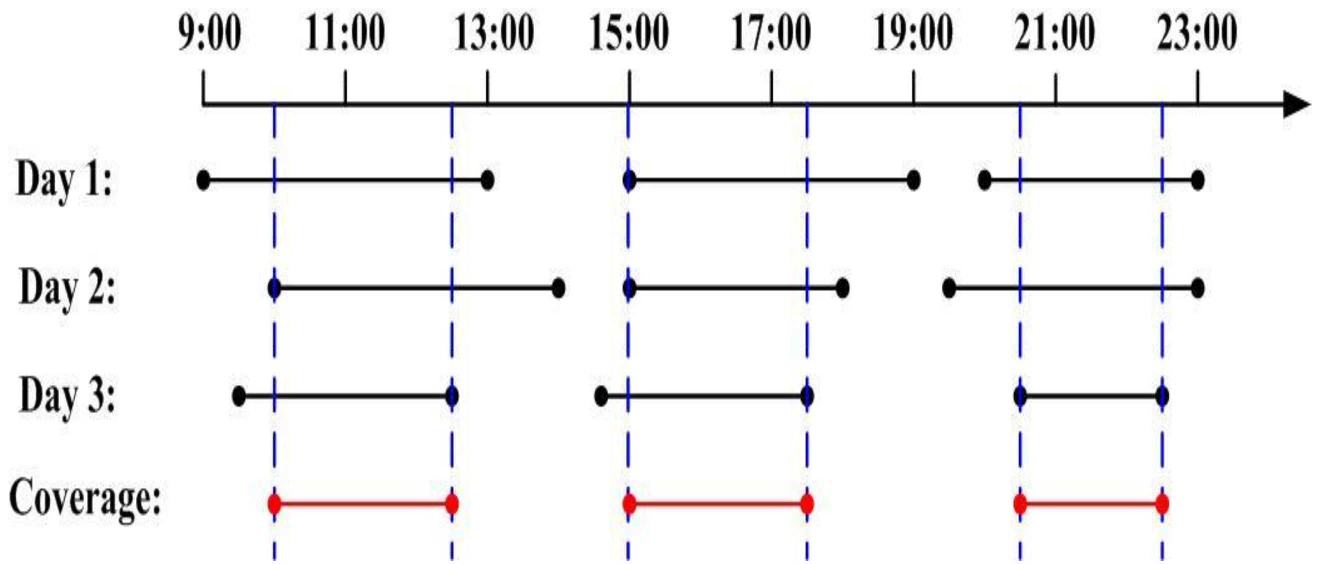
Strategic behavior by submitting dishonest bid price or arrival/departure time

Agent Selection

Objective: The cumulative online durations of the selected agents are desirable to cover the tasks as many as possible.

Constraint: The unit influence of any agent is larger than the constant δ

Coverage



Select the users with maximum marginal coverage

Unit Influence

Measure the matching of interests

$$Jac(\Gamma^j, i) = \frac{|T^j \cap I_i|}{|T^j \cup I_i|}$$

Influence function

$$I(Z, I_{max}) = (I_{max} - 1)\sqrt{1 - (1 - Z)^2} + 1$$

Unit influence

$$\frac{\sum_{i \in SN^j} I(Jac(\Gamma^j, i), I_{max})}{|\mathcal{H}^j|}$$

Online Reverse Auction

Step1:

Winner Selection & Payment Determination

Step2:

Density Threshold Updating

Step3:

Adjustment for Online Users

For each user who is online

Find i with maximum marginal value

If $b_i \leq \frac{V_i(S^j)}{\rho} \leq \mathcal{B}^j - \sum_{i' \in S^j} p_{i'}$, **add user i into winner set**

$p_i \leftarrow V_i(S^j)/\rho$

End for

Online Reverse Auction

Step1:

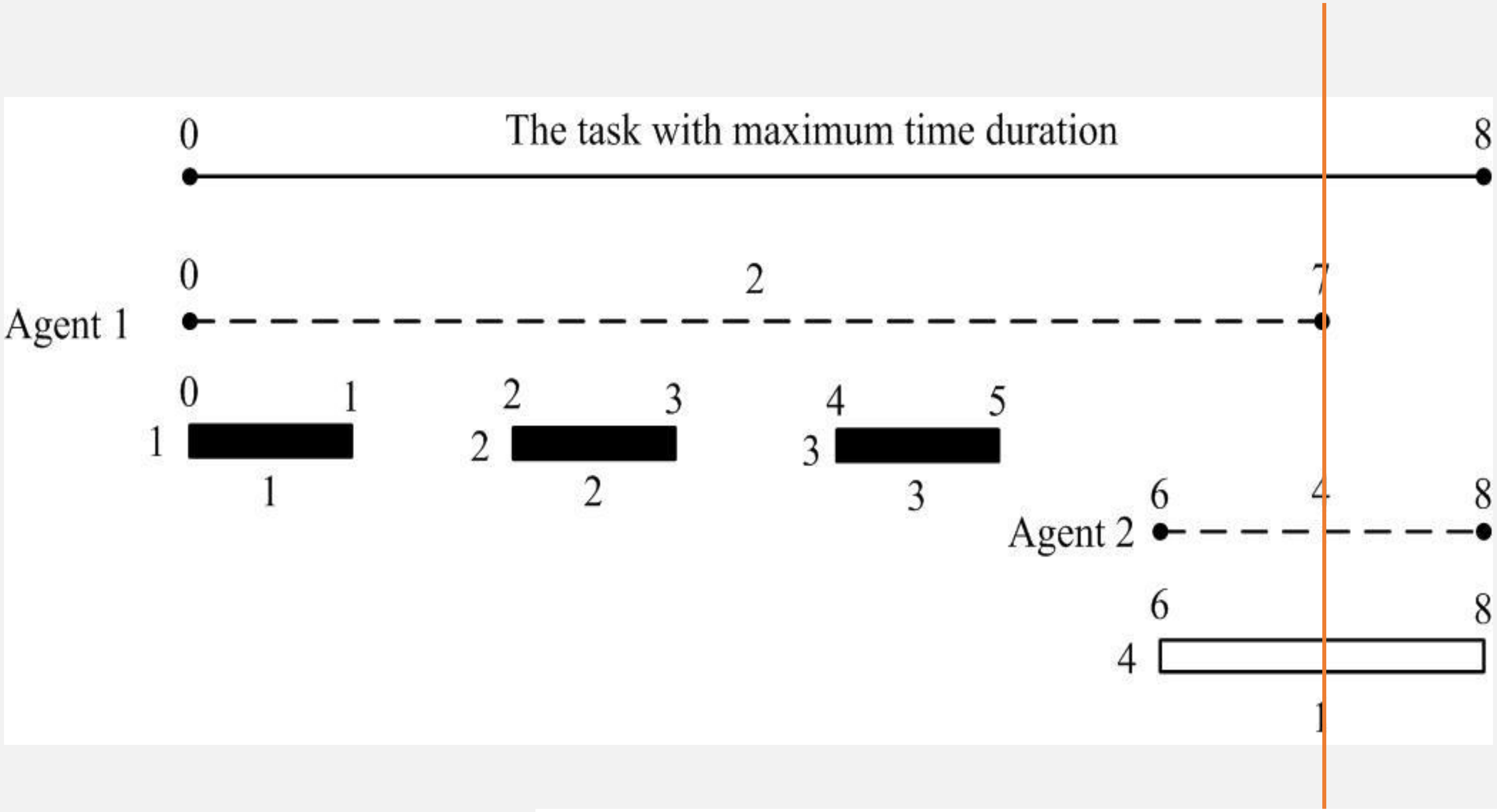
Winner Selection & Payment Determination

Step2:

Density Threshold Updating

Step3:

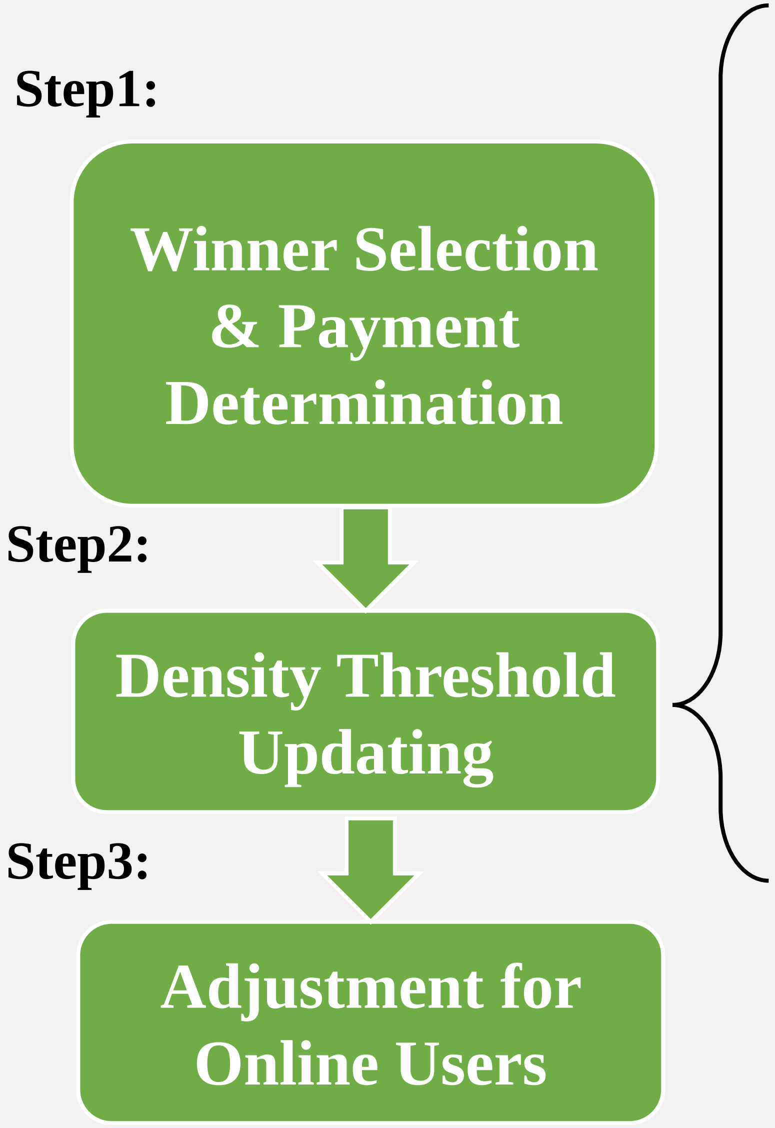
Adjustment for Online Users



Update the density threshold

multiple-stage sampling accepting process

Online Reverse Auction



Input: agent k's budget $\mathcal{B}^k$, sample set S'

$\mathcal{G} \leftarrow \emptyset; i \leftarrow argmax_{j \in S'} \frac{V_j(\mathcal{G})}{b_j};$

while $b_i \leq \frac{V_i(\mathcal{G})\mathcal{B}^k}{V(\mathcal{G} \cup \{i\})}$ **do**

$\quad \mathcal{G} \leftarrow \mathcal{G} \cup \{i\});$

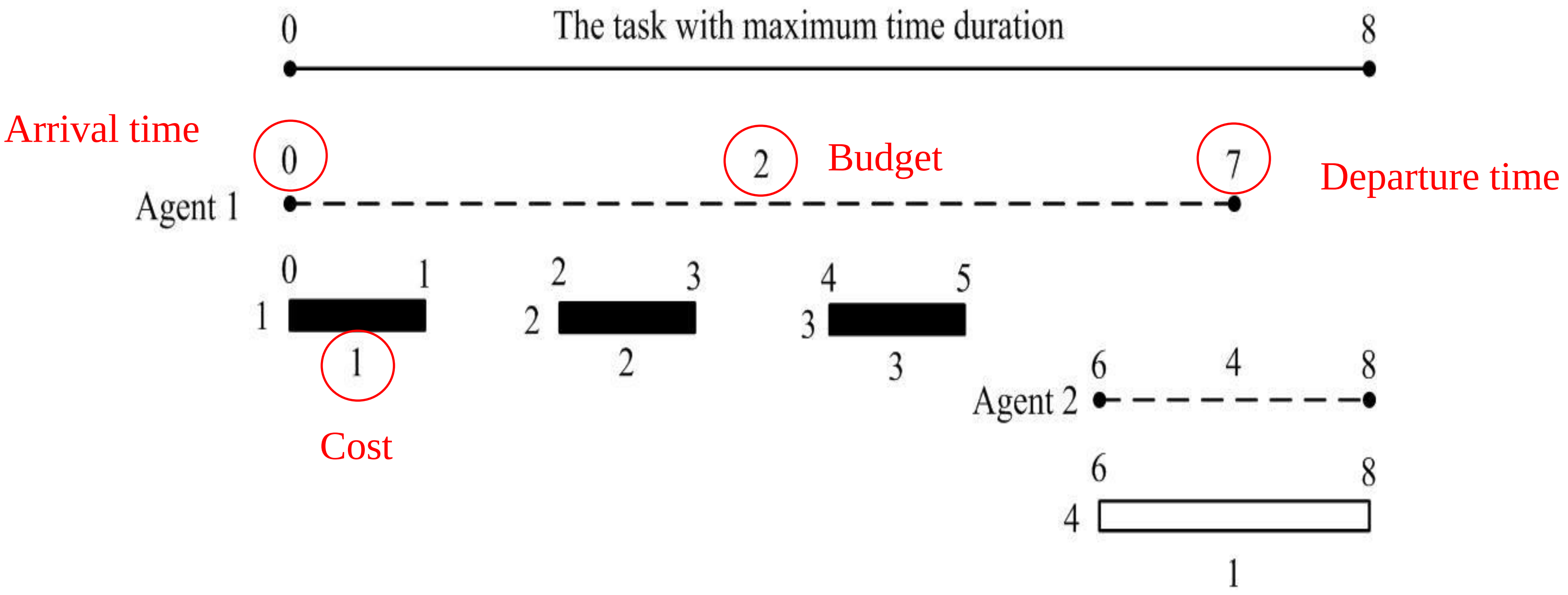
$\quad i \leftarrow argmax_{j \in S' \setminus \mathcal{G}} \frac{V_j(\mathcal{G})}{b_j};$

end

return $V(\mathcal{G})/\mathcal{B}^k;$

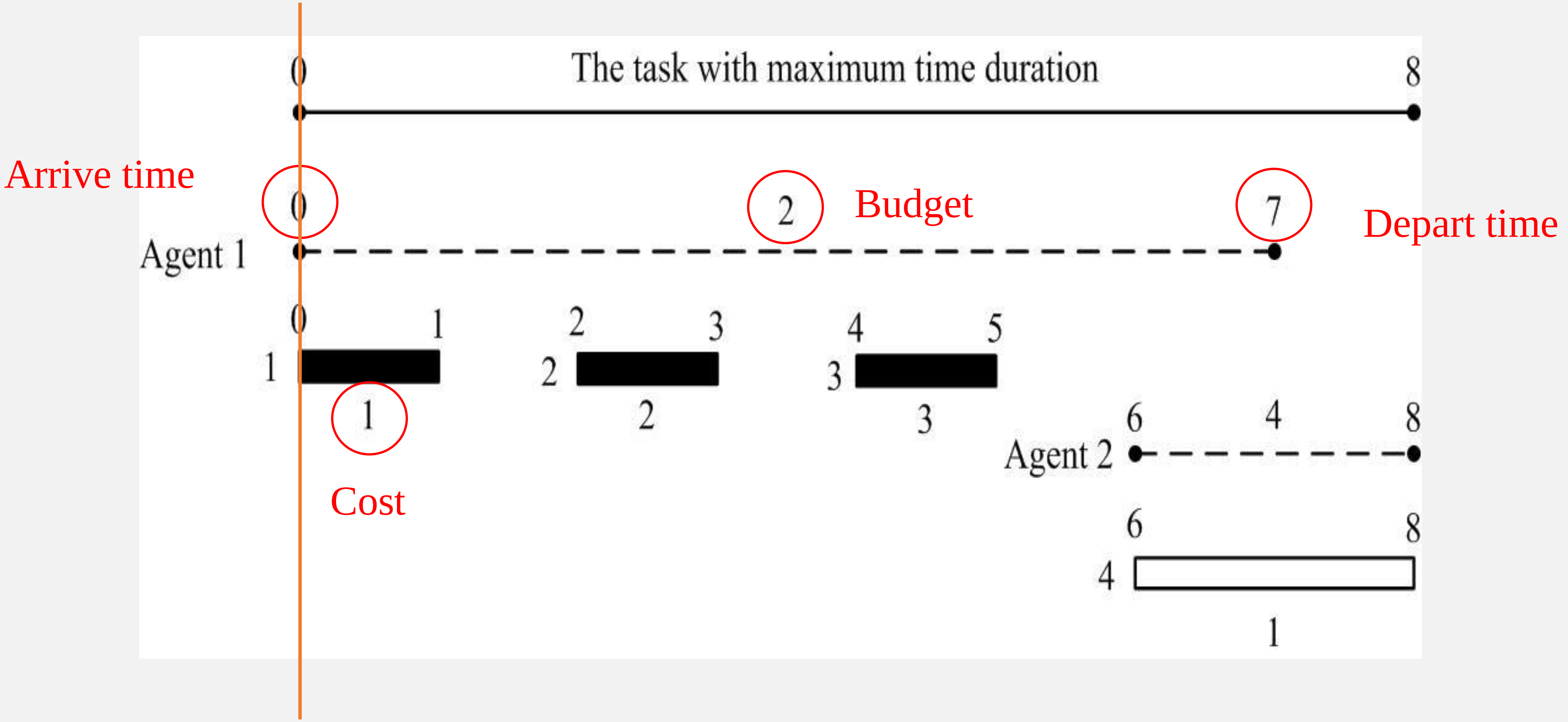
Repeat Step1 for online users

A Walk-through Example



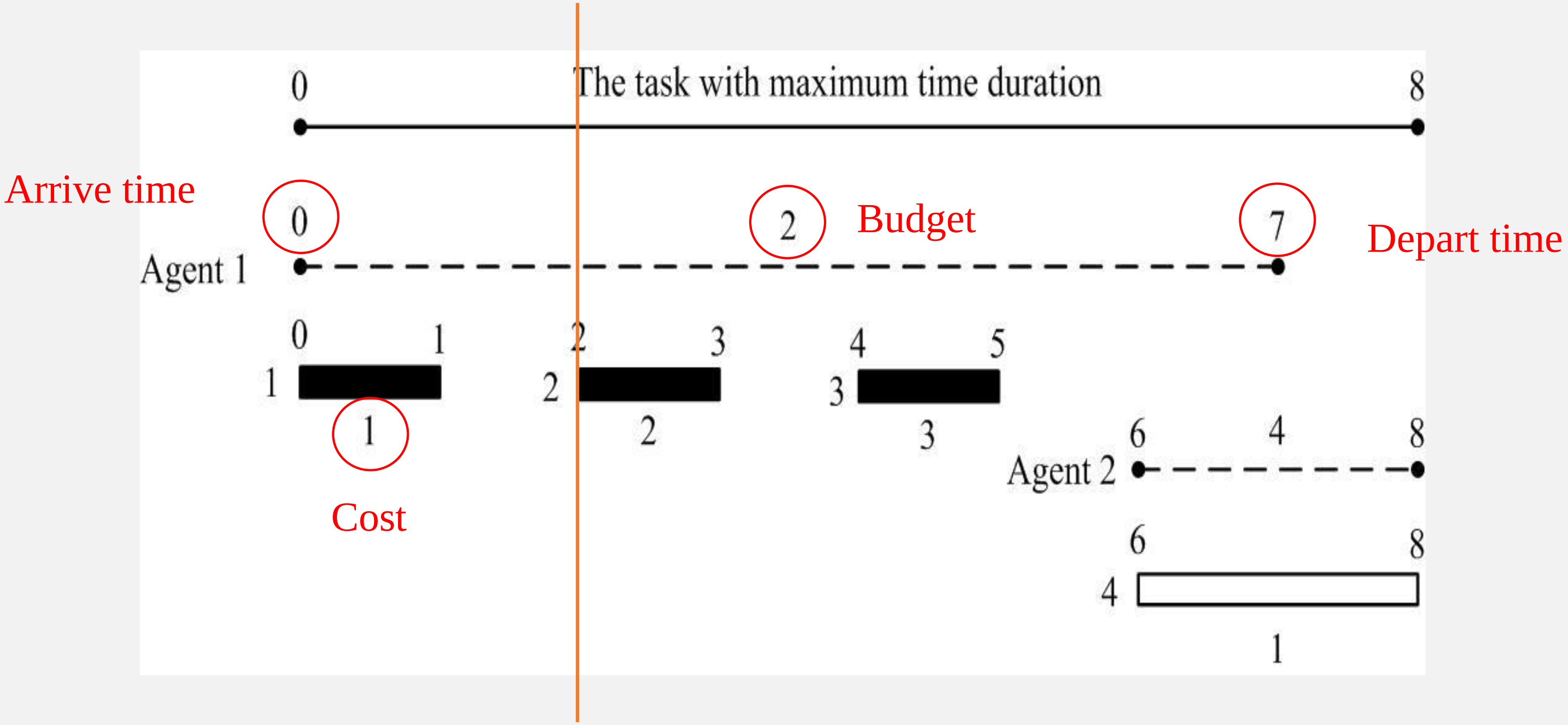
Each social neighbor has the same marginal value 1/2. $\rho = 1/2$.

A Walk-through Example



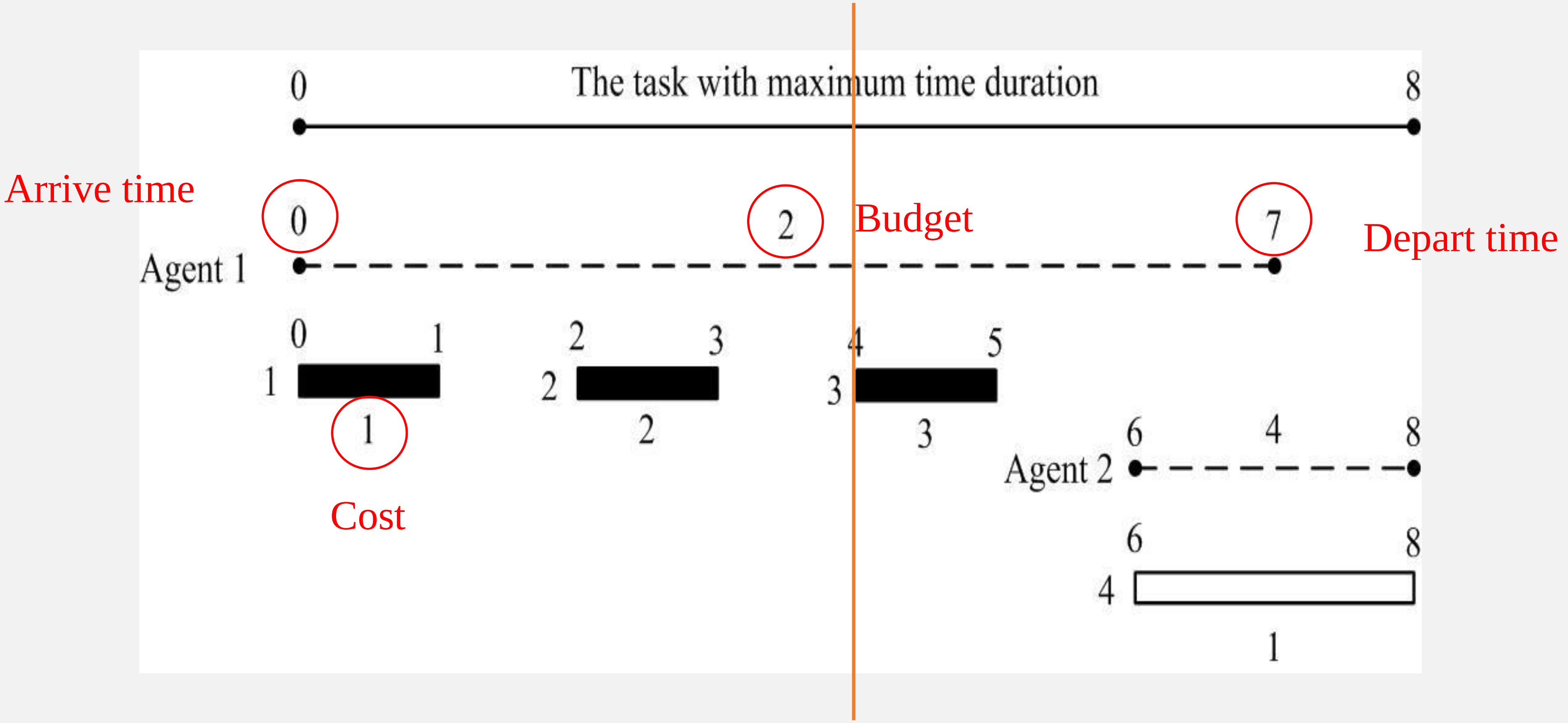
$t=0$: $S^1=\emptyset$, $\rho=1/2$, $b_1=1\le\frac{V_1(S^1)}{\rho}=\frac{1/2}{1/2}=1\le\mathcal{B}^1=2$, thus $p_1=\frac{V_1(S^1)}{\rho}=1$, $S=\{1\}$.

A Walk-through Example



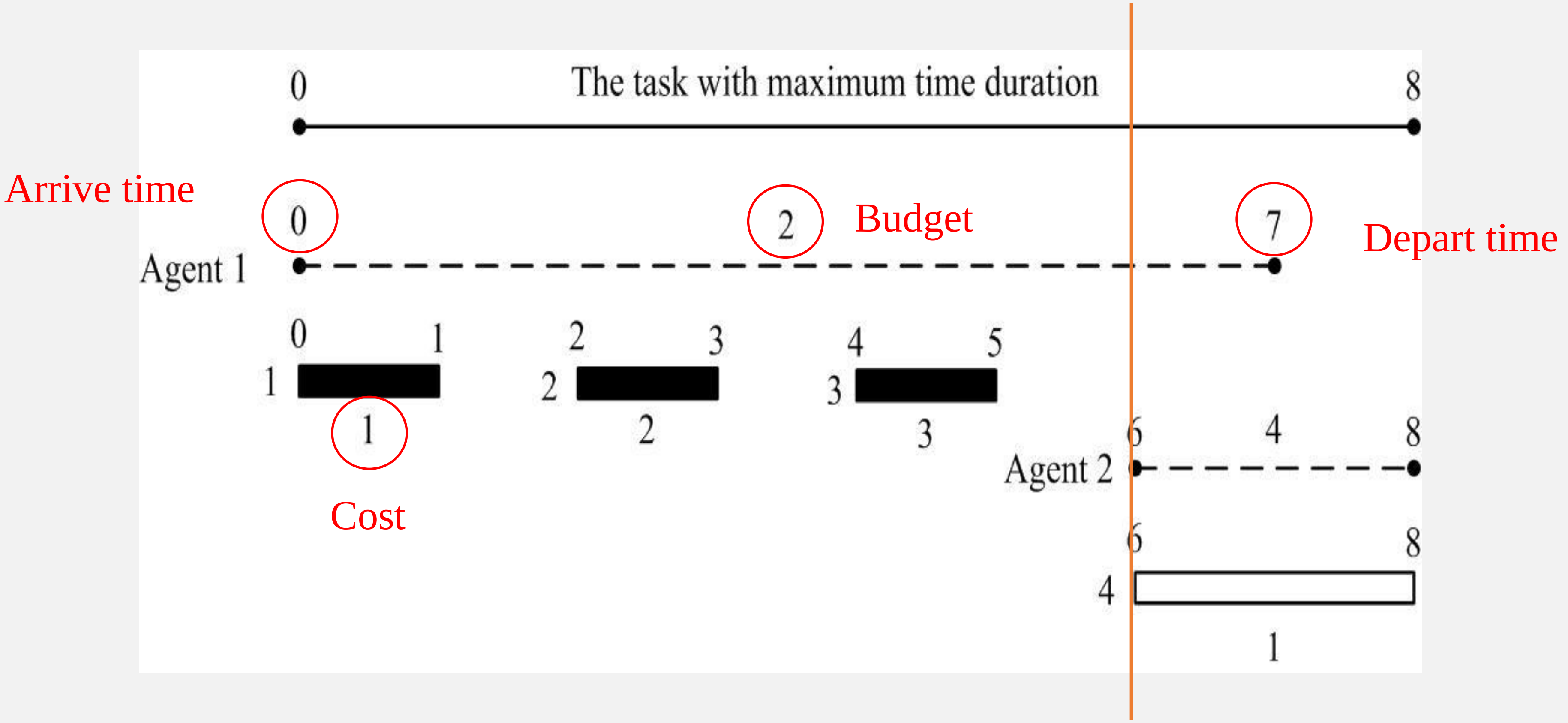
$t = 2$: $S^1 = \{1\}$, $\rho = 1/2$, $b_2 = 2 > \frac{V_2(S^1)}{\rho} = \frac{1/2}{1/2} = 1$, thus $p_2 = 0$.

A Walk-through Example



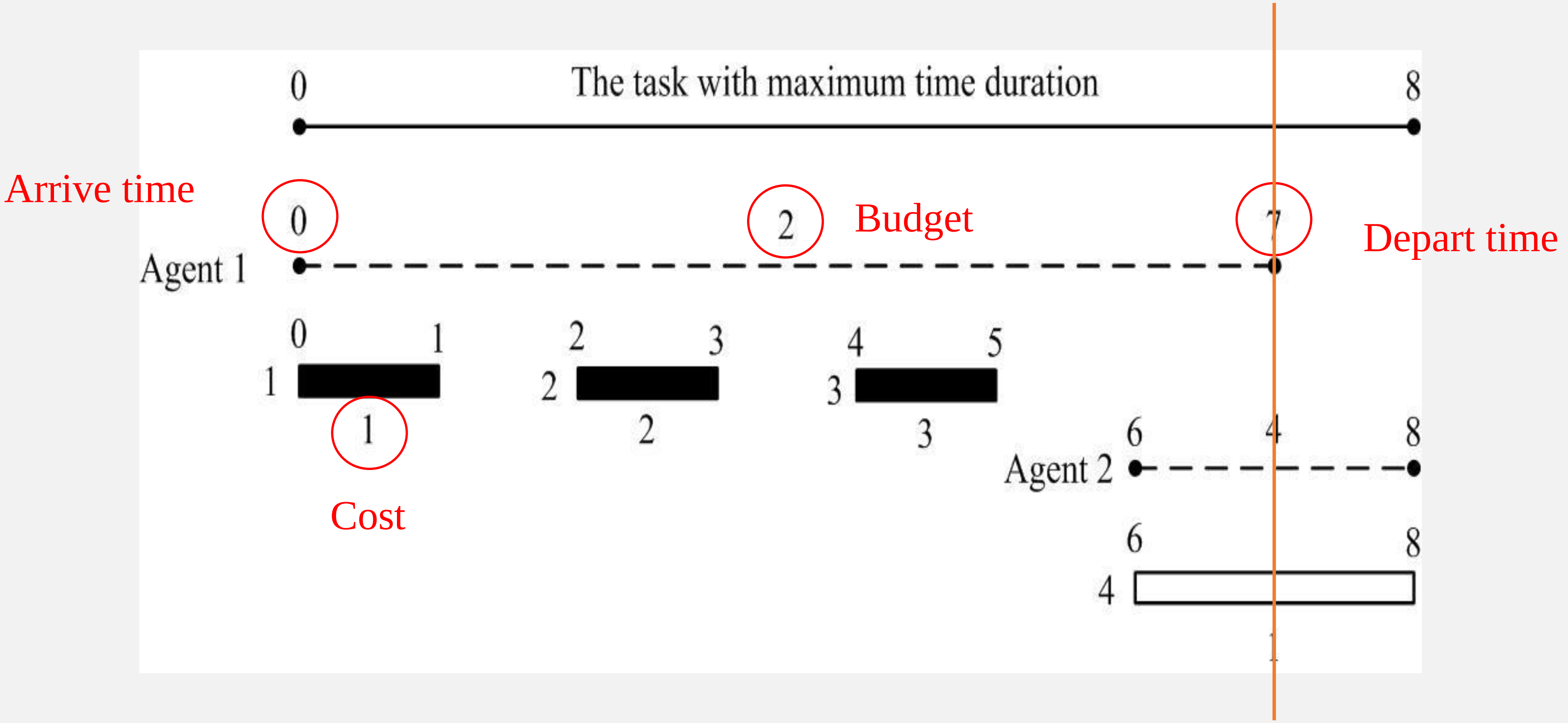
$$t = 4: S^1 = \{1\}, \rho = 1/2, b_3 = 3 > \frac{V_3(S^1)}{\rho} = \frac{1/2}{1/2} = 1, \text{ thus } p_3 = 0.$$

A Walk-through Example



$$t = 6: S^2 = \emptyset, \rho = 1/2, b_4 = 1 \leq \frac{V_4(S^2)}{\rho} = \frac{1/2}{1/2} = 1 \leq \mathcal{B}^2 = 4, \text{ thus } p_4 = 1, S = \{1, 4\}.$$

A Walk-through Example



$t = 7$: $d^1 = t$ $S' = \{1,2,3\}$, $\mathcal{B}^1 = 2$, update $\rho = 1/4$. $b_4 = 1 \le \frac{V_4(S^2 \setminus \{4\})}{\rho} = \frac{1/2}{1/4} = 2 \le \mathcal{B}^2 - p_4 + p_4 = 4$, and $\frac{V_4(S^2 \setminus \{4\})}{\rho} = 2 > p_4 = 1$, thus increase p_4 to 2.

Theoretical Analysis

Lemma 1. ***MTSC is computationally efficient.***

Agent Selection: $O(max\{max_{j\in J}|SN^j|nm^2, n^2\})$ Online Reverse Auction: $O(|SN|m^2)$

Lemma 2. ***MTSC is individually rational.***

Each user will have a non-negative utility

Lemma 3. ***MTSC is budget feasible.***

The total payment to the users is smaller or equal to the total budget

Lemma 4. ***MTSC is truthful (cost-truthful and time-truthful).***

No user can improve its utility by submitting false cost, arrival/departure time, no matter what others submit.

Performance Evaluation

Three Benchmark algorithms:

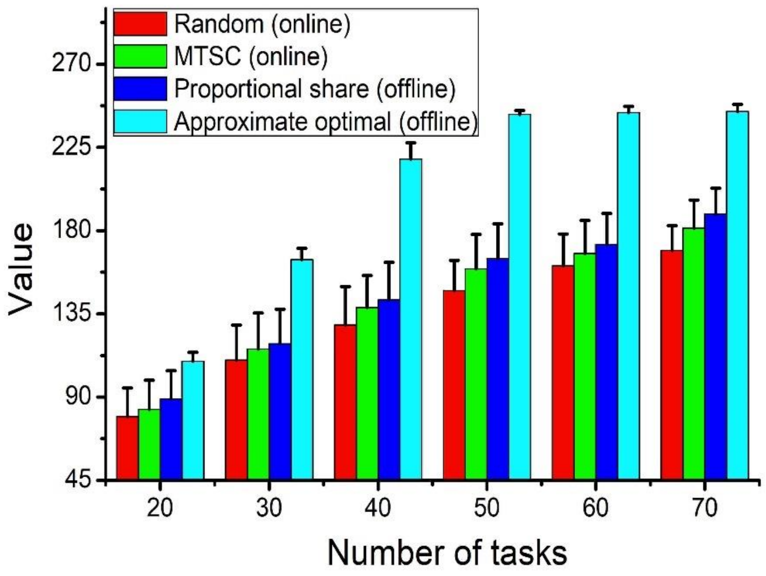
Approximate optimal (offline)[S. Khullera,1999]:
untruthful, with full knowledge, $(1 - 1/e)$ approximation

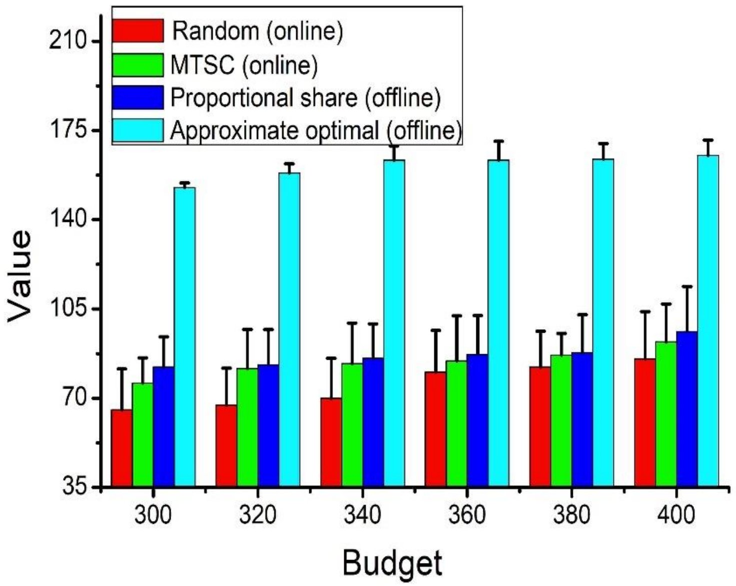
Proportional share (offline)[Y. Singer,2010]:
truthful, using the proportional share rule

Random (online):
truthful, selecting the agents randomly

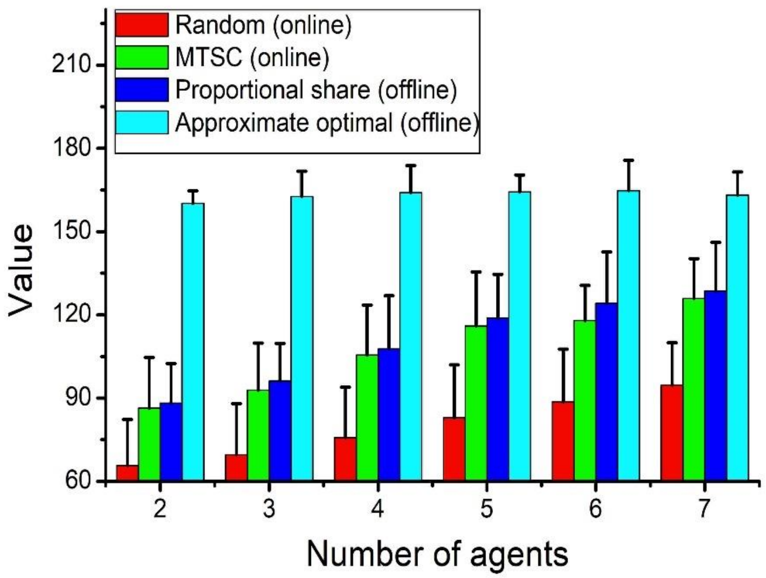
Dataset: social circle data from Facebook

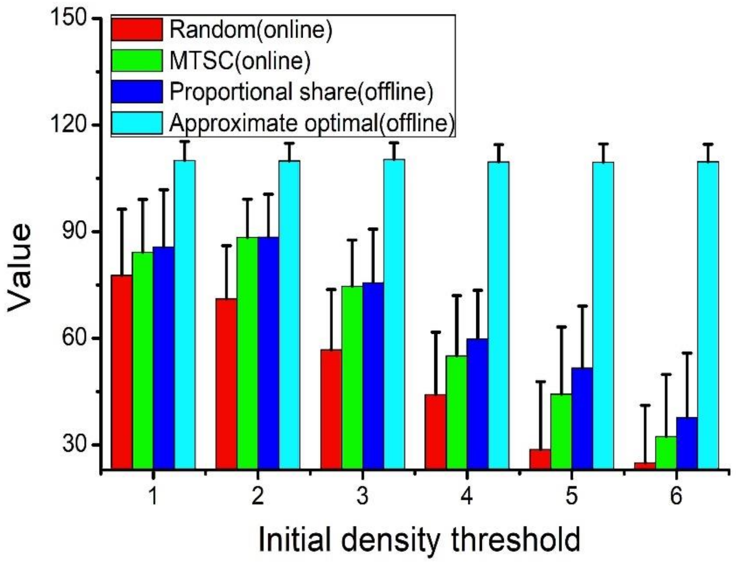
A. Value





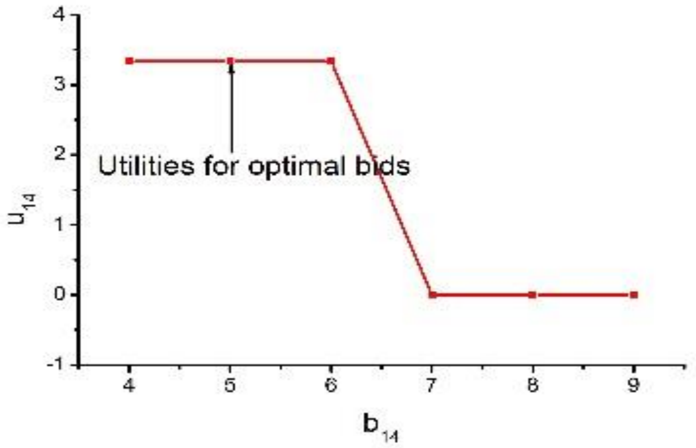
The MSTC always achieves better performance than random mechanism.



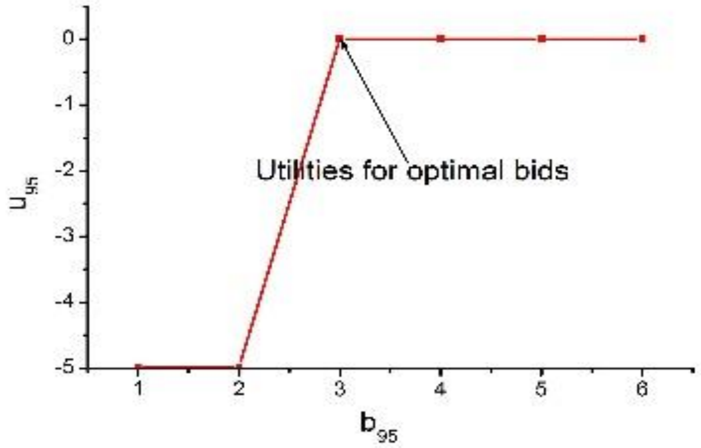


The gap between MSTC and Proportional Share (the best in truthful offline mechanisms) is very small.

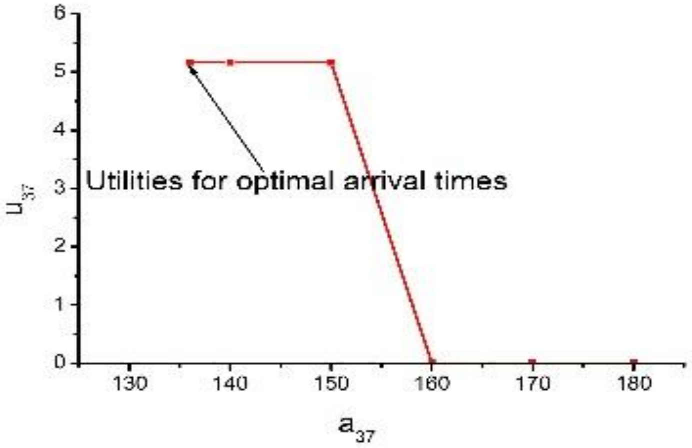
B. Truthfulness



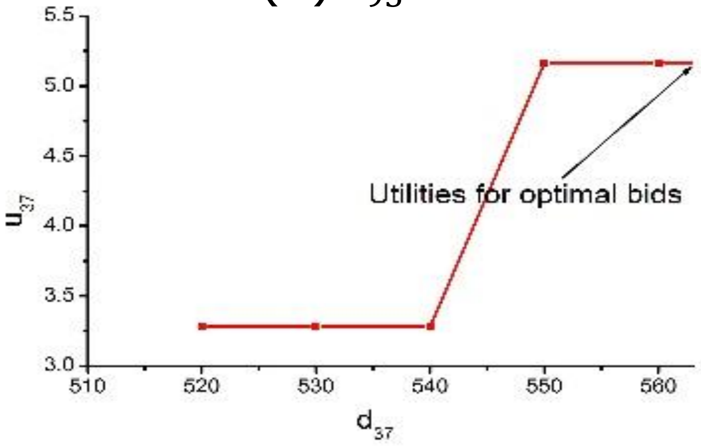
(a) $c_{14} = 5$



(b) $c_{95} = 3$



(c) $ra_{37} = 136$



(d) $rd_{37} = 563$

The users cannot improve their payoff by submit false cost, arrival time or departure time.

Conclusion

We present a two-tiered social crowdsourcing architecture to solve the insufficient participation problem using the social network in online scenario.

We propose the *Agent Selection* algorithm based on the historical information to optimize the online duration coverage and the unit influence simultaneously.

We design the *Online Reverse Auction* for selecting the social neighbors and calculating payments. We show that the designed auction satisfies the desirable properties of computational efficiency, individual rationality, budget feasibility, and truthfulness.

Thank You!

Q & A

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