

CrowdManager

Combinatorial Allocation and Pricing of Crowdsourcing Tasks with Time Constraints

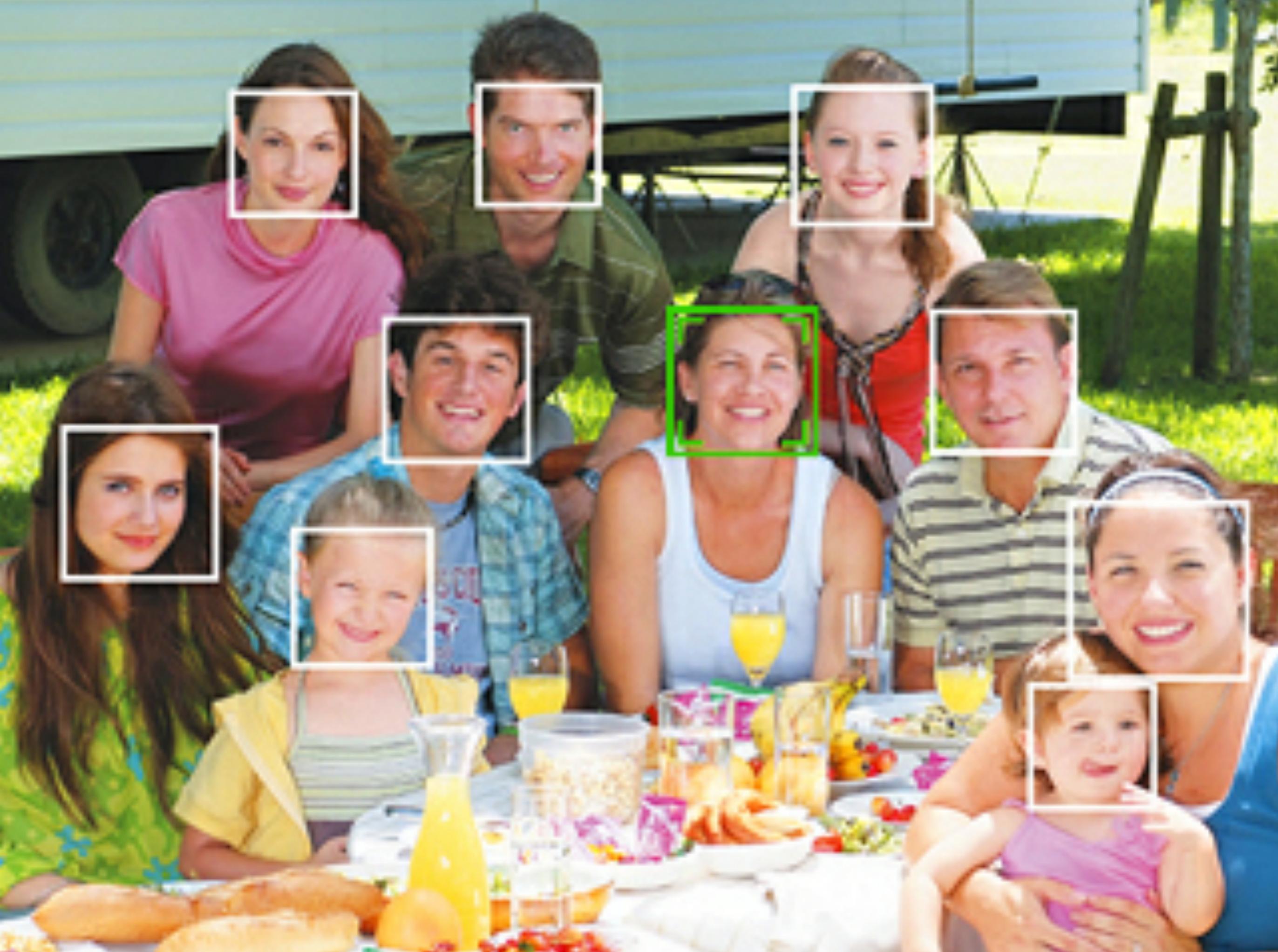
Patrick Minder, Sven Seuken, Abraham Bernstein, Mengia Zollinger



**Dynamic and Distributed
Information Systems**



**University of
Zurich^{UZH}**





“Guess” the price per task

Post the task on Mechanical Turk

Wait

Crowdsourcing under Time-Constraints

Applications

- **Text Shortening** (e.g., Bernstein et al. 2010)
- **Real-Time On-line Services** (e.g., Bigham et al. 2010)
- **Text Translation** (e.g., Minder & Bernstein 2012)
- **Fraud-Detection**

Crowdsourcing under Time-Constraints

Challenges



Crowd Latency vs. Time-Constraints



Quality Management



Dynamic Pricing

Related Work

- **Retainer Model [Bernstein et al. 2011]**
 - Pre-recruit workers
 - Price per task is fixed ex-ante
- **On-line Pricing Mechanism [Singer 2011]**
 - Maximize number of solved tasks under budget
 - Mechanism-design inspired approach
 - No other constraints considered

Contributions

- CrowdManager's framework architecture
- A mechanism for the combinatorial allocation and pricing of crowdsourcing tasks under budget, completion time, and quality constraints
- Initial evaluation incorporating a simulation

- 1 Formal Model**
- 2 Platform
- 3 Mechanism
- 4 Evaluation
- 5 Discussion

Formal Model - Requestor

- Single requestor with work package W containing a set of m similar tasks
- Requestor has a budget (B), completion time (T), and quality (Q) constraints
- Requestor has a quasi-linear utility $U = B - C$ if all m task get solved within T and under Q , and $U = -C$ otherwise

Formal Model - Worker

- Each worker has private costs $c > 0$ for solving a task
- A worker wants to solve at most $j > 0$ tasks
- We rate a worker's qualification level $q \in [0, 1]$
- A estimate a workers completion time $t > 0$ for solving a task

Limitations

- **Assumptions:**
 - Workers can't fake completion time and quality
 - No worker leaves the Retainer
- **Beyond the scope of this paper**
 - Recruitment process
 - Moral hazard
 - Evaluation of quality

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Time-Constrained Text Translation

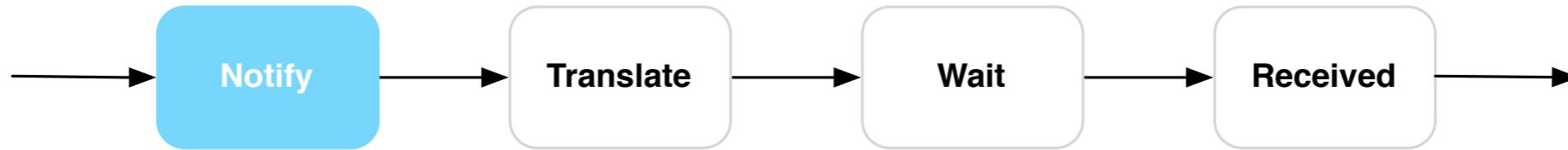
- Translate 10 pages from German to English
- Within the next 20 minutes
- In good quality
- As cheap as possible, but for at most 10\$



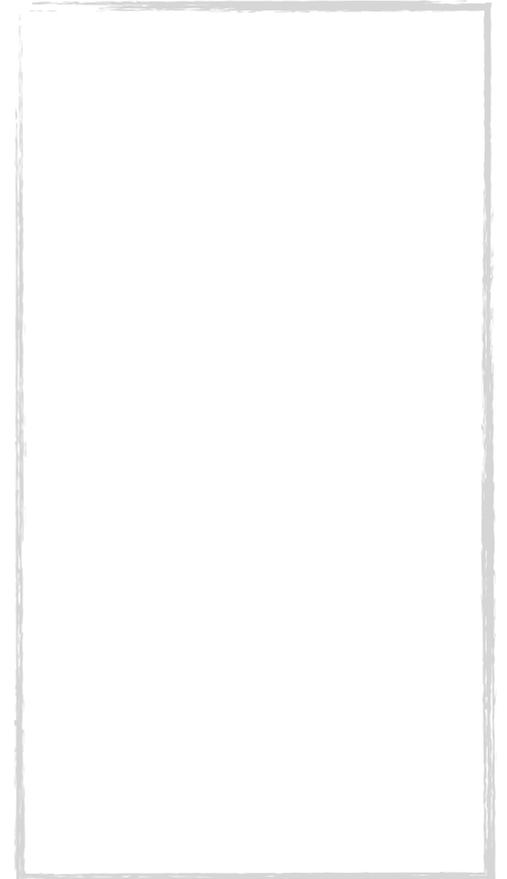
Time-Constrained Text-Translation

Walkthrough

Requestor



CrowdManager



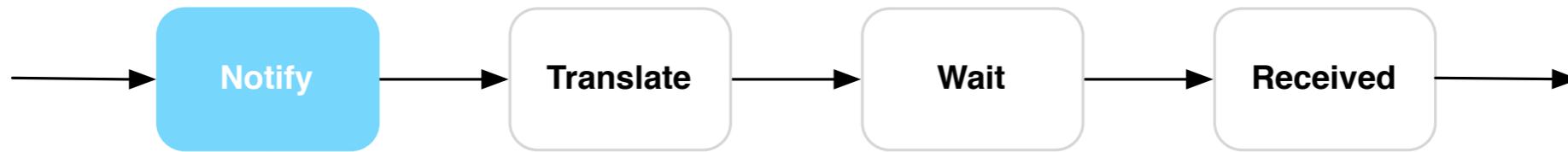
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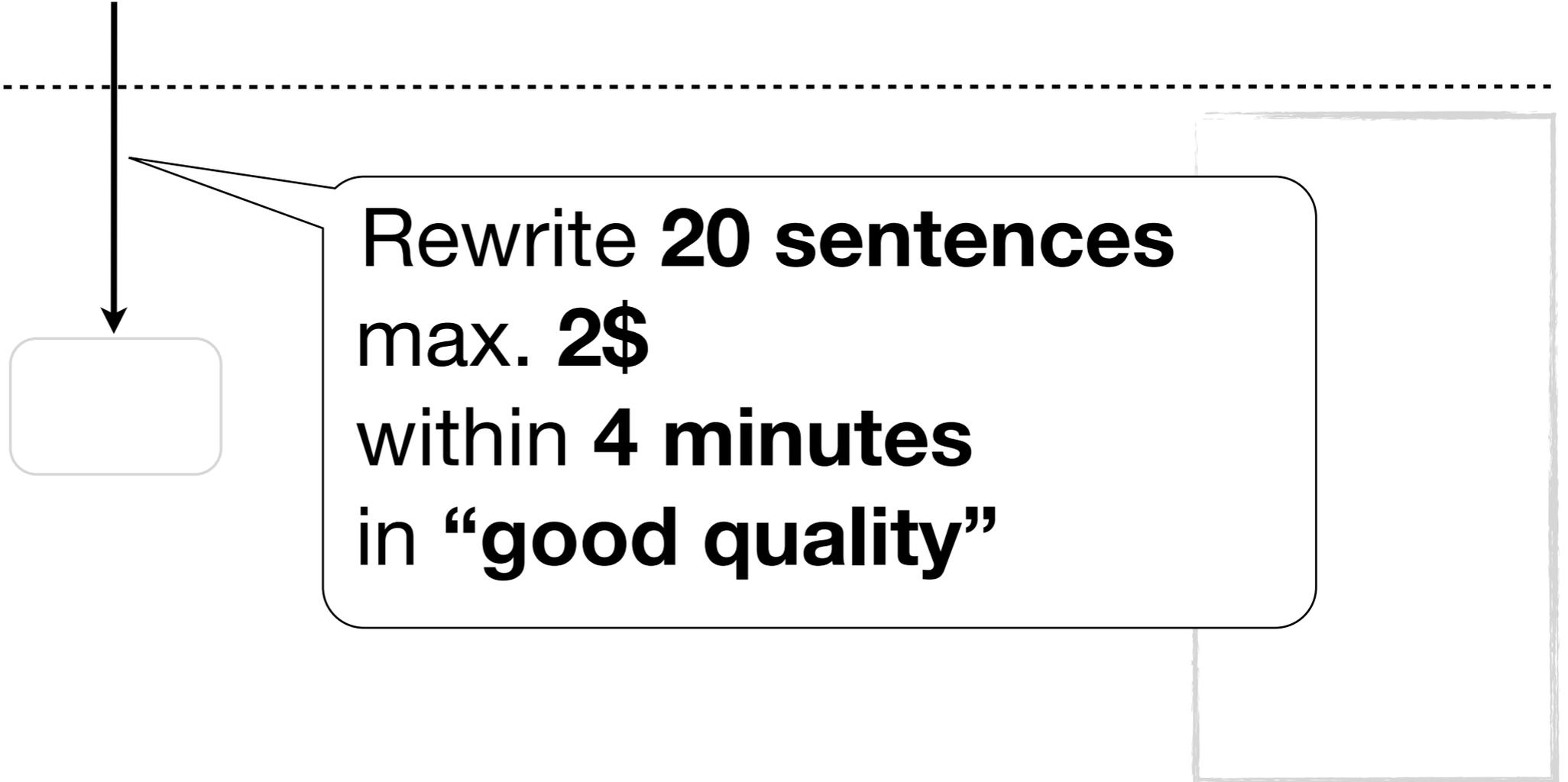
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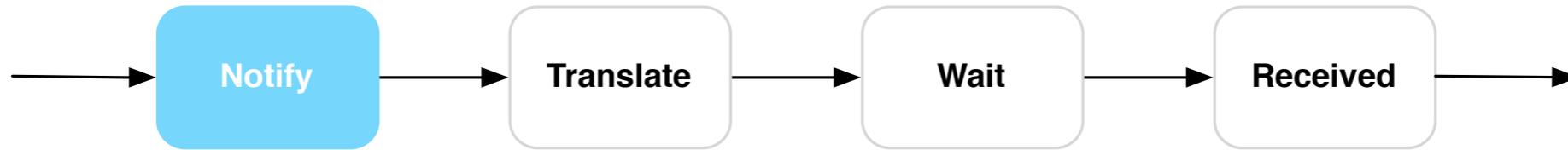
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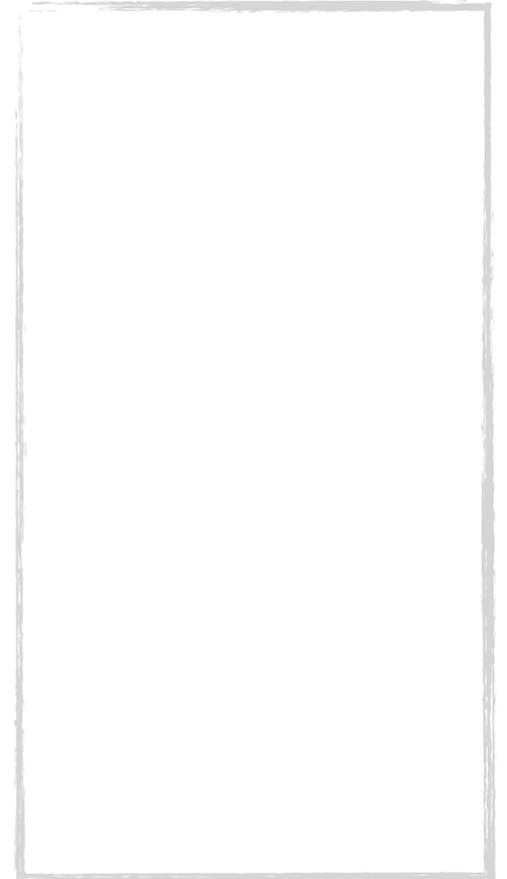
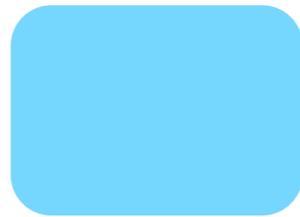
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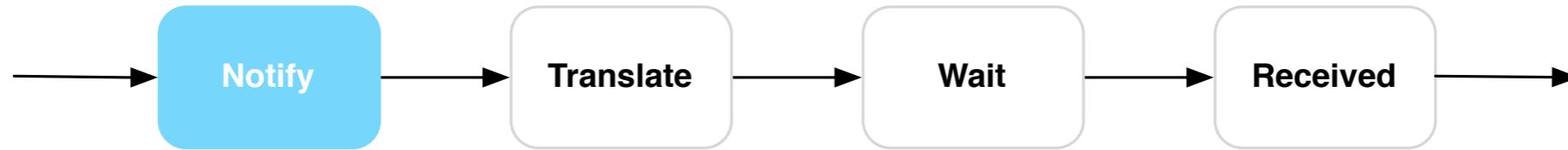
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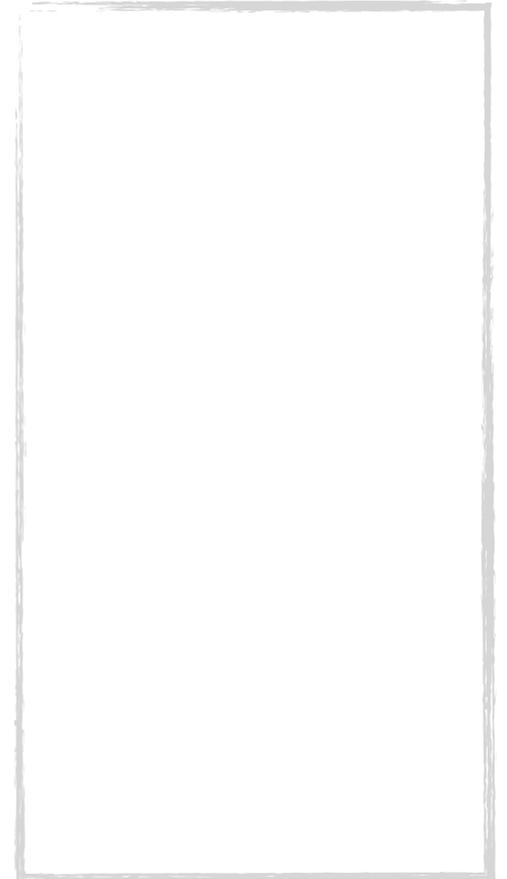
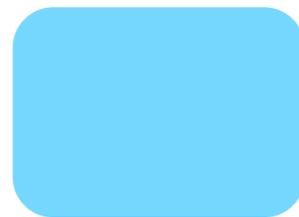
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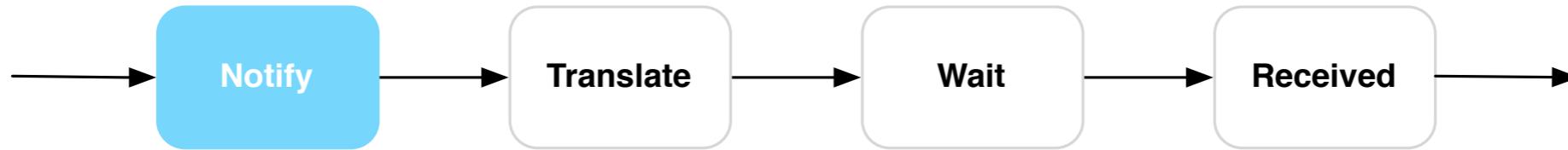
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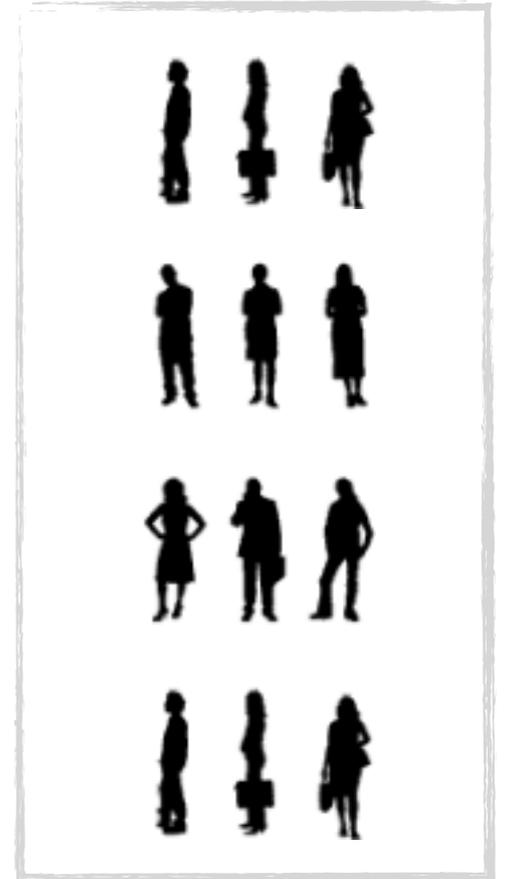
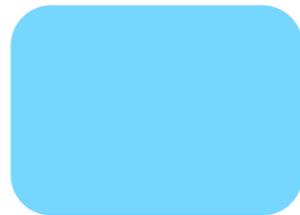
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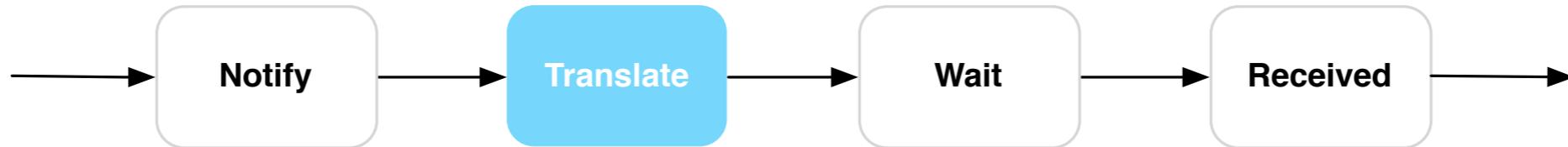
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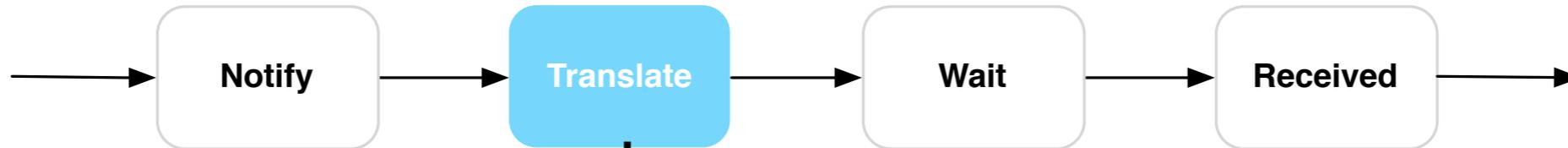
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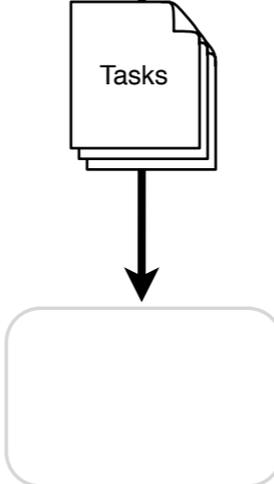
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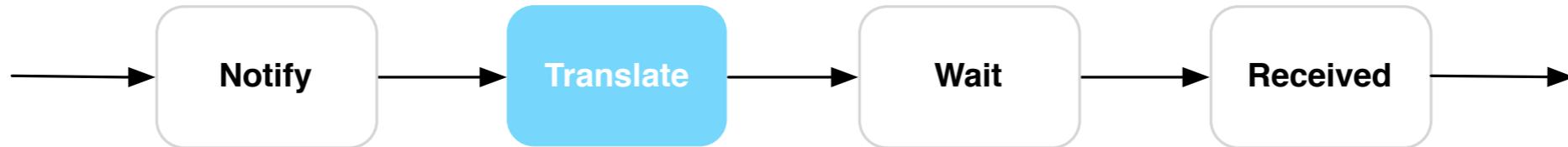
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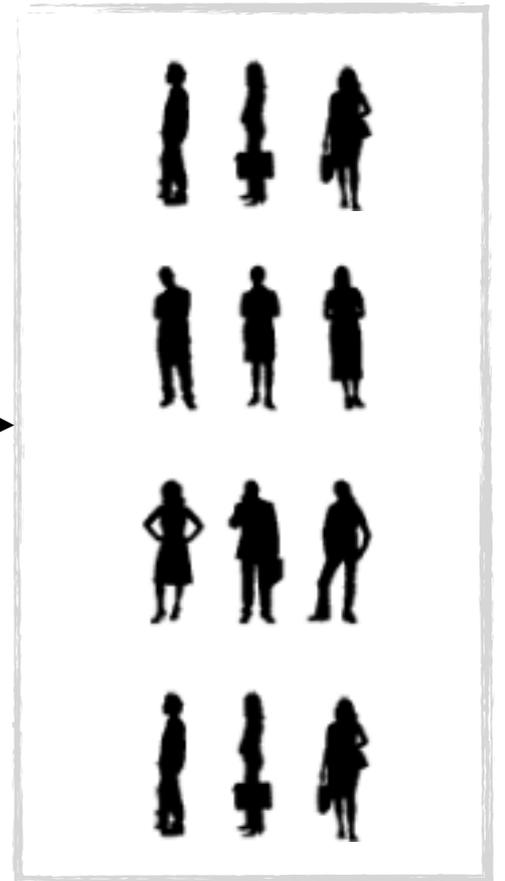
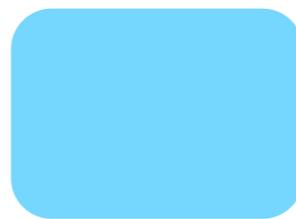
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CrowdManager



Crowd



CrowdManager's Bidding Interface

We have 25 translation tasks to complete. Please solve the following sample task. We will use your answer to determine whether you can participate in this translation exercise. Afterwards, please specify how many of such translation tasks you would like to solve, and which minimum wage per task you would accept.

Example Task

Please improve the following sentence by correcting grammatical errors and making the sentence more comprehensible.

"Wikipedia is a Founded in January 2001 free online encyclopedia in many languages."

Answer:

Wikipedia is a free online encyclopedia that is available in many languages and was founded in January 2001. ✎

How many of those tasks do you want to solve?



What is the minimum wage per task you would accept?



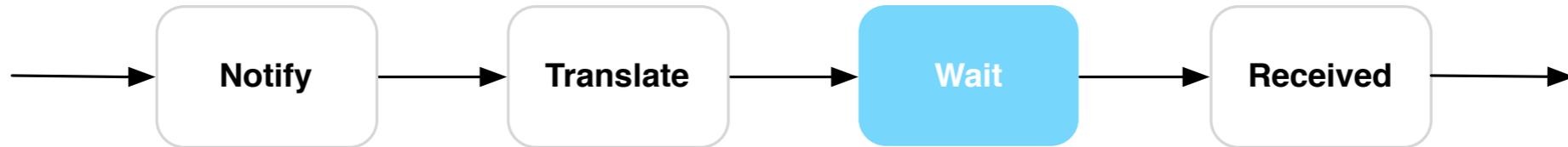
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Leave Retainer

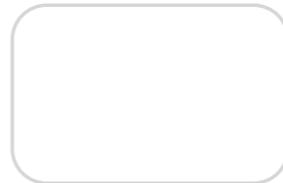
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CrowdManager



Crowd

ClickWorker

CrowdFlower

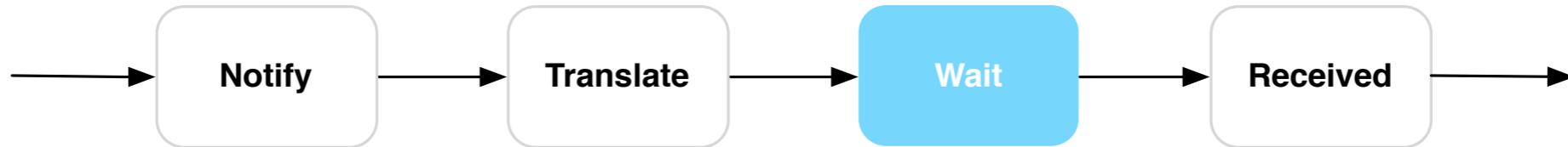
MTurk

Elance

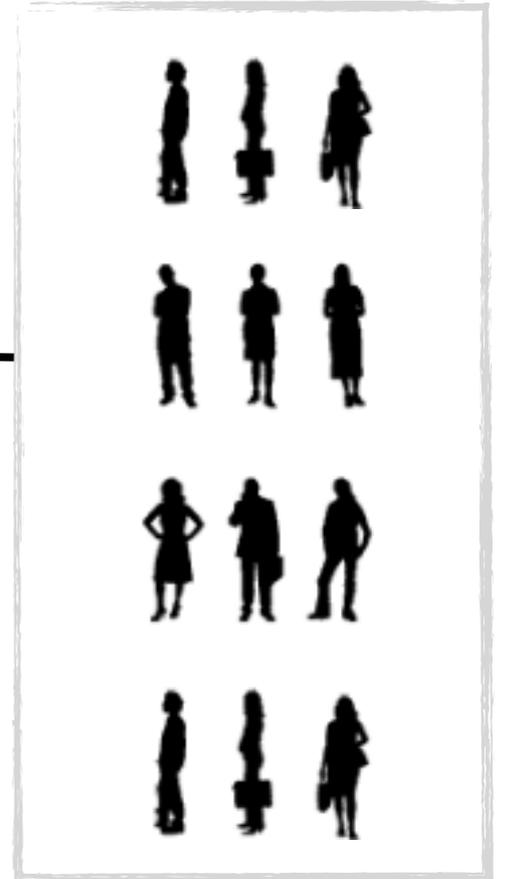
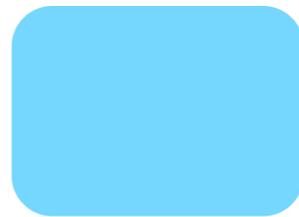
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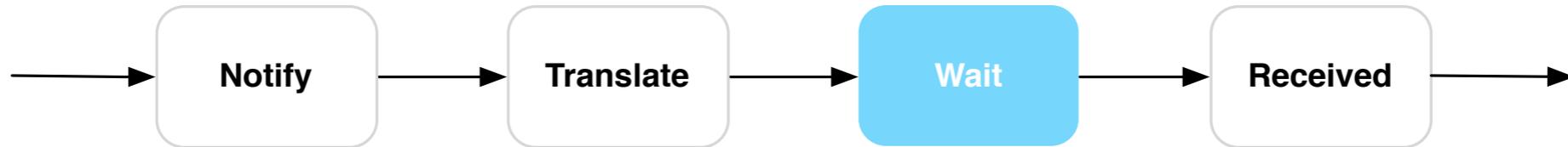
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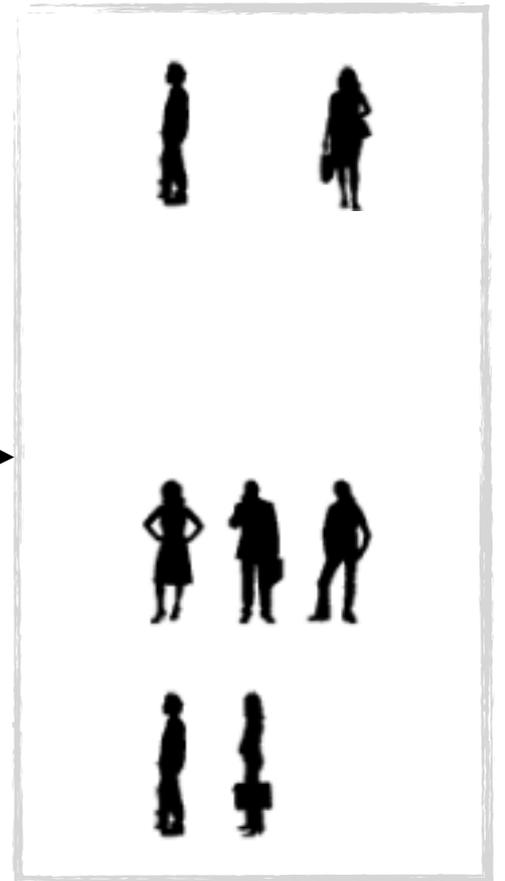
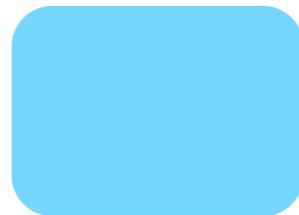
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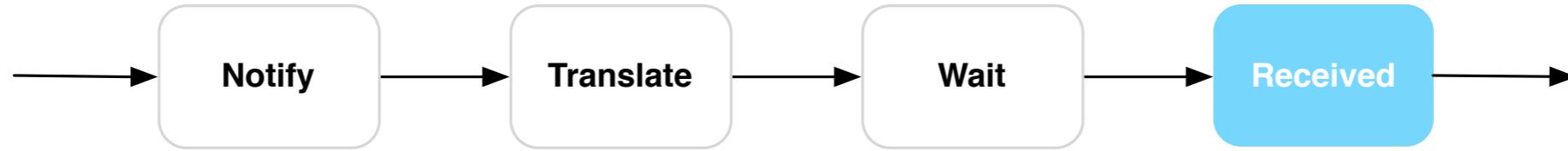
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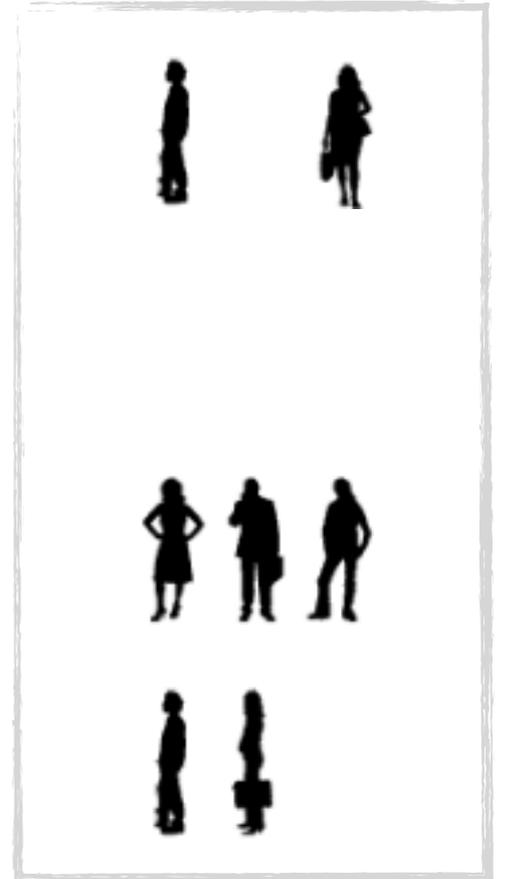
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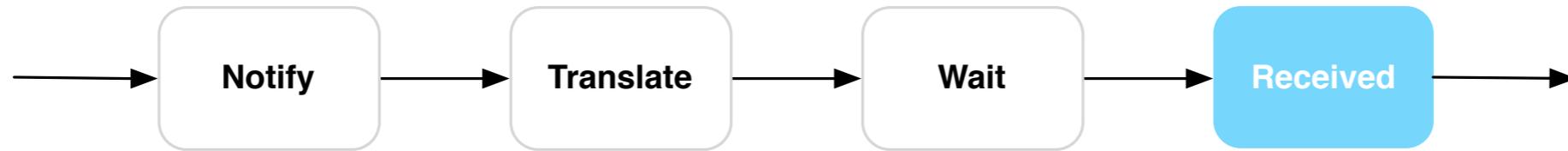
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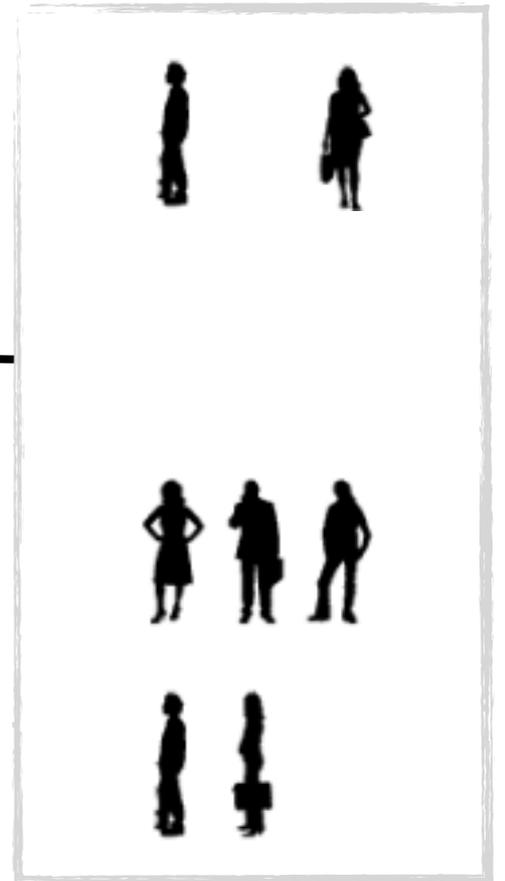
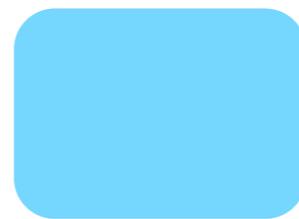
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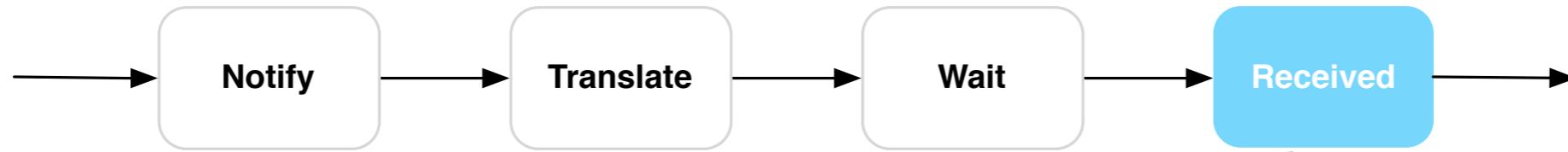
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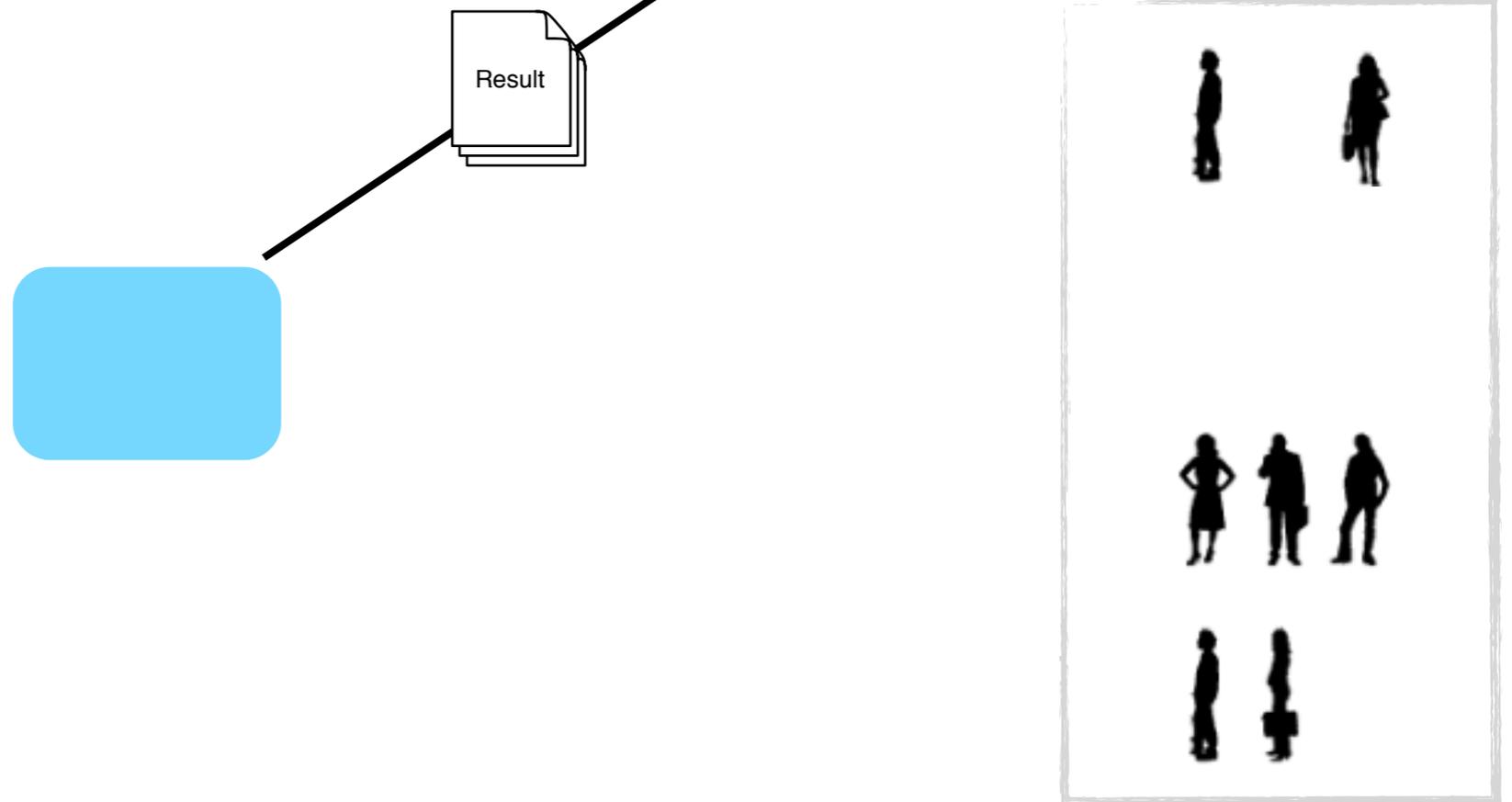
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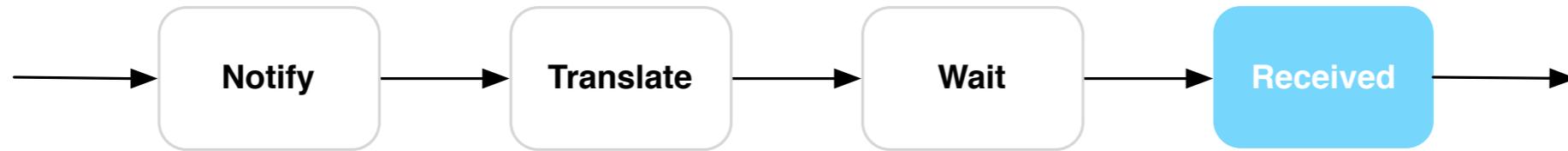
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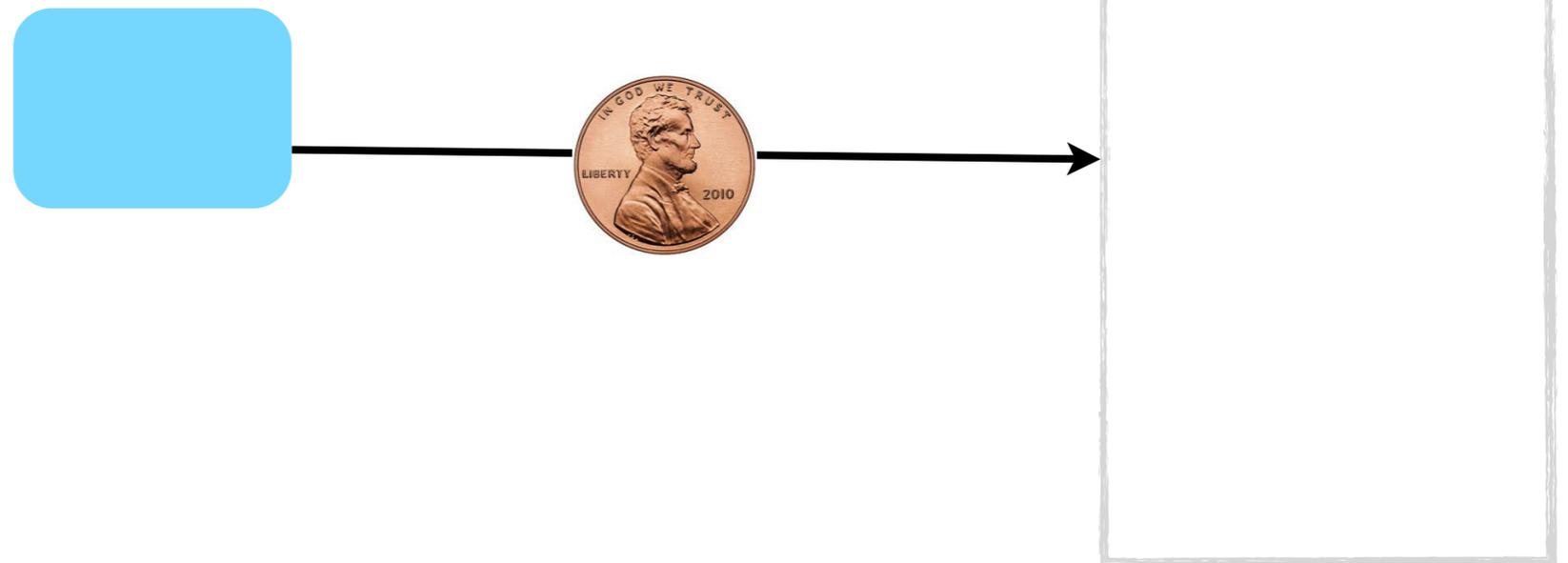
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Crowd



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Allocation and Pricing Mechanism

Algorithm

Require: I, W, B, T, Q

$\hat{\theta} = \text{runProcurementAuction}(I, \text{QualificationTest}, m)$

$x = \text{allocationMechanism}(\hat{\theta}, W, T, Q)$

if x is feasible **then**

$p = \text{paymentMechanism}(\hat{\theta}, x)$

else

return no completion time feasible allocation found

end if

$\text{costs} = \sum_{i \in I} p_i \cdot x_i$

if $\text{costs} \leq B$ **then**

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Allocation Mechanism

Combinatorial Optimization Problem

maximize
social welfare

$$\min_{x_1, \dots, x_n} \sum_{i=1}^n \hat{c}_i x_i$$

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All Tasks
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$$\text{s.t.} \quad \sum_{i=1}^n x_i = m$$

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$$x_i \cdot \hat{t}_i \leq T, \quad \forall i \in I$$

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Maximal number of tasks

$$x_i \leq \hat{j}_i, \quad \forall i \in I$$

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No fractional tasks

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Vickrey-Clarke-Groves-Mechanism

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Experimental Set-up

- Simulation with 10'000 distinct trials
- **Baseline 1:** First-completed first-served allocation with ex-ante defined fixed prices
- **Baseline 2:** Optimal allocation (IP) with ex-ante defined fixed prices

$$\text{Price} = \frac{\text{Budget}}{\text{Number of Tasks}}$$

Results

Sanity Check

		Mechanism				
		CMM	Baseline 1		Baseline 2	
Budget			F	NF	F	NF
100%	F		55%	16%	60%	11%
	NF		14%	15%	23%	6%

Share of feasible (**F**) and non-feasible (**NF**) allocations found by each mechanism.

$$\text{Price} = \frac{\text{Budget}}{\text{Number of Tasks}}$$

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	NF		14%	15%	23%	6%
10%	F		0%	71%	16%	55%
	NF		1%	28%	1%	28%

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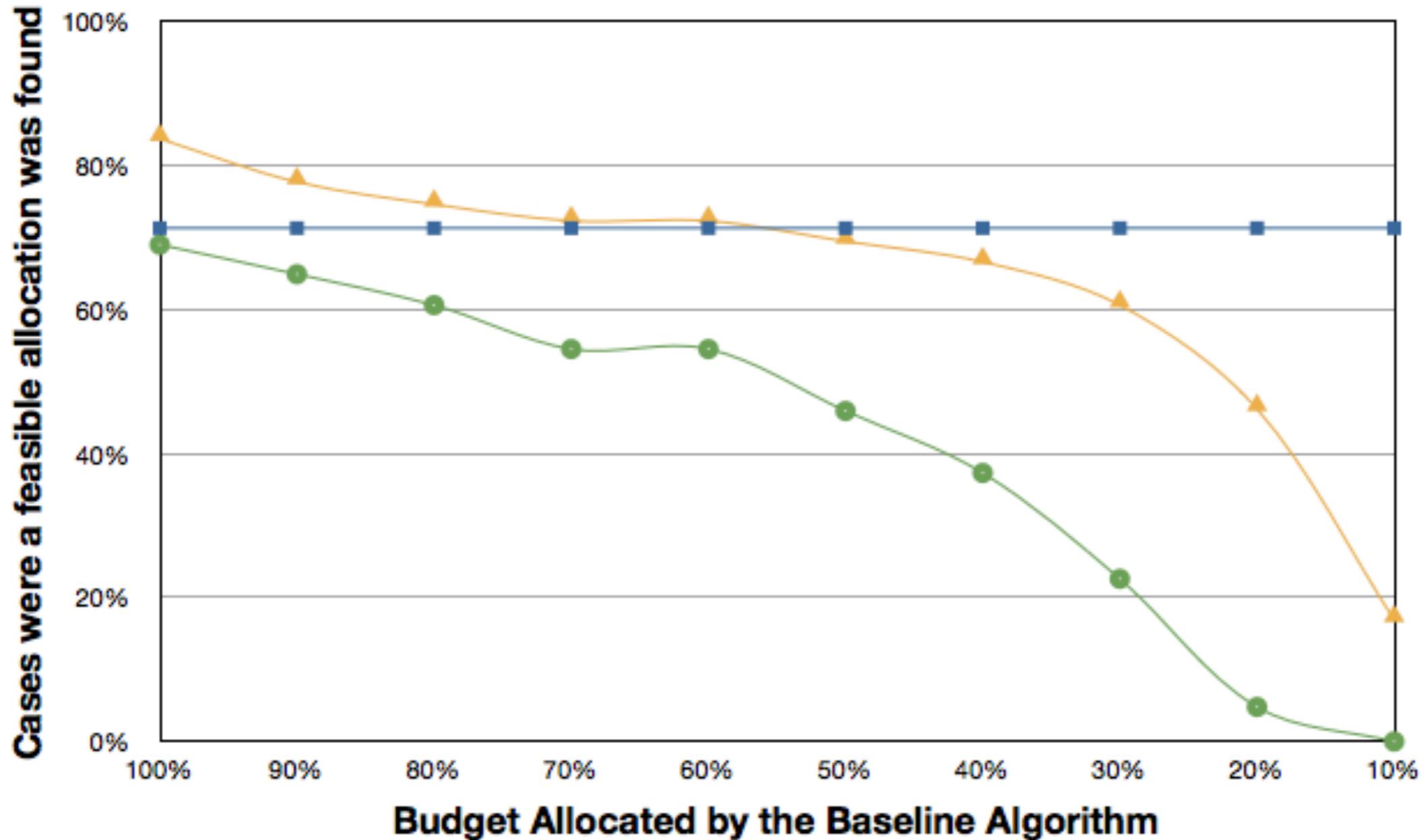
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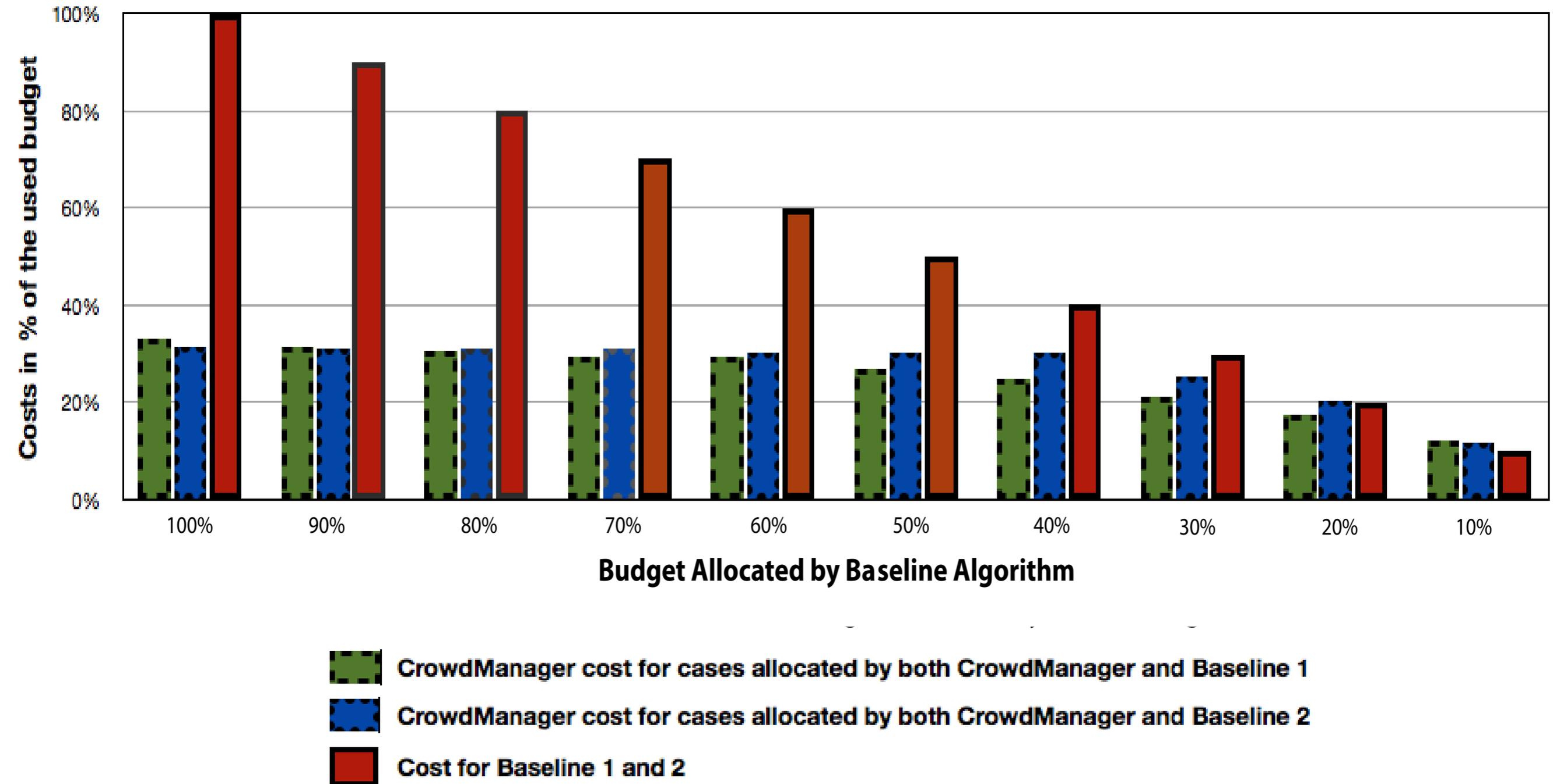
Number of Feasible Allocations



- ▣ Feasible solution found by CrowdManager
- Feasible solution found by Baseline 1
- △ Feasible solution found by Baseline 2

Results

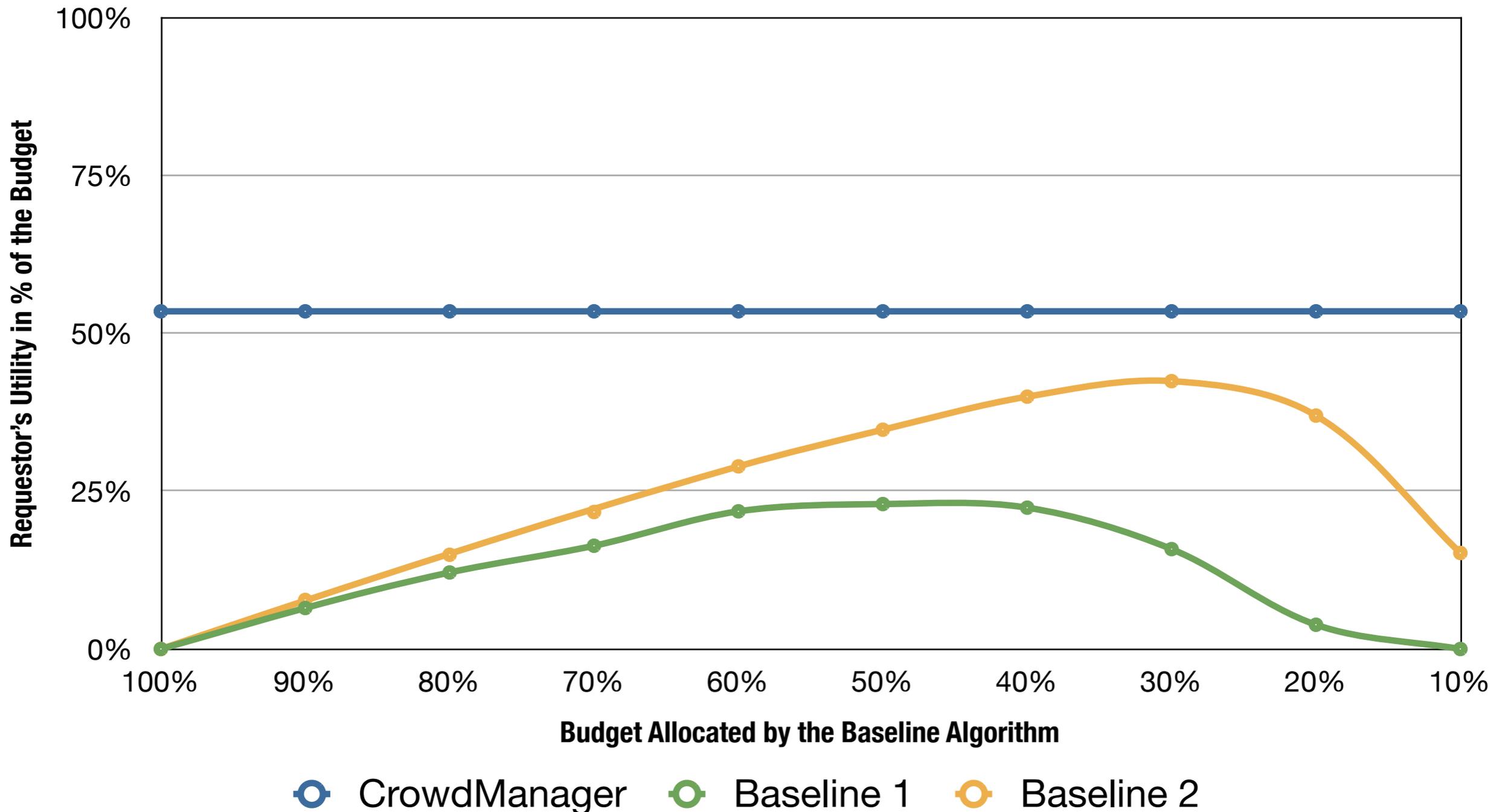
Comparison of Average Costs



Conclusion from the Simulation

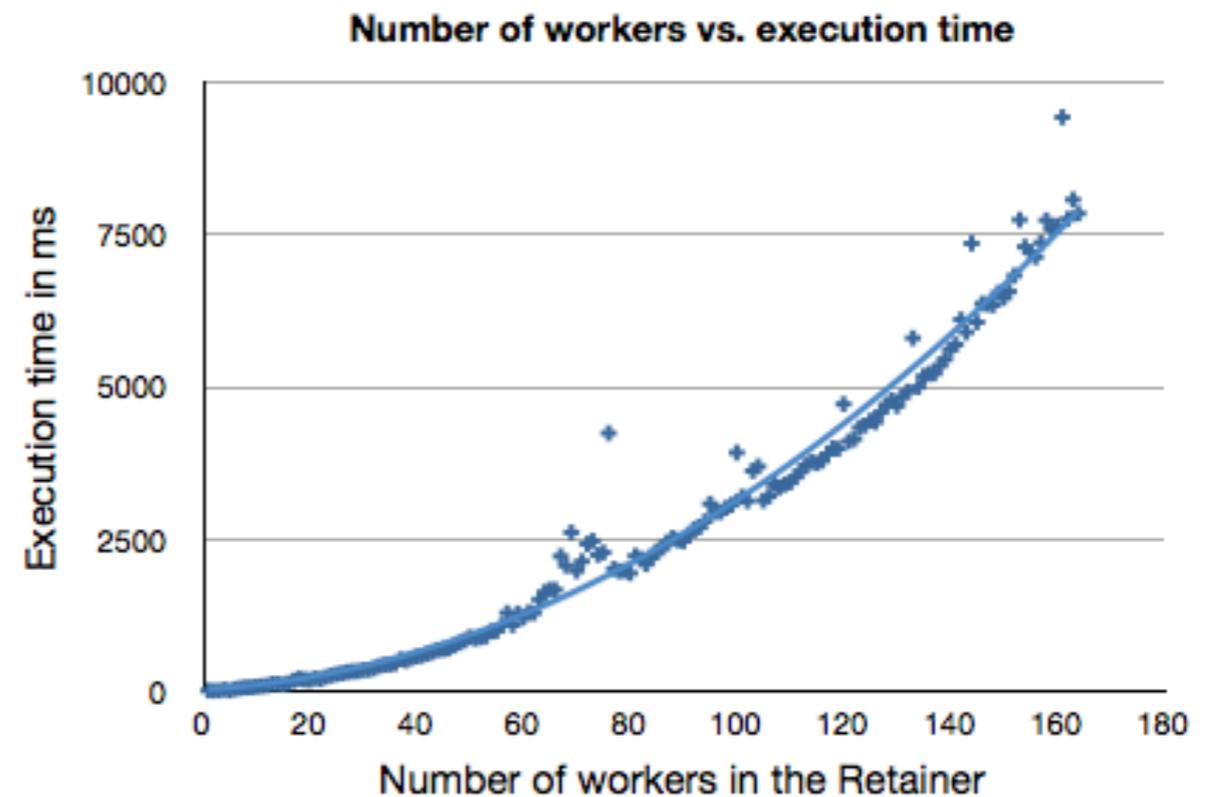
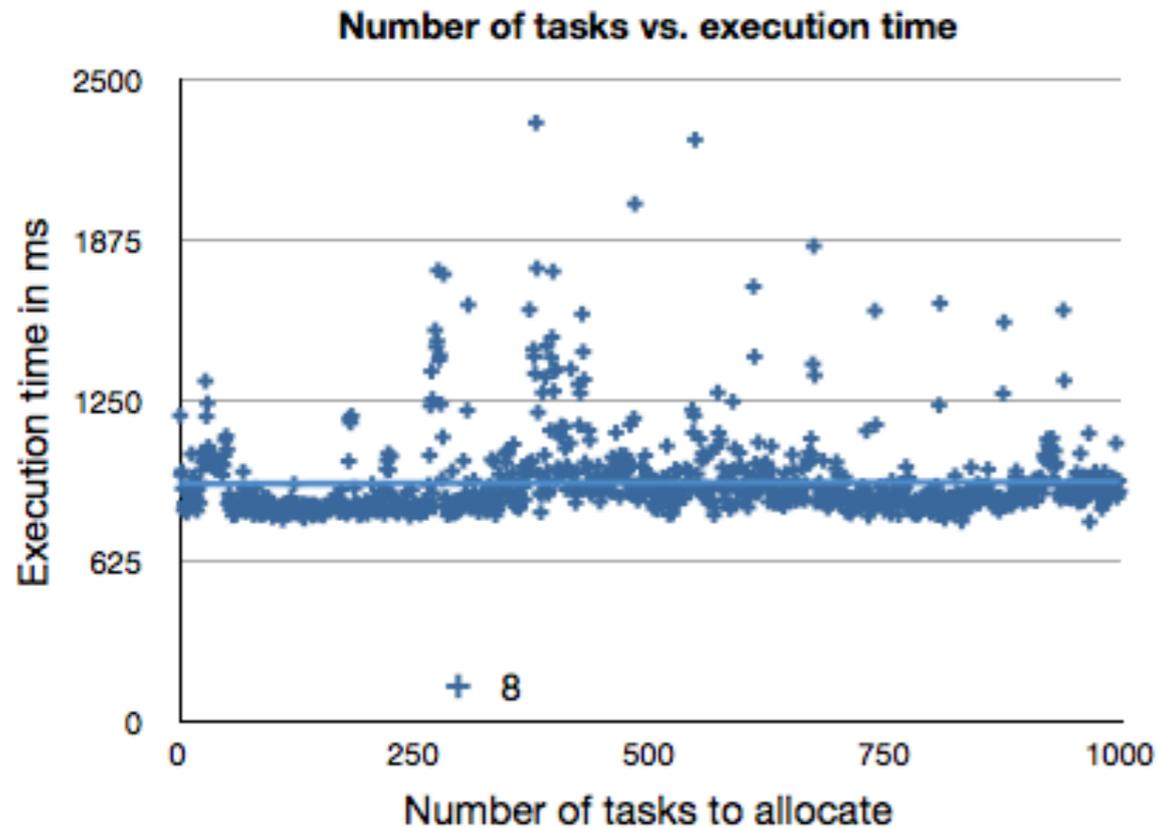
The Requestor's Average Utility

$$\text{Utility} = \text{Budget} - \text{Costs}$$



Results

Runtime Analysis



- Varying the number of tasks in to be allocated does not impact the execution time
- The execution time increases quickly as the number of workers in the retainer grows.

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VCG vs. Requestor-Optimal

- CrowdManager's mechanism leads to large cost savings in average, but does not directly minimize the requestor's cost
- Myerson-style mechanisms do not easily generalize to multiple dimensions
- Benefit of using a Myerson mechanism is likely to be negligible in practice
[Bulow & Klemperer, 1996]

Future Work

- Modeling learning effects / economies of scales vs. weariness effects
- Distributional assumptions for the variability of human performance
- Evaluation in a real-world experiment

Conclusion

- finds more feasible allocations under the requestor's budget, completion time, and quality constraints
- increases the requestor's utility
- leads to more efficient allocation
- offers a principled way for dynamic price task

No longer a need for “guessing the right price”

CrowdManager

Combinatorial Allocation and Pricing of Crowdsourcing Tasks with Time Constraints

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