

# Lecture 13

# Complex Tasks: Workflow Design

Chien-Ju (CJ) Ho

# Logistics: Assignments

- Assignment 3: Due yesterday
  - Assume you have enough late days, tomorrow is the final due
- Assignment 4: TBD

Nov 22      Buffer

Assignment 4  
(Expected Due: Nov 29)

Nov 24      **Thanksgiving (No Class)**

# Logistics: Project Milestone 2

- Milestone 2: Due Nov 4
  - Summarize your progress
    - Should make enough progress to know **whether the project is feasible**
  - Last chance to convert a research project to an extensive literature survey
- Midterm Pitch: Nov 1 (Tue), in lecture
  - Opportunity to engage other classmates
  - Every group will get some time from other groups
  - If you want to engage the entire class (for data collection, etc)
    - Let me know at least one week in advance
    - There might be time limits (e.g., 2~3 minutes)
  - Plan your progress to **utilize this discussion lecture**

# Complex Tasks: Workflow Design

# Crowdsourcing

- A lot of focuses are on *microtasks*
  - Labeling images
  - Transcribing a one-minute audio clips
  - Finding the address of a business
  - ...
- A common quality control mechanism
  - Duplicate tasks and perform aggregation
  - Design incentives

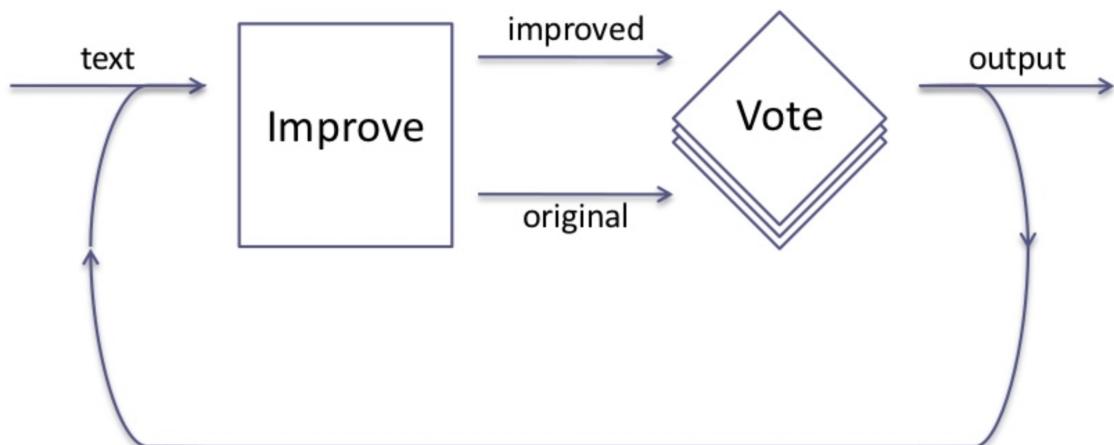
# What about Complex Tasks?

You mentioned several words. Please go back over what not. I am  
not able to check all the grammar mistakes. Overall your writing style  
is a bit too flowery. You do not have good friends,  
but they get lost amidst the writing

Jyoti

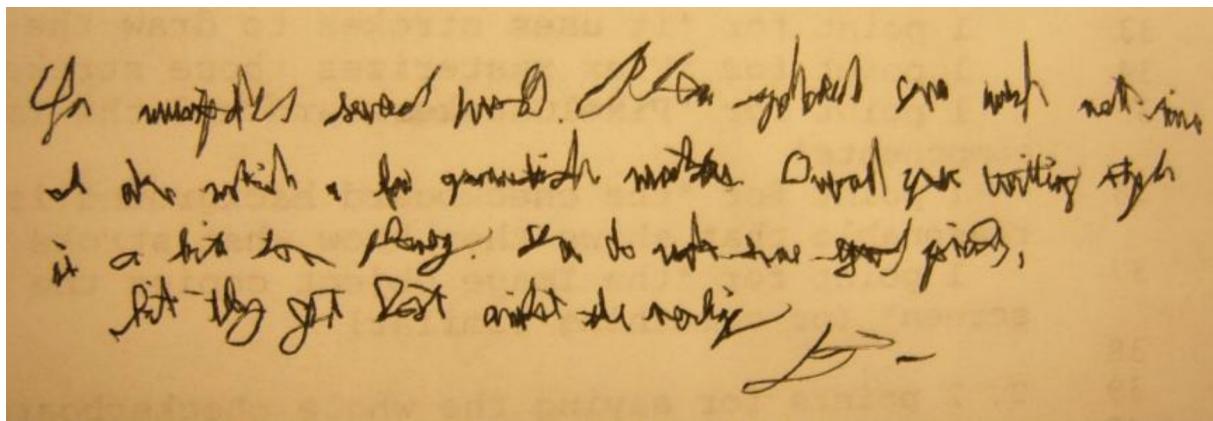
# Designing Workflows

- Dictionary definition of workflow
  - “the sequence of steps involved in moving from the beginning to the end of a working process”
- Decompose a **complex task** into a set of **microtasks**



- Some workers are asked to perform **improvement** tasks
- Some workers are asked to **vote** on whether the improvement is good

# Designing Workflows



## version 1:

You (?) (?) (?) (work). (?) (?) (?) work (not) (time). I (?) (?) a few grammatical mistakes. Overall your writing style is a bit too (phoney). You do (?) have good (points), but they got lost amidst the (writing). (signature)

## version 4:

You (misspelled) (several) (words). (?) (?) (?) work next (time). I also notice a few grammatical mistakes. ...

## version 5:

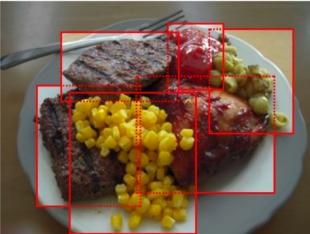
You (misspelled) (several) (words). (Plan?) (spellcheck) (your) work next time. I also notice a few grammatical mistakes. Overall your writing style is a bit too phoney. You do make some good (points), but they got lost amidst the (writing). (signature)

## version 6:

You (misspelled) (several) (words). Please spellcheck your work next time. I also notice a few grammatical mistakes. Overall your writing style is a bit too phoney. You do make some good (points), but they got lost amidst the (writing). (signature)

# Other Workflows

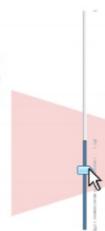
- Calculate nutrition values of a food photo [Noronha et al. UIST 2011]



**Tag – Identify - Measure**

- Proofreading and document editing [Bernstein et al. UIST 2010]

Automatic clustering generally helps separate different kinds of records that need to be edited differently, but it isn't perfect. Sometimes it creates more clusters than needed, because the differences in structure aren't important to the user's particular editing task. For example, if the user only needs to edit near the end of each line, then differences at the start of the line are largely irrelevant, and it isn't necessary to split based on those differences. Conversely, sometimes the clustering isn't fine enough, leaving heterogeneous clusters that must be edited one line at a time. One solution to this problem would be to let the user rearrange the clustering manually, perhaps using drag-and-drop to merge and split clusters. Clustering and selection generalization would also be improved by recognizing common text structure like URLs, filenames, email addresses, dates, times, etc.



Automatic clustering generally helps separate different kinds of records that need to be edited differently, but it isn't perfect. Sometimes it creates more clusters than needed, because the differences in structure aren't relevant to a specific task. Conversely, sometimes the clustering isn't fine enough, leaving heterogeneous clusters that must be edited one line at a time. One solution to this problem would be to let the user rearrange the clustering manually using drag-and-drop edits. Clustering and selection generalization would also be improved by recognizing common text structure like URLs, filenames, email addresses, dates, times, etc.

**Find – Fix - Verify**

- Extracting steps from how-to videos [Kim et al. CHI 2014]

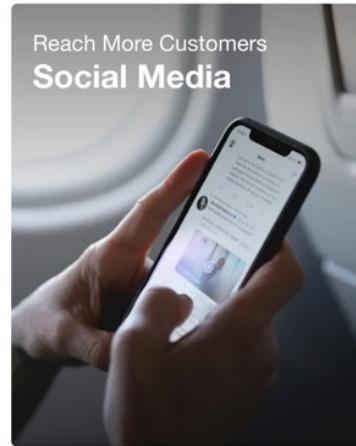
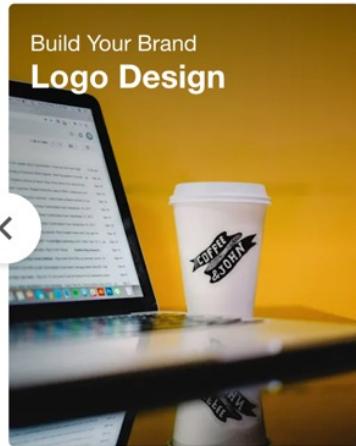


**Find – Verify – Expand**

# Another Approach [Focus of Next Lecture]

- We can recruit *experts* in doing the work
  - Traditional workplace approach
  - There exist such crowdsourcing marketplaces as well (e.g., Upwork or Fiverr)

## Popular Professional Services



# Designing Workflows

- Treating humans as computation units
- Question:
  - Can we incorporate humans in the computational framework?
  - Can we implement human computation as function calls?

```
ideas = []
for (var i = 0; i < 5; i++) {
  idea = mturk.prompt(
    "What's fun to see in New York City?
      Ideas so far: " + ideas.join(", "))
  ideas.push(idea)
}

ideas.sort(function (a, b) {
  v = mturk.vote("Which is better?", [a, b])
  return v == a ? -1 : 1
})
```

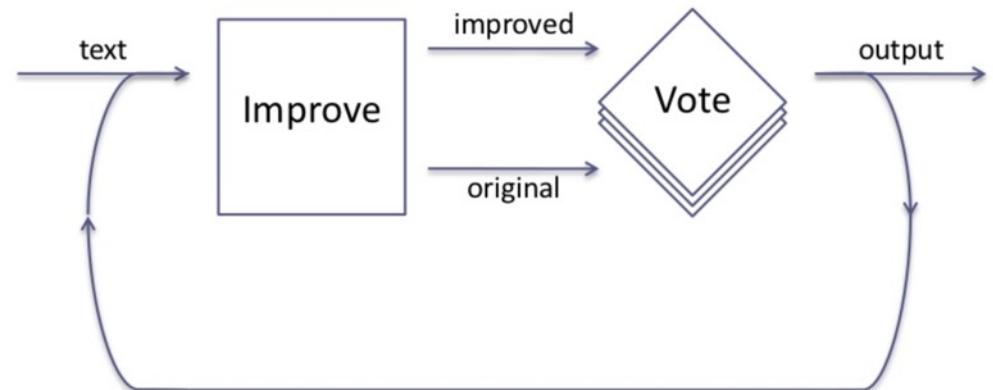
- We are simultaneously collecting data from humans to train AI/ML.
- May gradually replace human computation function calls with automatic process when AI/ML catches up.

# TurKit: Human Computation Algorithms

Little et al. UIST 2010

# Example: Iterative Writing

- Task: Have workers iteratively refine the description for the image.



```
// generate a description of X
// and iterate it N times
var text = ""
for (var i = 0; i < N; i++) {
    // generate new text
    var newText = mturk.prompt(
        "Please write/improve this paragraph
        describing " + X + ": " + text)

    // decide whether to keep it
    if (vote("Which describes " + X + " better?",
        [text, newText]) == newText) {
        text = newText
    }
}
```

# Example: Iterative Writing

- Task: Have workers iteratively refine the description for the image.



**Iteration 1:** Lightening strike in a blue sky near a tree and a building.

**Iteration 2:** The image depicts a strike of fork lightening, striking a blue sky over a silhouetted building and trees. (4/5 votes)

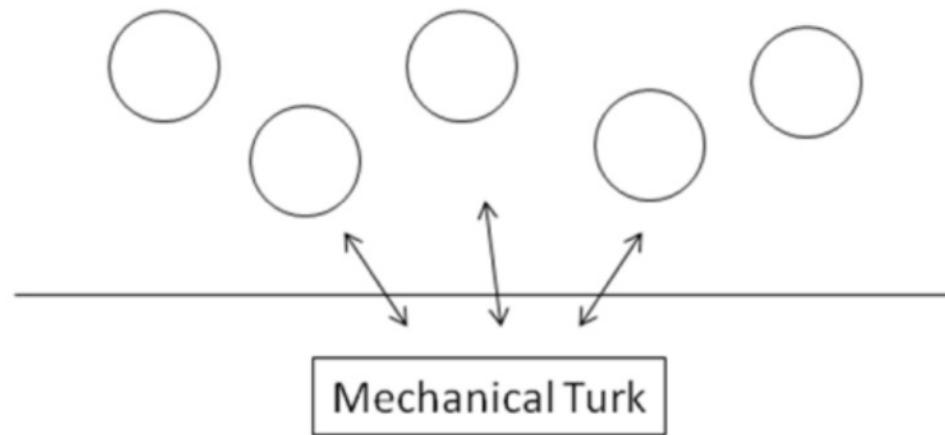
**Iteration 3:** The image depicts a strike of fork lightning, against a blue sky with a few white clouds over a silhouetted building and trees. (5/5 votes)

**Iteration 4:** ~~The image depicts a strike of fork lightning, against a blue sky wonderful capture of the nature.~~ (1/5 votes)

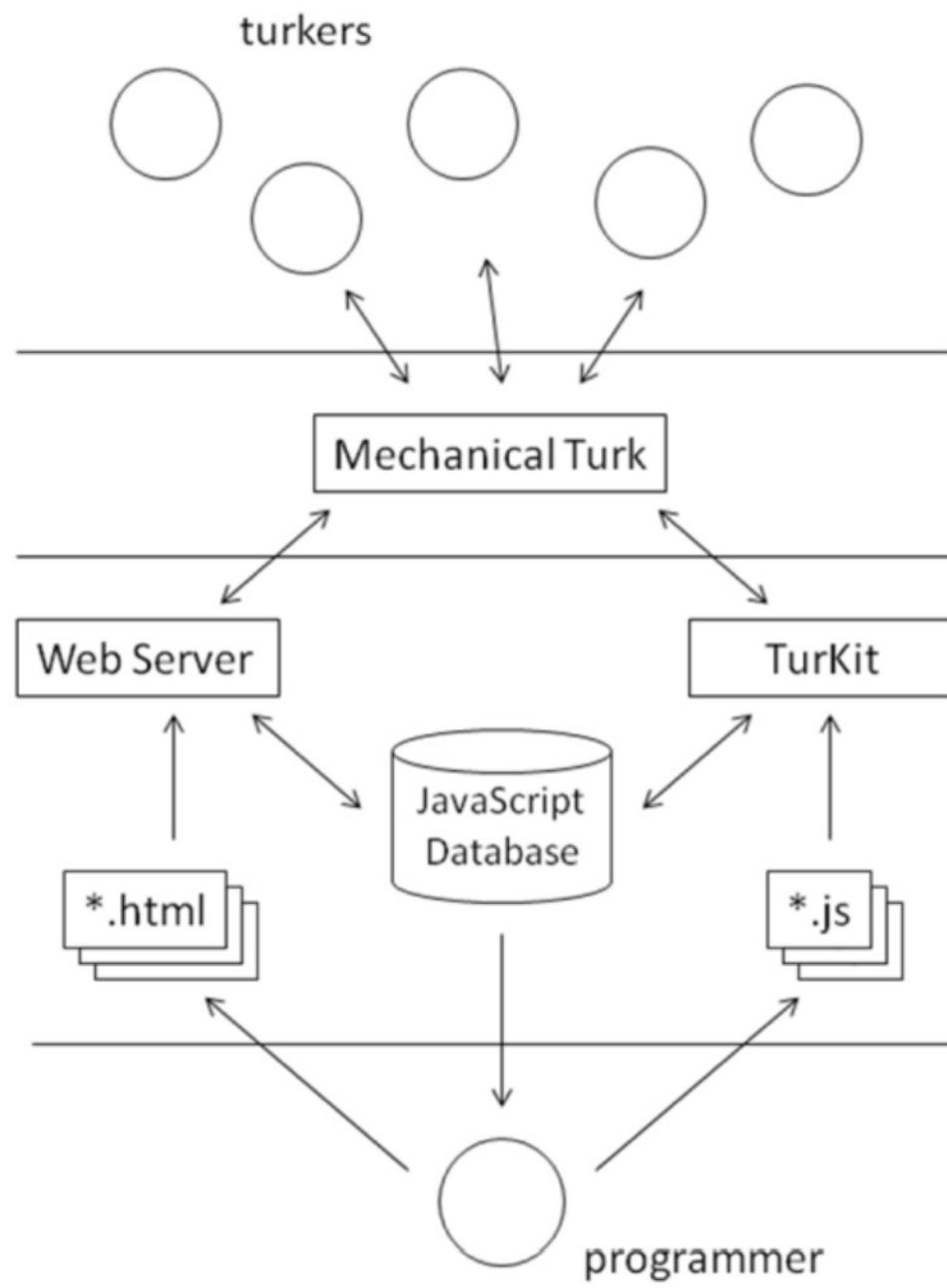
**Iteration 5:** This image shows a large white strike of lightning coming down from a blue sky with the tops of the trees and rooftop peaking from the bottom. (3/5 votes)

**Iteration 6:** This image shows a large white strike of lightning coming down from a blue sky with the silhouettes of tops of the trees and rooftop peeking from the bottom. The sky is a dark blue and the lightening is a contrasting bright white. The lightening has many arms of electricity coming off of it. (4/5 votes)

turkers



programmer



# Human Computation Algorithms

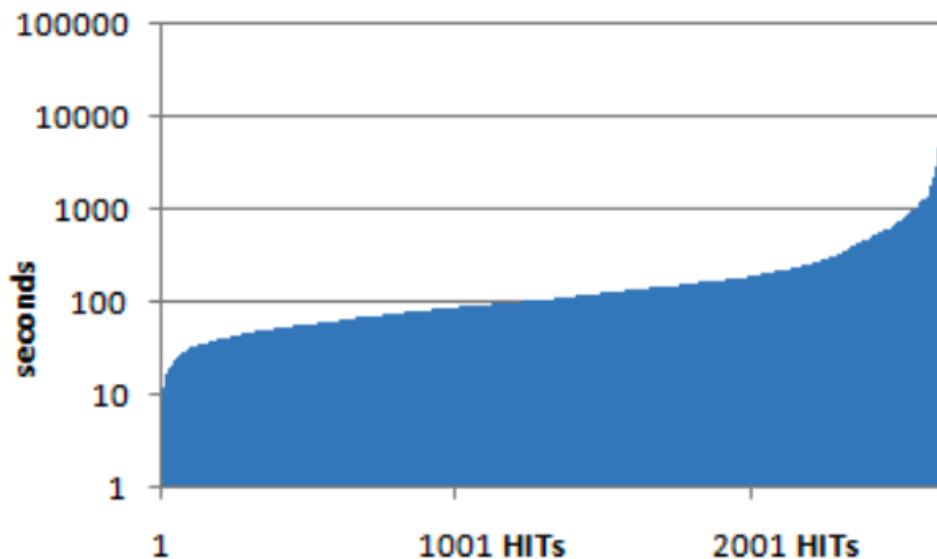
- Key Properties:
  - Human computation **costs more** than machine computation
  - Web applications are generally prone to **errors**
- Goal: Design a robust algorithmic framework for human computation algorithms

# Crash-and-Rerun Programming

- Intuitions:
  - Store the results of human computation function calls to database (DB).
  - If error happens, **crash** the program and **rerun** from the start
    - For costly operations, obtain results from the DB instead of running it
- Implementation: introduce keyword *once*
  - Remove non-determinism
  - Store costly operations
- Provide functionalities
  - prompt, vote, sort
  - fork, join
  - work with MTurk APIs

# Performance Evaluation

- The paper demonstrates the results for a couple of applications.
- They also measure the time for completion for 1-cent HITs.



Can we reduce the latency?

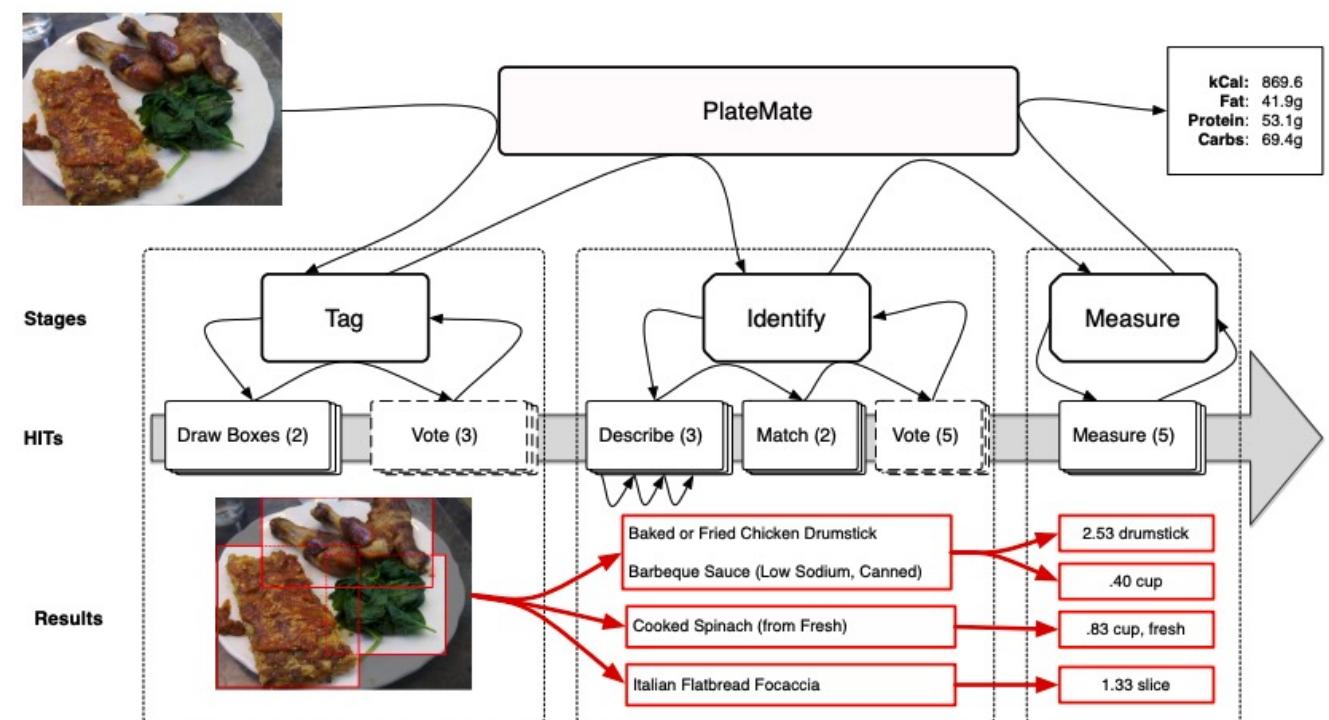
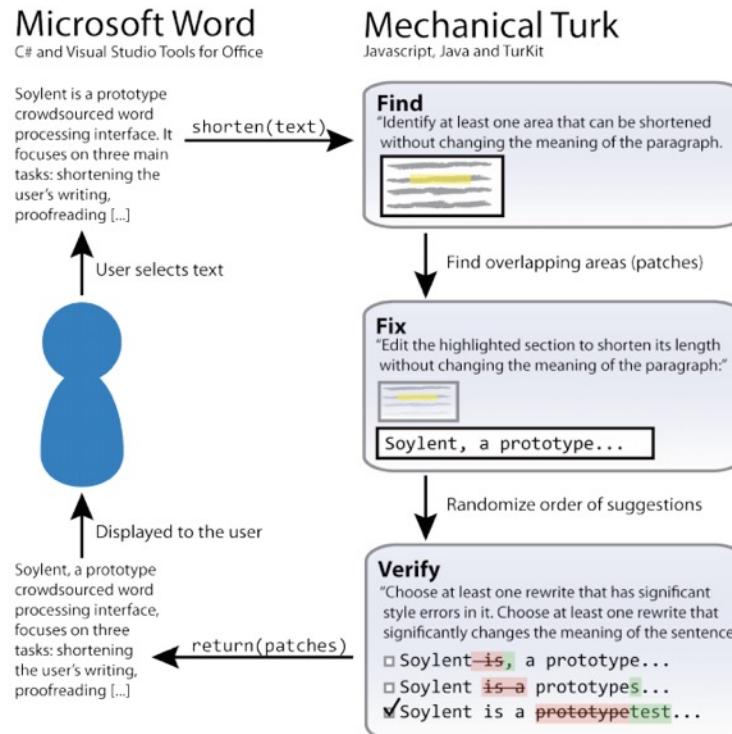
Real-time crowdsourcing

# Other Frameworks

- AutoMan
  - <https://emeryberger.com/research/automan/>
  - Developed by the team at UMass Amherst
  - Provide support for quality and budget control
- TurkServer
  - <https://github.com/TurkServer>
  - Support multi-worker collaborations

# We can write workflows with TurKit, however...

- Workflow design is domain specific and requires a great amount of effort



# The Ultimate Goal

How many calories does the food in the photo contain?

CROWDSOURCE IT!

Can we utilize the crowd to design workflows...

Can we utilize AI to help design workflows...

# Discussion

- What's your general thoughts on TurKit? What additional functionalities do you hope they also provide?
- We usually use **time** and **space** complexity to characterize how good an algorithm. Imagine you are now trying to develop a similar theory for human computation algorithms, what do you think are the key factors that should be considered?
- How can we utilize the crowd to design workflows?
  - Assume we require each worker can only do **microtasks** worth less than 20 cents

# Turkomatic: A workflow for designing workflows

Kulkarni, Can, and Hartmann. CSCW 2012.

# Example Task

Create a new blog about Mechanical Turk with two posts.

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**mtworker**

*Just another WordPress.com site*



Home About

**How much should I pay for my HIT?**

Posted on April 30, 2011

You may be inclined to price your HITs at the lowest possible rate, but this isn't always the best choice. Instead, you should base your pricing on:

- How long will the HIT take?
- Is the HIT similar to other HITs? If so, price it slightly less than theirs.
- If the HIT involves a lot of qualifications, you may want to price it higher, to attract more qualified workers.

In general, higher priced HITs are great for attracting more skilled workers! You can use this in conjunction with worker qualifications, which I'll talk about next.

Posted in Uncategorized | leave a comment

Recent Posts

- How much should I pay for my HIT?
- Hello
- Hello world!

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# Price-Divide-Solve

- A divide-and-conquer workflow
- Price: Can this task be solved for 20 cents
- If yes: Solve the task and return the answer
- If no: Divide the task into multiple steps
  - For each step, start from the price step
  - Merge steps into solutions

# Price-Divide-Solve

- A divide-and-conquer workflow
- **Price**: Can this task be solved for 20 cents
- If yes: **Solve** the task and return the answer
- If no: **Divide** the task into multiple steps
  - For each step, start from the price step
  - Merge steps into solutions

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

Price

Can we solve it for  
20 cents?

No.

Can this task be solved for 20 cents?

Write a blog about Mechanical Turk

Yes  
 No

Submit

Timer: 00:00:00 of 30 minutes

Want to work on this HIT?

Accept HIT

Total Earned: \$79.60  
Total HITs Submitted: 707

Estimate a fair price for this HIT! Fast and easy!

Requester: Berkeley Turks

Reward: \$0.10 per HIT

HITs Available: 1

Duration: 30 minutes

Qualifications Required: HIT approval rate (%) is not less than 90, Location is US

## Can the task below be solved for under twenty cents?

**Instructions:** We are dividing a large task among several workers on Mechanical Turk. This is an experiment to see how complicated tasks can be shared between multiple workers on Mechanical Turk.

**Your question:** Is twenty cents a fair price to pay on Mechanical Turk for someone to do the following task?

Create a new blog about Mechanical Turk, with at least two posts.

Yes

No

Don't know

Answer carefully! You will be paid only if your answer matches the answers given by other Turkers.

Optional: click [here](#) to email us feedback about this HIT.

Want to work on this HIT?

Accept HIT

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

**Divide**

Divide it into two  
or more steps.

Break down the following task.

Write a blog about Mechanical Turk

Step 1:

Step 2:

Add Step

Submit

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

**Divide**

Divide it into two  
or more steps.

Create a new blog on  
Wordpress.com.

Write one entry for  
a blog.

Write a second entry  
for a blog.

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

## Price

Create a new blog on  
Wordpress.com.

Write one entry for  
a blog.

Write a second entry  
for a blog.

Can we solve it for  
20 cents?

Yes.

Can we solve it for  
20 cents?

Yes.

Can we solve it for  
20 cents?

Yes.

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

Solve

Create a new  
Wordpress.co

Can we solve  
20 cent

Yes

Solve the following task.

Create a new blank blog on Wordpress

Submit

and entry

ive it for  
ts?

Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

Solve

Create a new blog on Wordpress.com.

Write one entry for a blog.

Write a second entry for a blog.



"Welcome to my blog about Mechanical Turk! Here, I'll be posting some of my favorite recipes for Mechanical Turk. You'll be able to follow along at home and create delicious HITs. From the comfort of your own home! Stay tuned and i'll show you some of the best strategies for keeping your Turk workers engaged."

"You may be inclined to price your HITs at the lowest possible rate, but this isn't always the best choice. Instead, you should base your pricing on:

- How long will the HIT take?
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Create a new blog about Mechanical Turk with two posts.

CROWDSOURCE IT!

Merge

Combine the results of solved steps.

Create a new blog on

Merge the following subtasks.

Write a blog about Mechanical Turk

Workers previously divided this task into simpler steps and solved each step. Combine their work into a complete solution.

Step 1: Create a blank blog about Mechanical Turk [answer: www...]

Step 2: Write a blog post about Mechanical Turk. [answer: This post is...]

Submit

mtworker.wordpress.com



[Home](#)   [About](#)

## How much should I pay for my HIT?

Posted on [April 30, 2011](#)

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Create a new blog about Mechanical Turk with at least two posts.

[CROWDSOURCE IT!](#)

## Requester Interface

**mtworker** Just another WordPress.com site

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Posted on April 30, 2011

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Created by [BerkeleyTurks](#) | [Leave a comment](#)

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## System Output



## Algorithm

**Timer:** 00:00:00 of 30 minutes      **Want to work on this HIT?** [Accept HIT](#)

**Total Earned:** \$79.60      **Total HITs Submitted:** 707

**Estimate a fair price for this HIT!** **Fast and easy!**      **Reward:** \$0.10 per HIT      **HITs Available:** 1      **Duration:** 30 minutes  
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**Your question:** Is twenty cents a fair price to pay on Mechanical Turk for someone to do the following task?

Create a new blog about Mechanical Turk, with at least two posts.

Yes  
 No

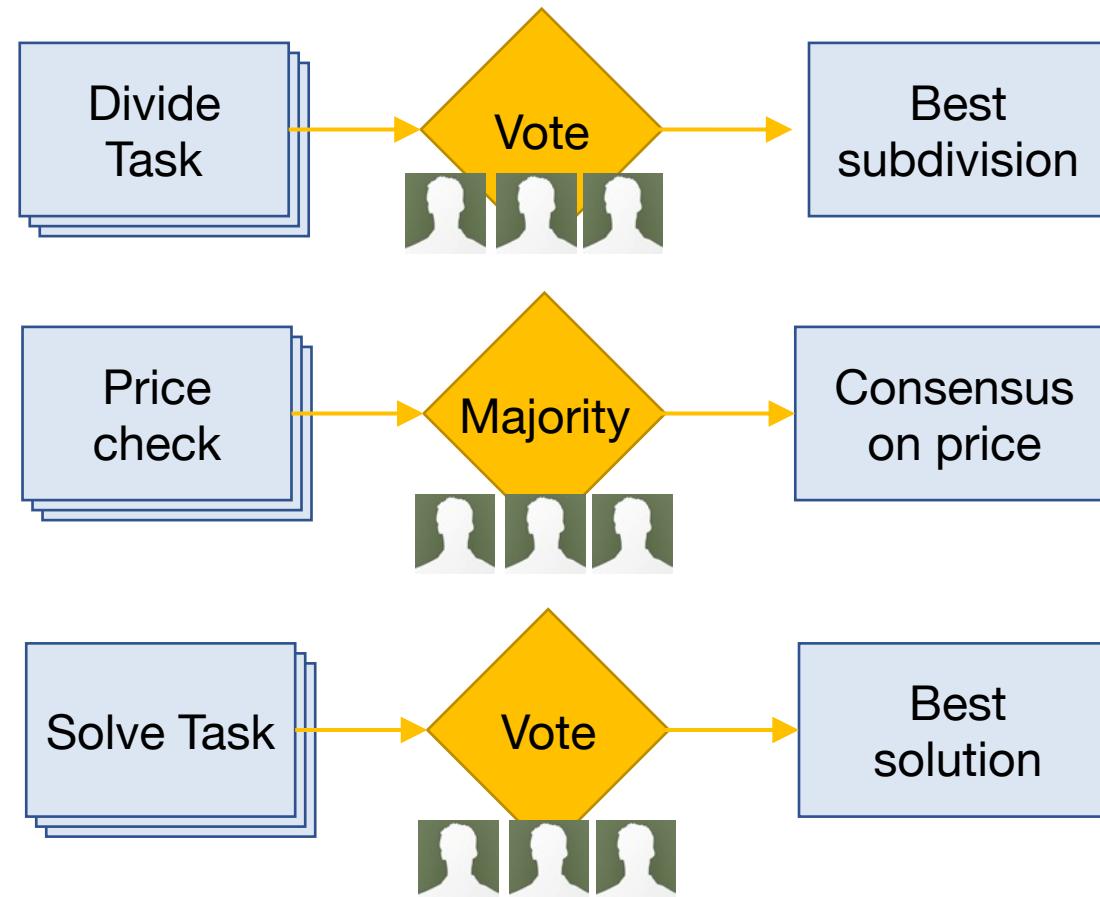
Answer carefully! You will be paid only if your answer matches the answers given by other Turkers.

Optional: click [here](#) to email us feedback about this HIT.

**Want to work on this HIT?** [Accept HIT](#)

## Worker Interface

# Using Majority Vote to Ensure Quality



# Short Discussion

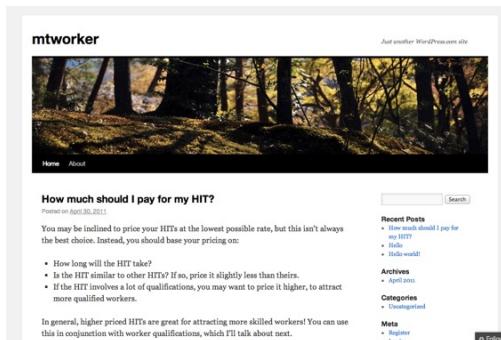
- Can you come up with scenarios/situations that this approach might fail? What are the potential fixes?



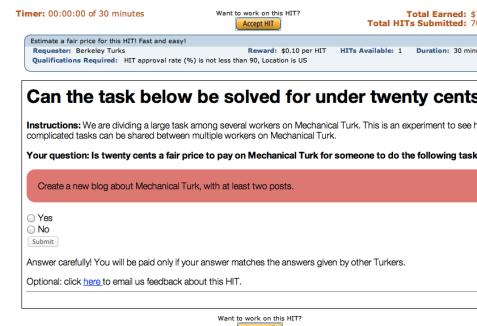
Requester Interface



Algorithm



System Output



Worker Interface

# Success Experiment

Write a 3-paragraph essay about whether it's ever OK to lie.

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Write one paragraph arguing it's OK to lie sometimes.

Write one paragraph suggesting it's never OK to lie.

Write a conclusion reconciling the two.

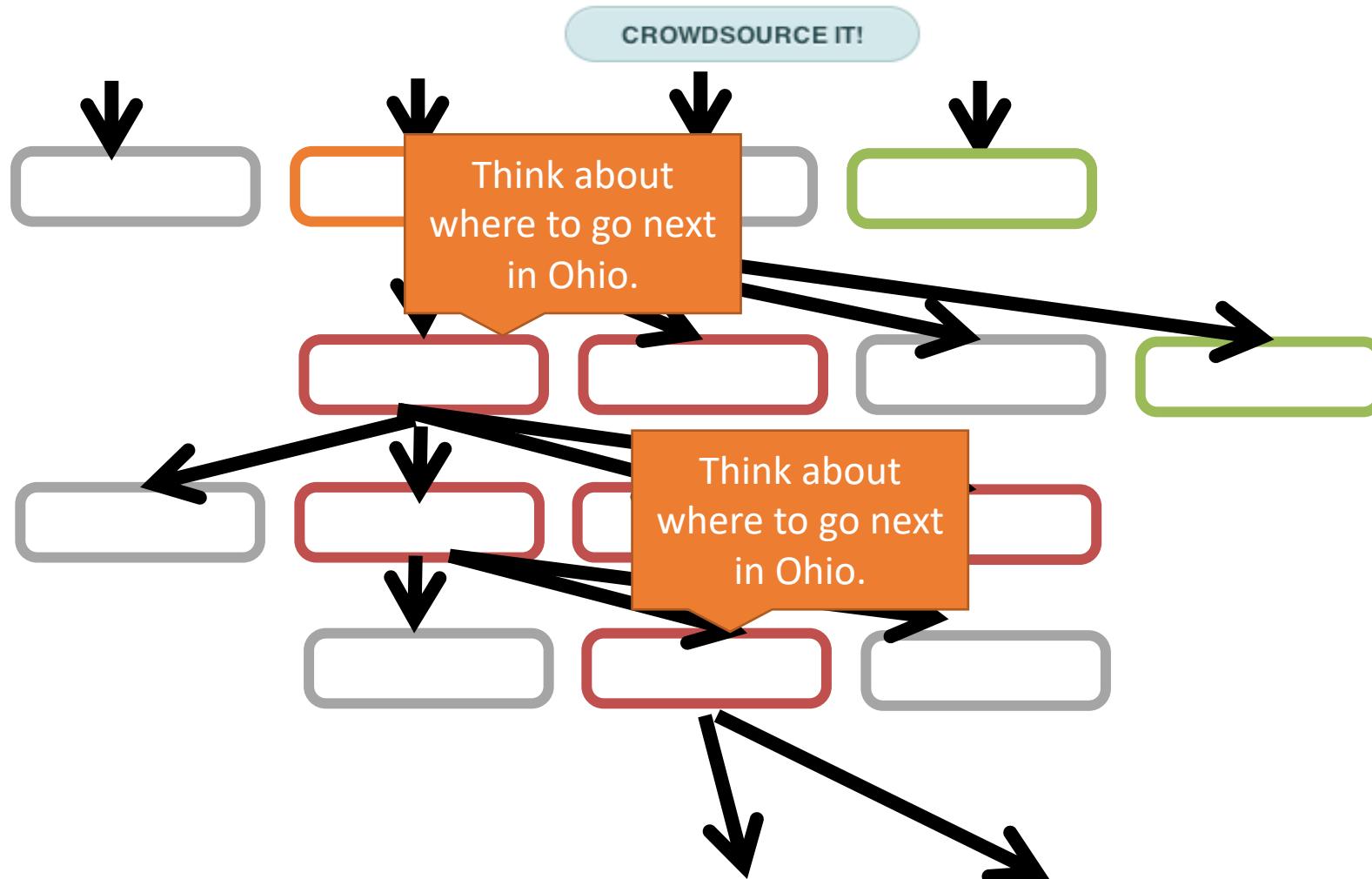
Write one sentence to open the conclusion.

Write 2-3 sentences in the middle of the conclusion.

Write a concluding sentence.

# Failed Experiment 1

Plan a trip from New York to S.F. that visits 5 interesting places.



**Failing to Terminate**

# Failed Experiment 2

List the department chairs of the top 20 US programs in CS.

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aalto armchair  
poang lounge chair  
adirondack chair  
aeron chair  
balans chair  
ball chair  
....

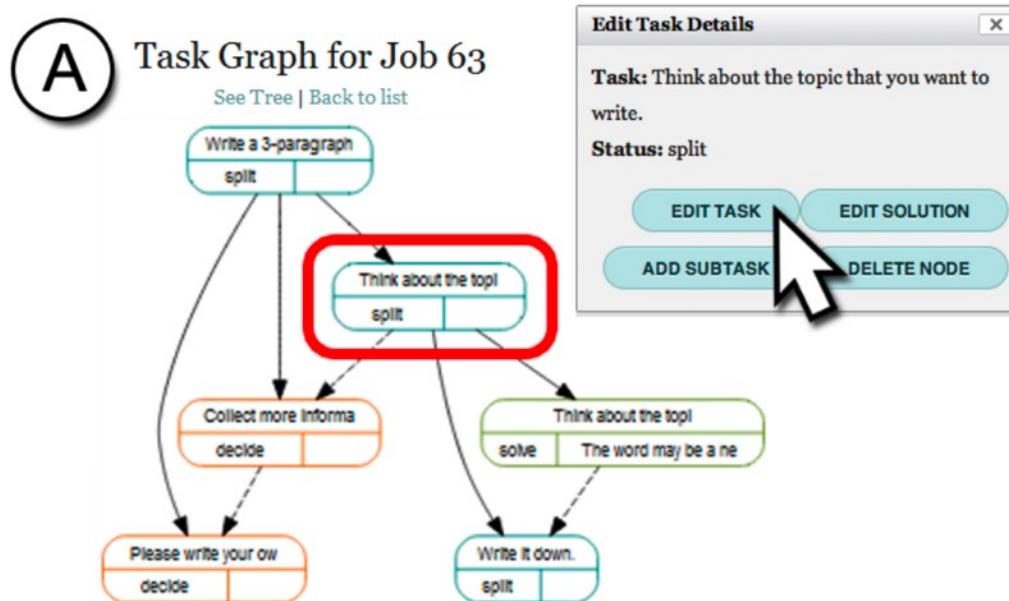
Turkomatic worker:

“...I’ve taken a look at your instructions, and I understand them perfectly. However, this task seems to have been inadvertently sabotaged by other turkers who do not understand what you are asking them to do...”

**Early mistakes propagate**

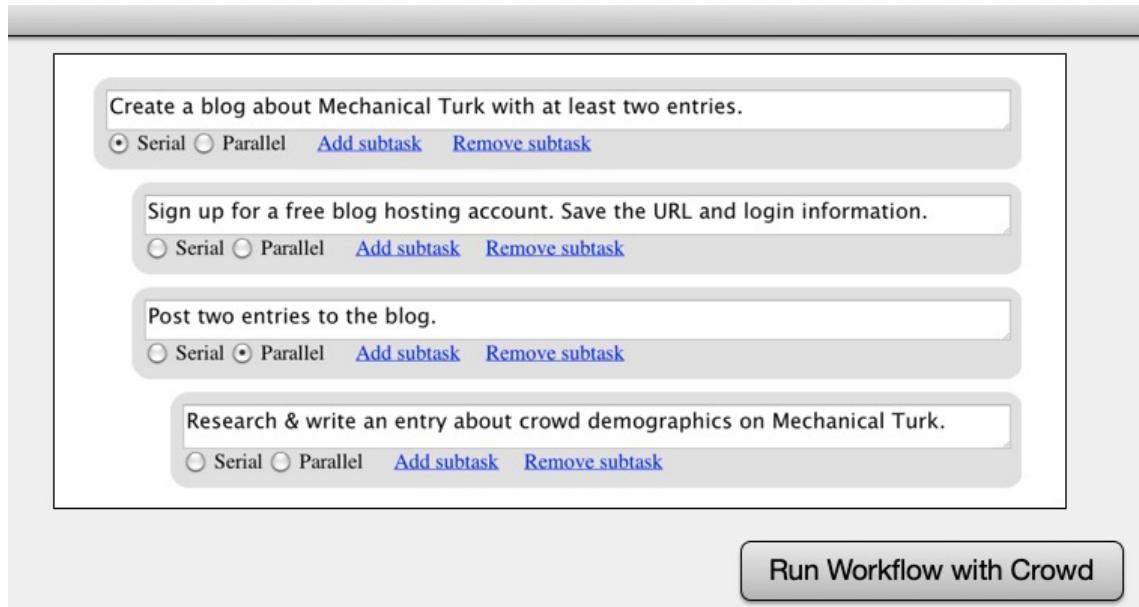
# Proposed Fixes

- Utilizing more skilled workers
  - The experiments using graduate students as workers are all successful
- Including requester interventions
  - Designing visualizations, and enable requesters to modify the workflow on the fly



# Proposed Fixes

- Utilizing more skilled workers
  - The experiments using graduate students as workers are all successful
- Including requester interventions
  - Designing visualizations, and enable requesters to modify the workflow on the fly
  - Allow requesters to provide seed workflows



# AI-Assisted Workflow Design

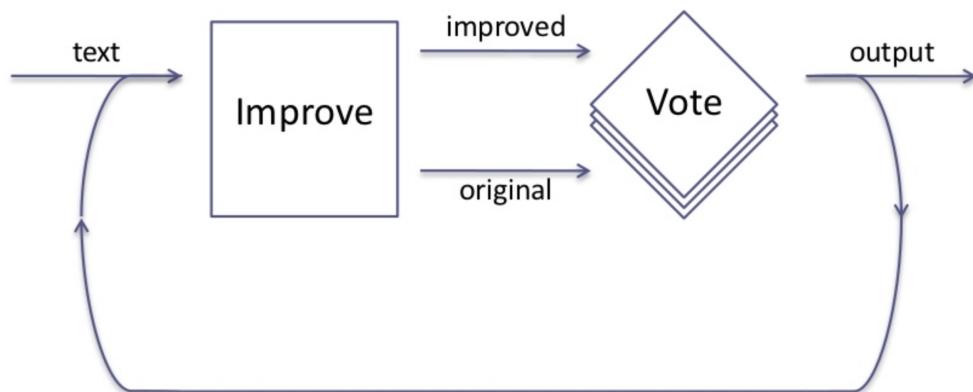
(utilizing AI to help tune the parameters of workflow)

Decision-theoretic Control of Crowd-sourced Workflows.

Peng Dai, Christopher H. Lin, Mausam, Daniel S. Weld. AI Journal 2013.

# Example

You wrote a short note. It's a good one with nothing  
in it which is too grammatical mistakes. Overall your writing style  
is a bit too flowy. You do make some good points,  
but they get lost amidst the noise.

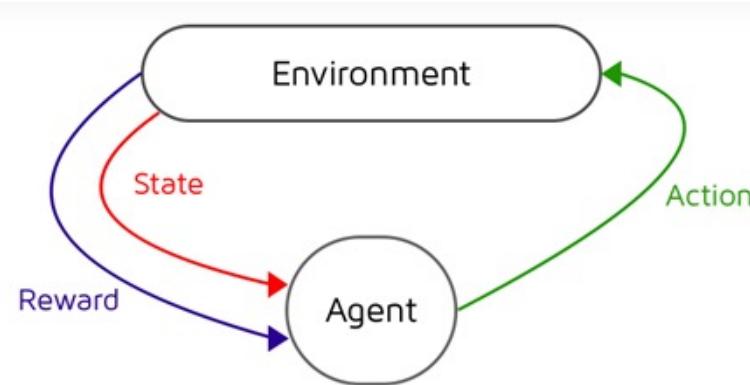


- Decisions to make at each step
  - Should we keep voting?
  - Should we create an improvement task?
  - Should we terminate the process and output the results?

This is a **sequential decision-making** problem under uncertainty.

# Markov Decision Process

- Markov decision process (MDP)

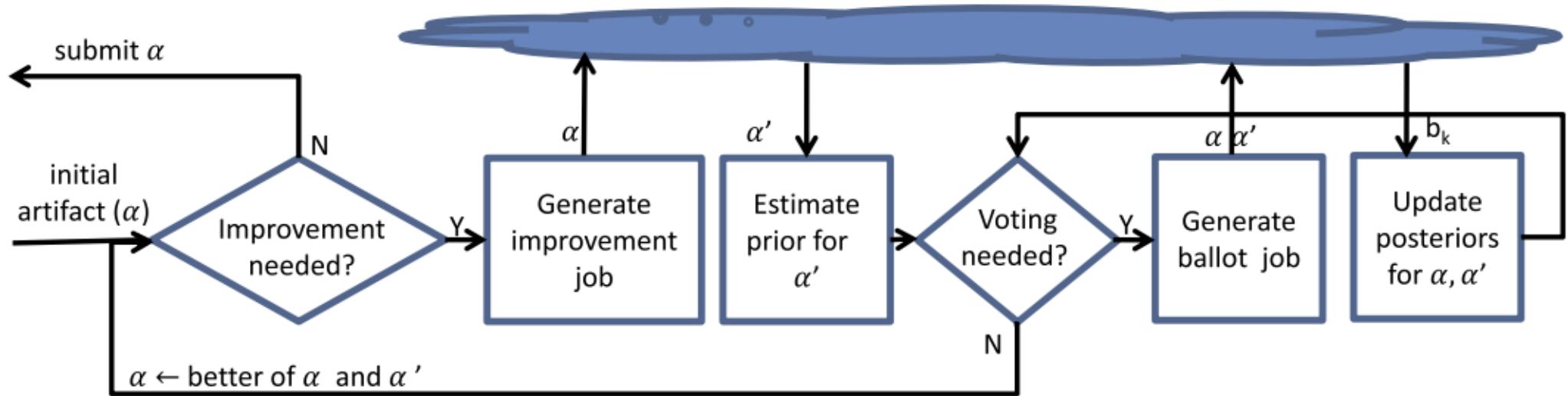


- Main components
  - States (of the environment)
  - Action
  - State transitions
  - Rewards

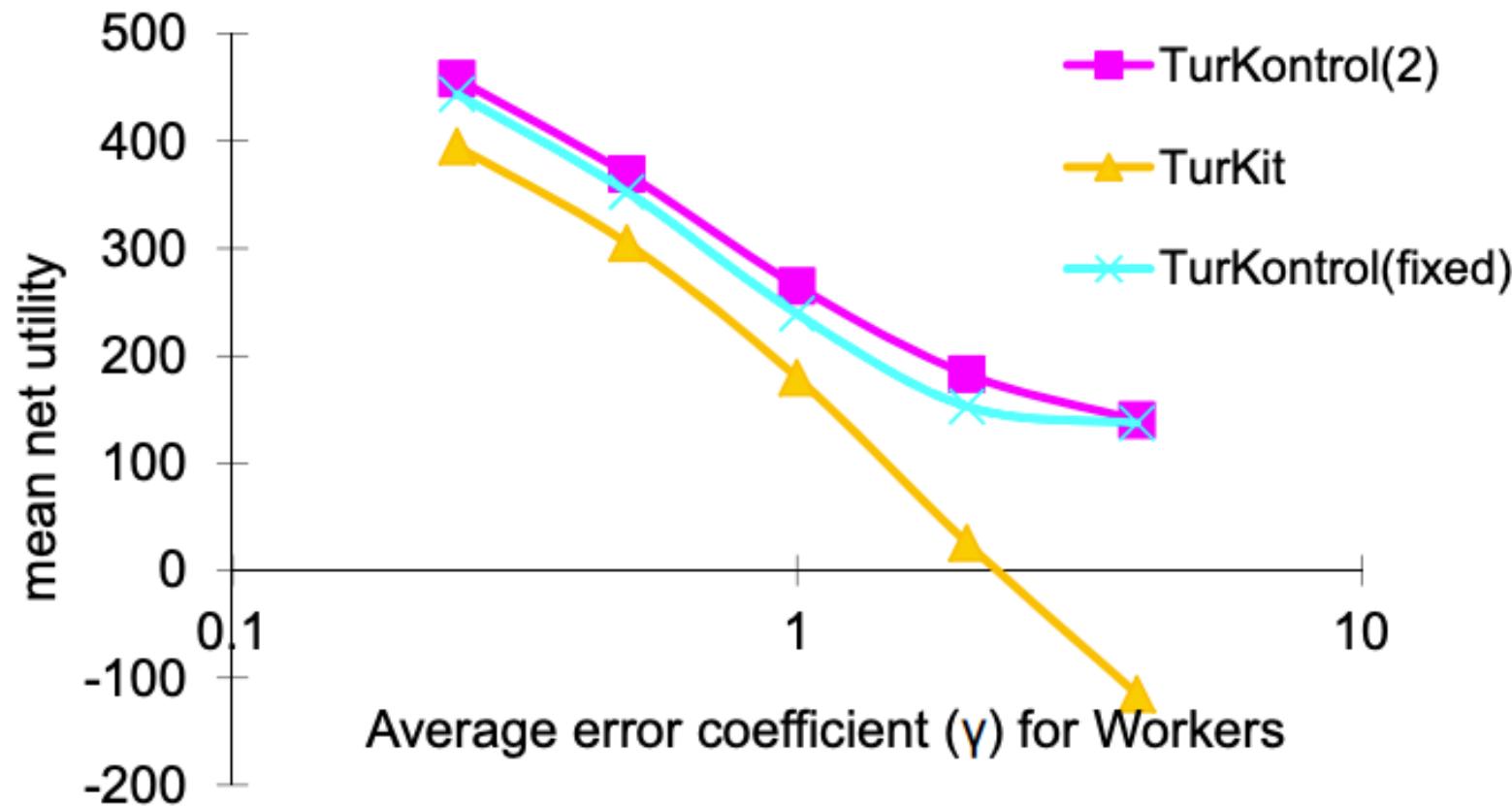
- Partial observable Markov decision process (POMDP)
  - State is not directly observable,
  - We can observe some output/signals depending on the state
    - (think about problem 2 of assignment 3)
  - Require additional reasoning

# TurKontrol

- POMDP formulation
  - Actions = {vote, improve, terminate}
  - State =  $\{(\alpha, \alpha')\}$  ( $\alpha$ : the original quality of the article,  $\alpha'$  the improved one)
  - State transition, observation, rewards are defined w.r.t. to the inference



# Improvements over Fixed Parameters



# Discussion

- General thoughts on the two approaches
  - Utilizing the crowd to design workflows
  - Utilizing AI to design workflows
- These approaches are obviously not perfect yet. What are the other aspects of workflow design we can utilize AI/crowd to help? How?

Can we use the idea of workflows  
in our daily tasks?

# Selfsourcing Personal Tasks

Teevan, Liebling, and Lasecki. CHI WiP 2014.

# How long can you continuously focus on work?

before being interrupted by

- checking emails
- checking Facebook/Instagram/Twitter
- ...

# Microproductivity: Designing Workflows for Yourself

## **Task Structure** – Break tasks into microtasks

- What we know: Examples of many complex tasks can be broken down
- Still needed: What tasks can be broken down? How to capture context?

## **Task Completion** – Make it easy to do microtasks

- What we know: Microtasking is easier, especially when mobile
- Still needed: When to break tasks down? How to prioritize microtasks?

## **Task Sharing** – Get microtasks to the right person

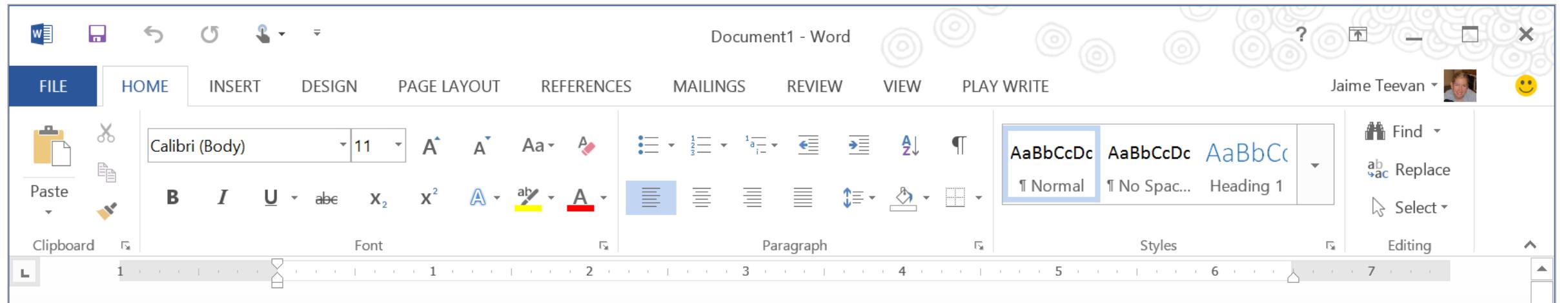
- What we know: Reduce collaboration overhead with colleagues, crowd
- Still needed: Who is the best person to do a microtask?

## **Task Automation** – Learn microtasks via hybrid intelligence

- What we know: Possible to incorporate automation into workflows
- Still needed: When can AI systems benefit from human input?

# Example: Article Writing

Slides from Jaime Teevan



## Microsoft Word

C# and Visual Studio Tools for Office

Soylent is a prototype crowdsourced word processing interface. It focuses on three main tasks: shortening the user's writing, proofreading [...]

shorten(text)

## Mechanical Turk

Javascript, Java and TurKit

### Find

"Identify at least one area that can be shortened without changing the meaning of the paragraph."

Find overlapping areas (patches)

### Fix

"Edit the highlighted section to shorten its length without changing the meaning of the paragraph."

Soylent, a prototype...

Randomize order of suggestions

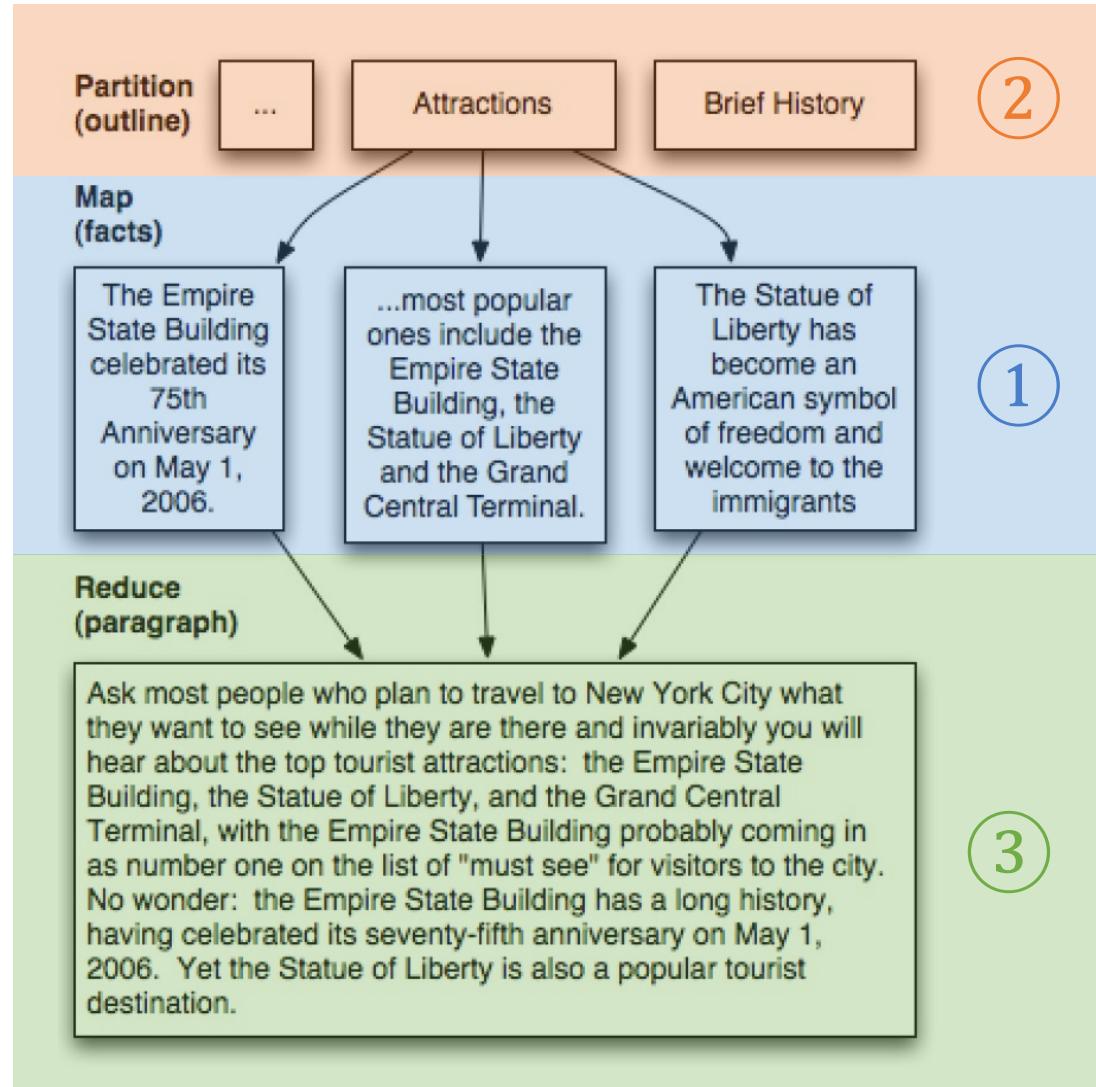
### Verify

"Choose at least one rewrite that has significant style errors in it. Choose at least one rewrite that significantly changes the meaning of the sentence."

Soylent ~~is~~, a prototype...

Soylent ~~is-a~~ prototypes...

Soylent is a ~~prototype~~test...



- ① Collect content
- ② Organize content
- ③ Turn content into writing

# ① Collect Content

The MicroWriter breaks writing into microtasks

Microtasks can be shared with collaborators

Microtasks can be done while mobile

Collaborative writing typically requires coordination

Collaborators can be known or crowd workers

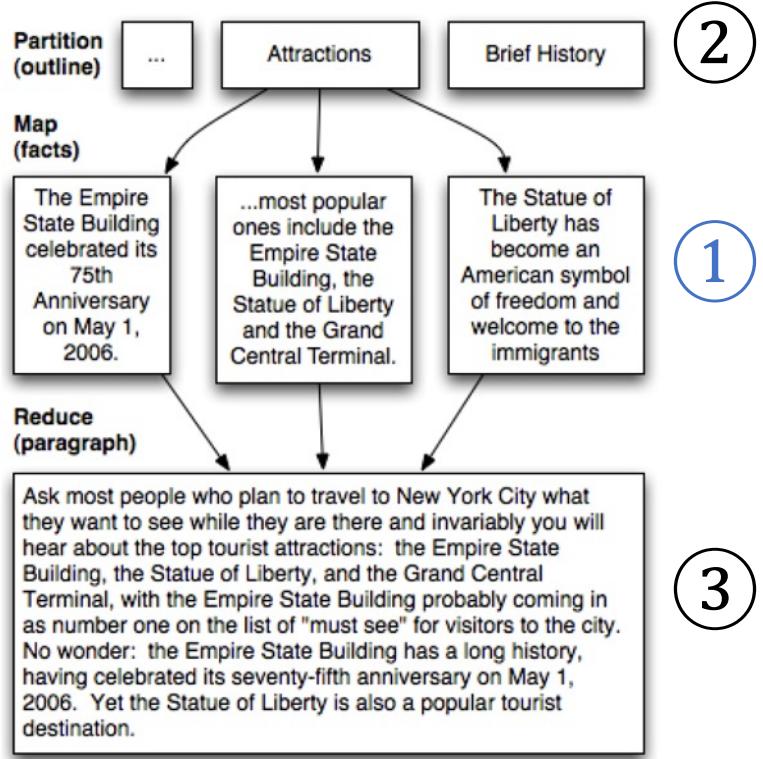
People have spare time when mobile

Structure turns big tasks into series of small microtasks

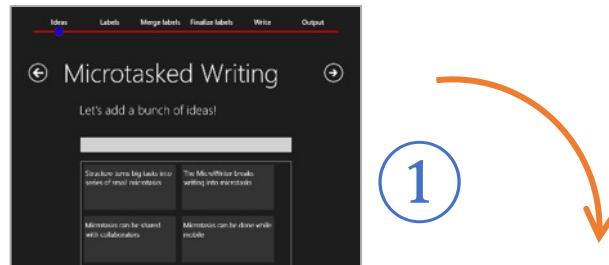
Microtasks make it easy to get started

# ① Collect Content





- ① Collect content
- ② Organize content
- ③ Turn content into writing



**Suggest Categories for tips about Traveling**

Read the tip below and tell us what category you see it belonging to. We are just asking for your judgement. Some tips are very hard to categorize. Please don't be discouraged. If you think a tip has a problem or is too hard to categorize, check the "pass" box (this should be rare).

#1 Flights are cold, make you constipated, and dehydrate you. So wear long pants/shirts, have earplugs and a jacket accessible. don't eat a lot (esp heavy foods). baby wipes feel awesome after traveling for 35 hours, as does lotion on your cracked hands. drink water.	Category: <input type="checkbox"/> pass
#2 Baggies, of all sorts - one for dirty clothes, liquids, medicine/first aid, converter/chargers/head lamp, etc. Bring a couple of empty grocery bags for trash, etc.	Category: <input type="checkbox"/> pass
#3 Using Dropbox, AirSharing, Evernote, or other technology, sync maps to your phone to guide you at your destination, where you may not have internet access. Itineraries, too.	Category: <input type="checkbox"/> pass

**Pick the best category for a travel tip**

**Instructions**

Read the following travel tip, and tell us which category is best. Feel free to use your judgement. In general:

- Pick categories whose name make the most sense to you
- Pick broad categories rather than narrow categories
- Avoid subjective categories such as "favorite tips"
- Good grammar is important but spelling and capitalization isn't

**Task**

Flights are cold, make you constipated, and dehydrate you. So wear long pants/shirts, have earplugs and a jacket accessible. don't eat a lot (esp heavy foods). baby wipes feel awesome after traveling for 35 hours, as does lotion on your cracked hands. drink water.

Category	Best
How to handle the long flights	<input checked="" type="radio"/>
travel organization and convenience	<input type="radio"/>
international flights	<input type="radio"/>
packing essentials	<input type="radio"/>

**Categorize Tips for Traveling**

**Instructions**

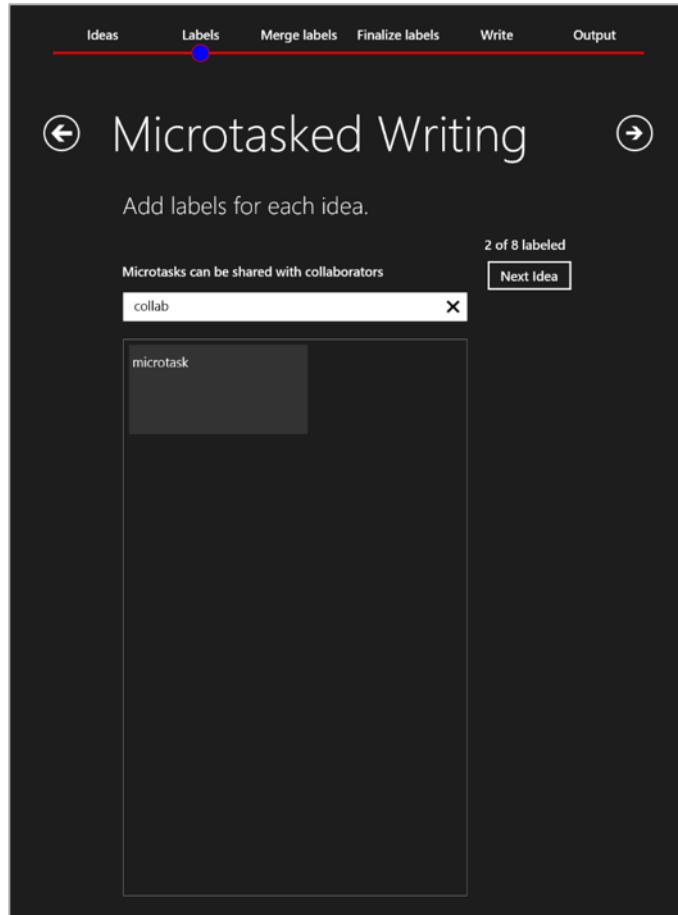
Read the tip below, then and read the suggested categories for it. For each suggested category, say whether you think the tip fits or doesn't fit.

**Task**

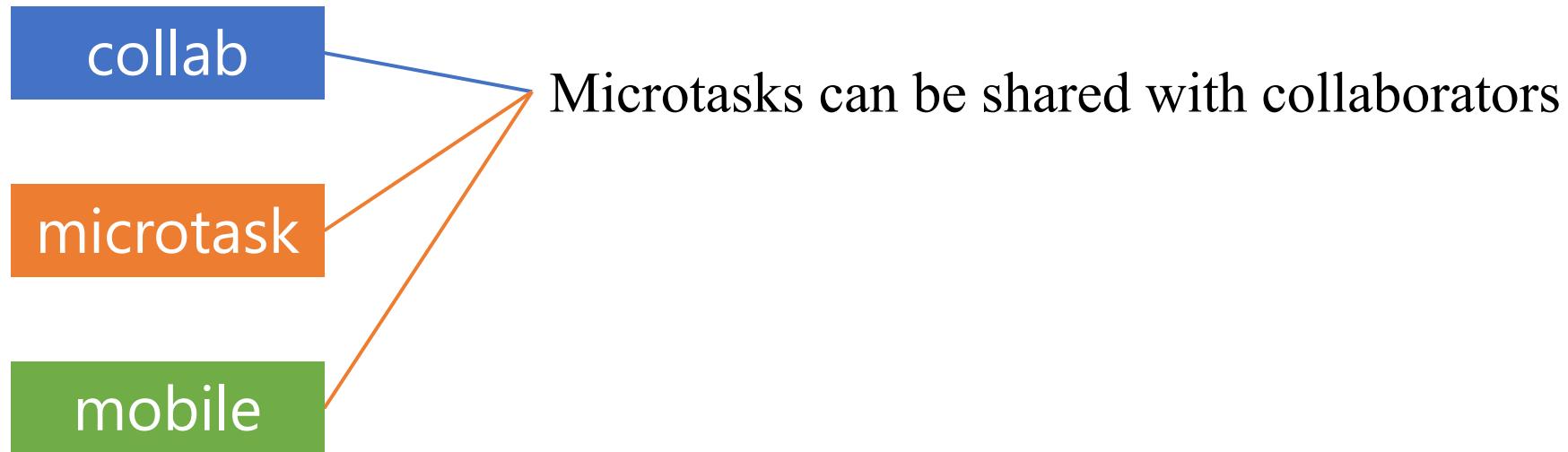
Flights are cold, make you constipated, and dehydrate you. So wear long pants/shirts, have earplugs and a jacket accessible. don't eat a lot (esp heavy foods). baby wipes feel awesome after traveling for 35 hours, as does lotion on your cracked hands. drink water.

Category	Fits	Doesn't Fit
How to handle the long flights	<input checked="" type="radio"/>	<input type="radio"/>
Travel organization and convenience	<input type="radio"/>	<input checked="" type="radio"/>
international flights	<input type="radio"/>	<input checked="" type="radio"/>
packing essentials	<input type="radio"/>	<input checked="" type="radio"/>

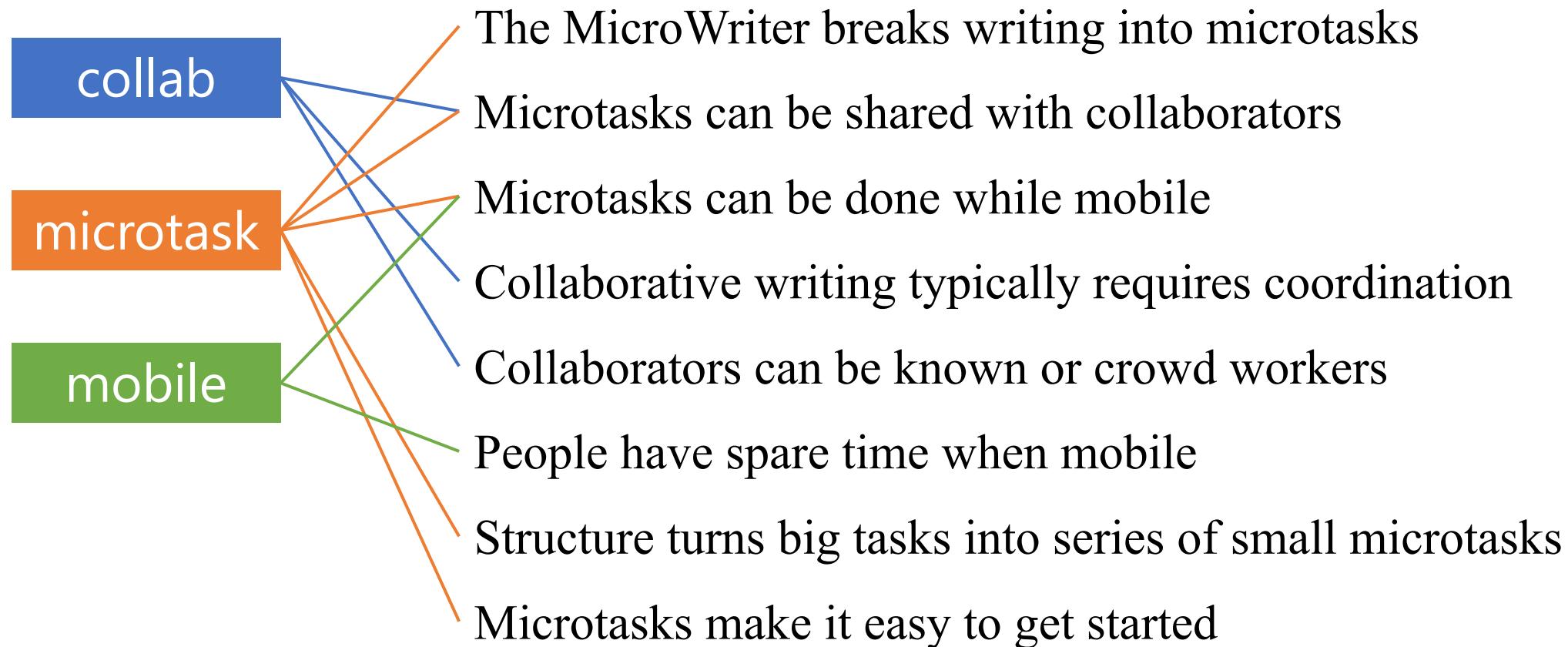
## ② Organize Content

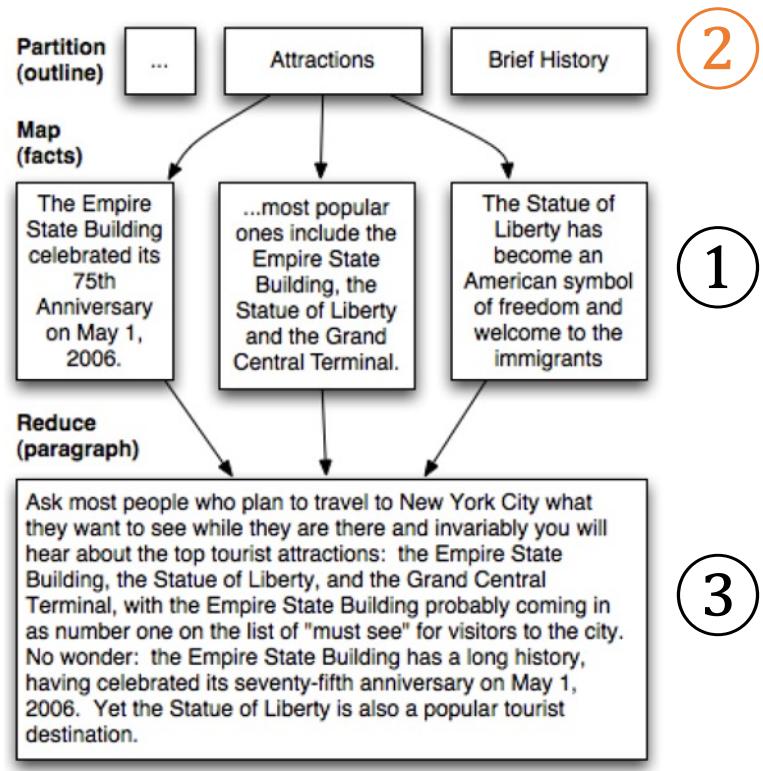


## ② Organize Content

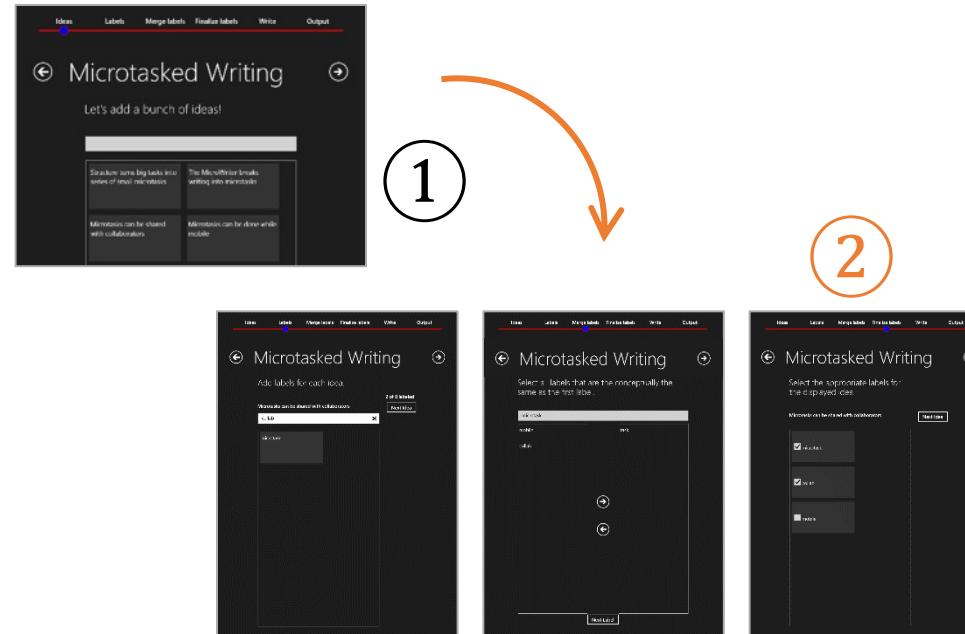
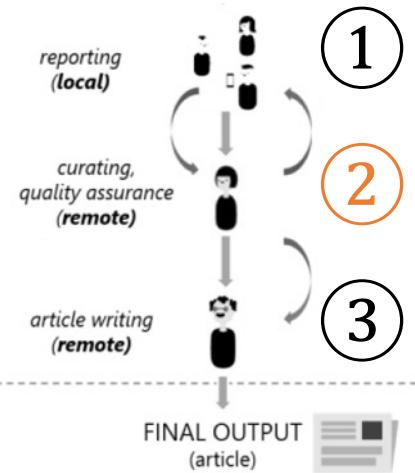


## ② Organize Content

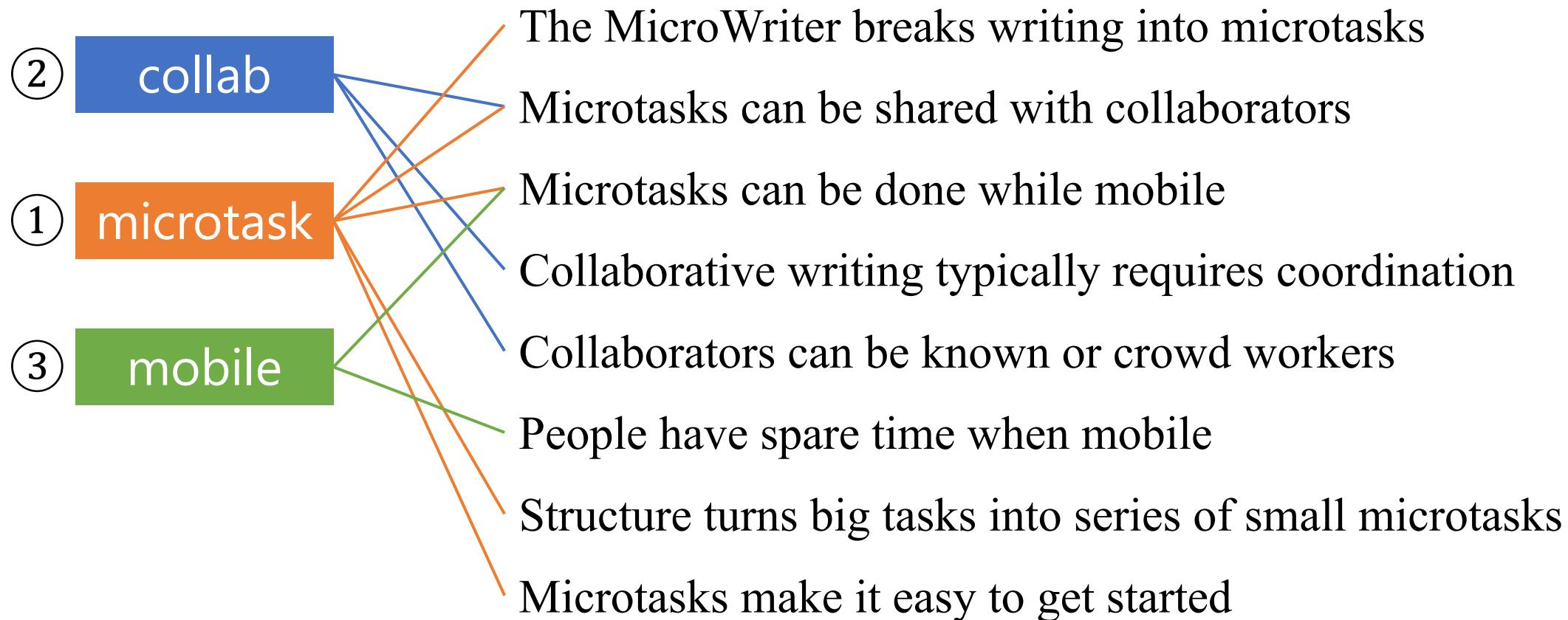




- ① Collect content
- ② Organize content
- ③ Turn content into writing



# ③ Turn Content into Writing



# ③ Turn Content into Writing

## microtask

- The MicroWriter breaks writing into microtasks
- Structure turns big tasks into series of small microtasks
- Microtasks make it easy to get started

## collab

- Microtasks can be shared with collaborators
- Collaborative writing typically requires coordination
- Collaborators can be known or crowd workers

## mobile

- Microtasks can be done while mobile
- People have spare time when mobile

# ③ Turn Content into Writing

The image shows a dark-themed digital interface for writing. At the top, there is a horizontal navigation bar with six items: "Ideas", "Labels", "Merge labels", "Finalize labels", "Write", and "Output". A red line with a blue circular marker is positioned under the "Write" button, indicating it is the current step. Below the navigation bar, the word "Write" is displayed in a large, white, sans-serif font, flanked by left and right arrow icons.

Write a paragraph using these ideas...

Microtasks can be shared with collaborators  
Collaborators can be known or crowd workers  
Collaborative writing typically requires coordination

Next Idea

# ③ Turn Content into Writing

## collab

- Microtasks can be shared with collaborators
- Collaborative writing typically requires coordination
- Collaborators can be known or crowd workers

*Collaborative writing typically requires coordination. However, microtasks are easy to share with collaborators without the need for coordination. The collaborators can be known colleagues, or paid crowd workers.*

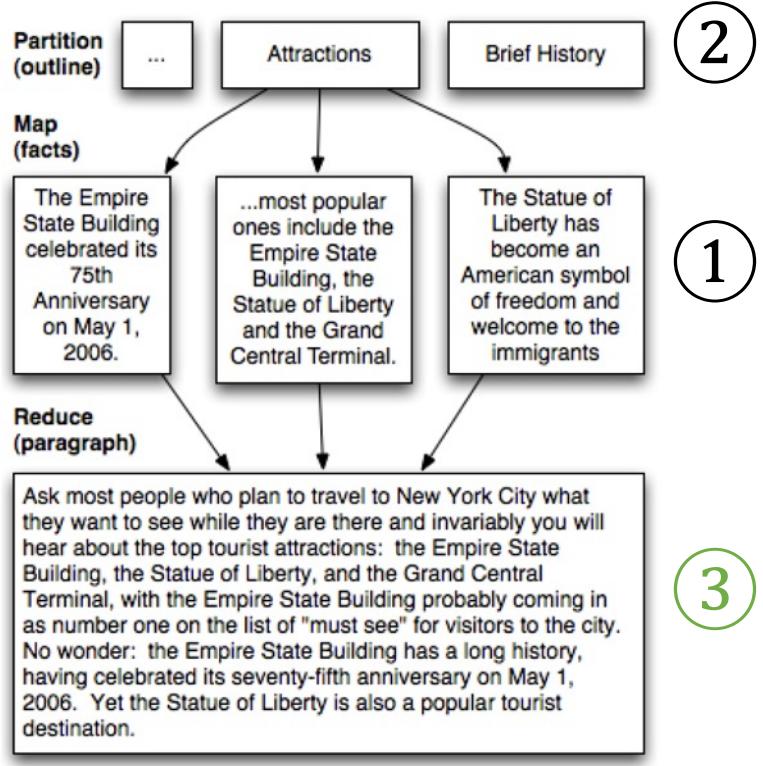
## ③ Turn Content into Writing

- Complete output:

*Structure makes it possible to turn big tasks into a series of smaller microtasks. For example, the MicroWriter breaks writing into microtasks. These microtasks make the larger task easier to start.*

*Collaborative writing typically requires coordination. However, microtasks are easy to share with collaborators without the need for coordination. The collaborators can be known colleagues, or paid crowd workers.*

*People have spare time when mobile, and these micromoments are ideal for doing microtasks.*



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# Discussion

- What tasks in your life do you think that might benefit through adopting microproductivity?
- How should you decompose the task? Can you share some of the microtasks? Can you automate some of the microtasks?