Programming the Crowd

Crowdsourcing and Human Computation

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Website: crowdsourcing-class.org

Algorithms for Human Computation

- MTurk provides an on-demand source for human computation
- Potential opportunities for exploring algorithms that use people as a fn call
- However, MTurk isn't set up to support algorithms

MTurk limitations

- MTurk requesters can post batches of independent jobs
- Perfect for tasks that can be done in parallel like labeling 1000 images
- But poorly suited for tasks that build on each other
- **What is MTurk missing that is essential in algorithms or programming languages?**

TurKit: A programming language for the crowd

```
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
})
```

What new concerns exist for crowd programming?

What new concerns exist for crowd programming?

- When posting a HIT to MTurk it can take hours before Turkers complete it, so latency could cause algorithms to take days
- What is the behavior if your program crashes?
- What if this happens after you have already spend money on a bunch of HITs?

Crash and re-run

- TurKit introduces a new programming paradigm called crash and rerun
- Designed for long running processes where local computation is cheap, and remote work is costly
- ~~Crash~~ Cache and re-run

Quicksort

```
quicksort(A)
 if A.length > 0
  pivot ← A.remove(A.randomIndex())
  left ← new array; right ← new array
  for x in A
   if compare(x, pivot)
    left.add(x)
   else
        right.add(x)
quicksort(left)
quicksort(right)
A.set(left + pivot + right)
```

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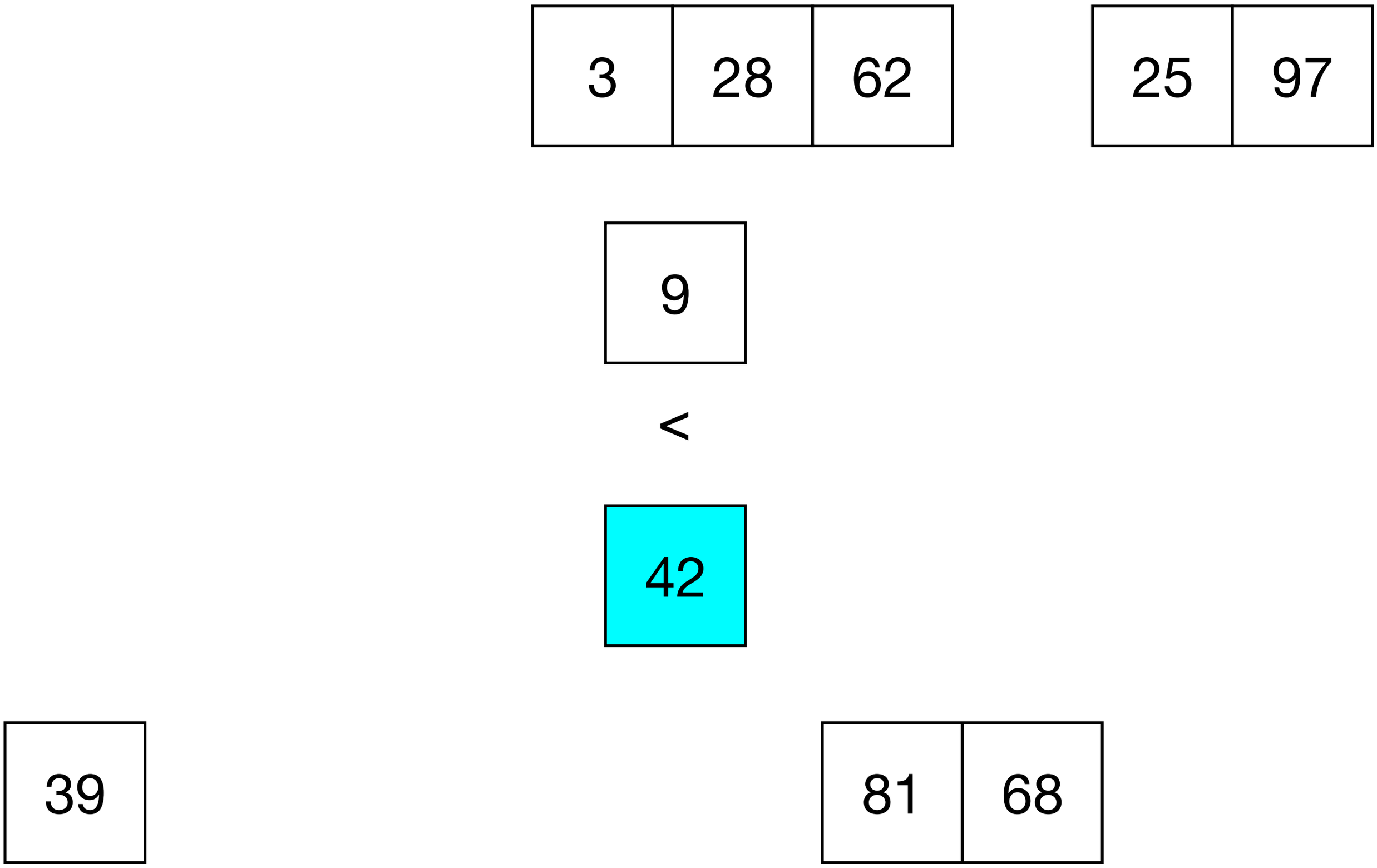
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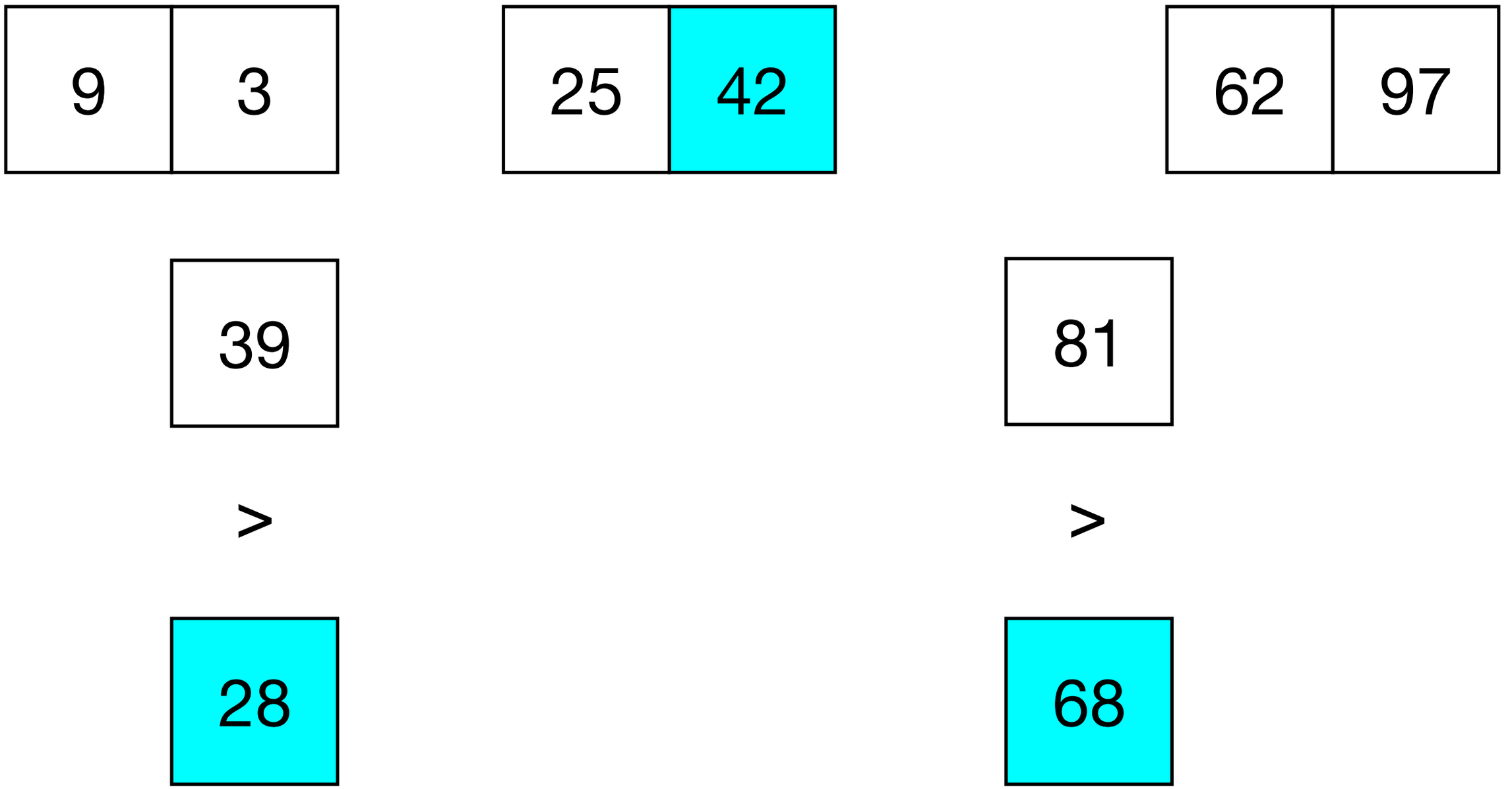
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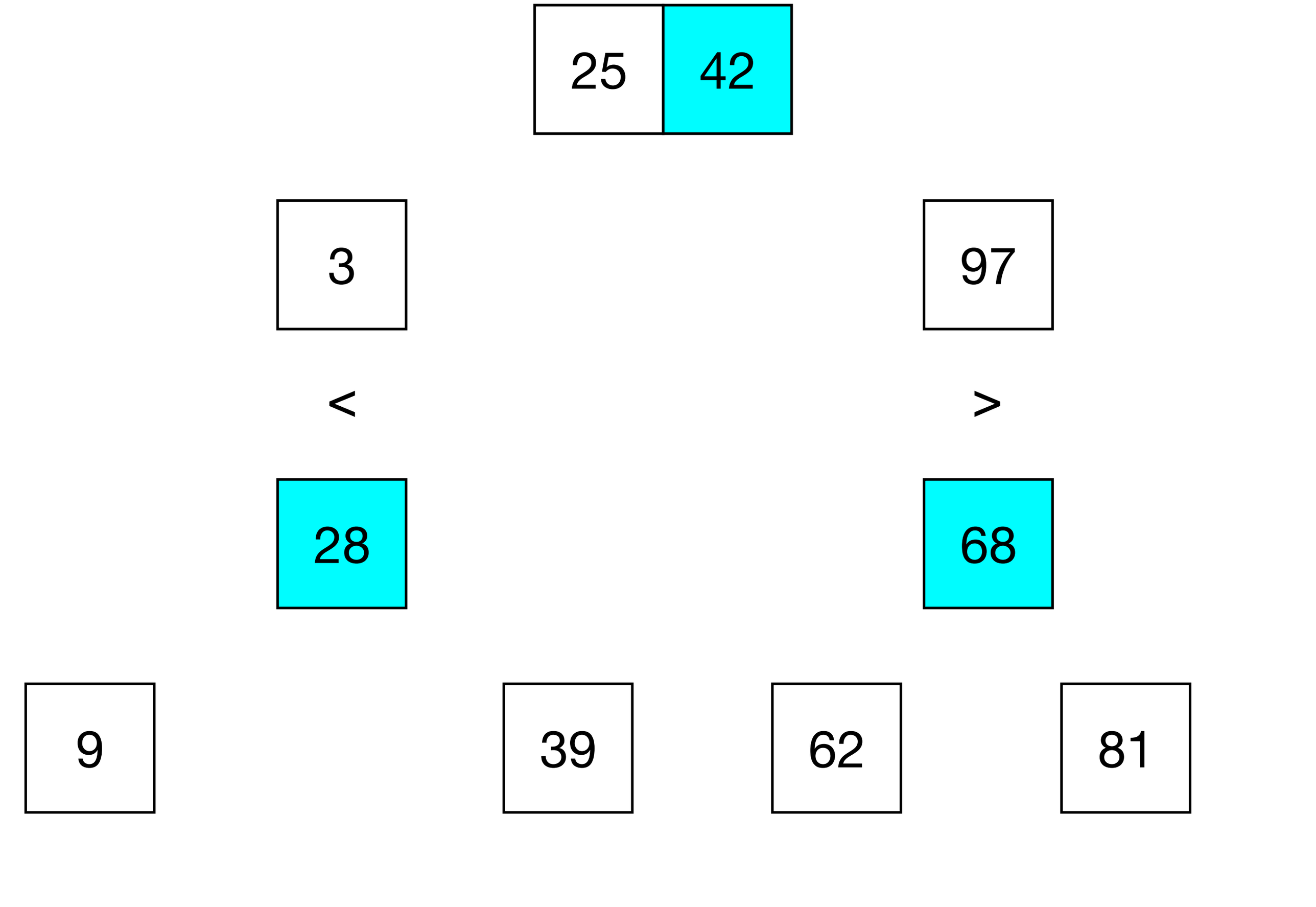
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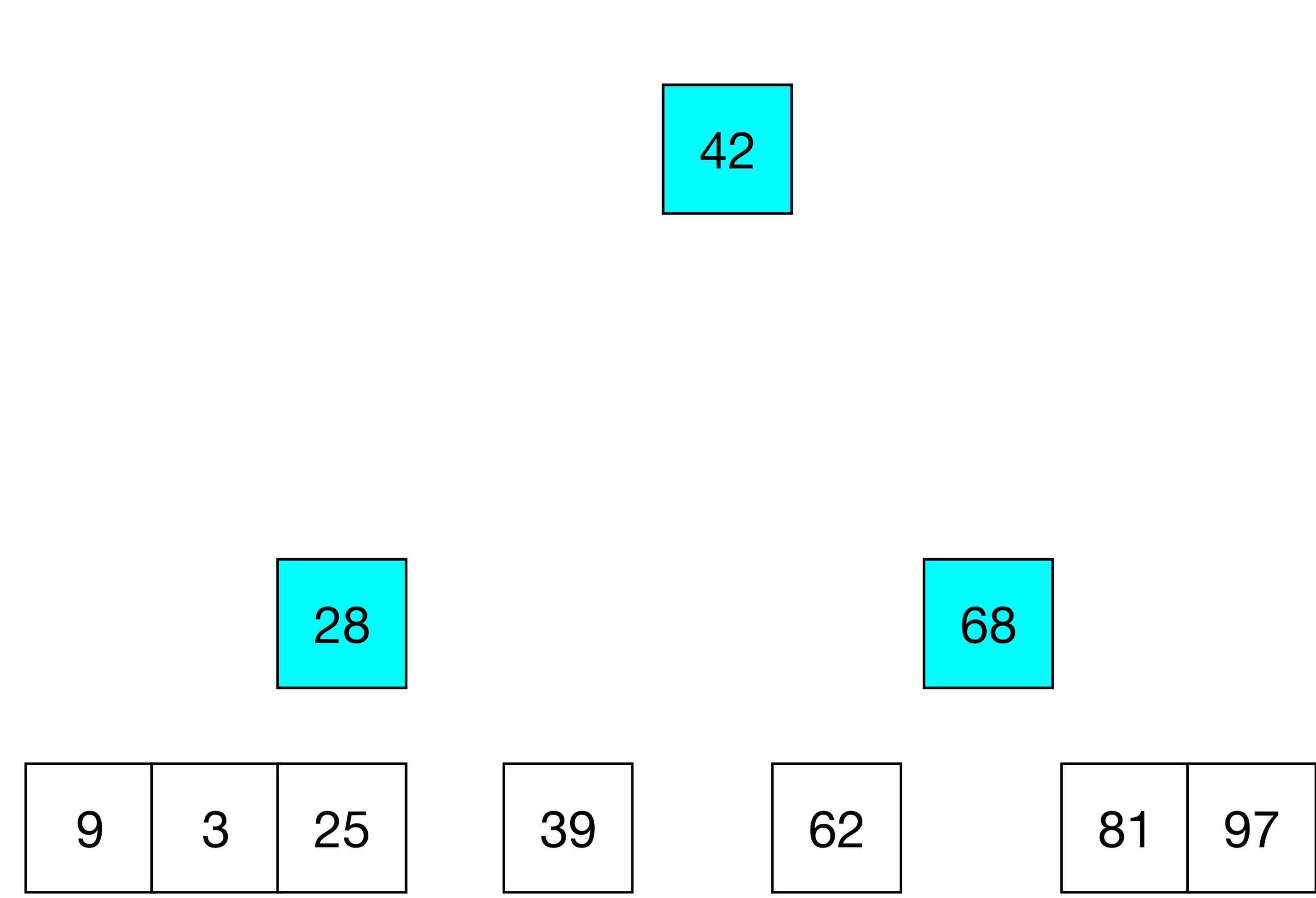
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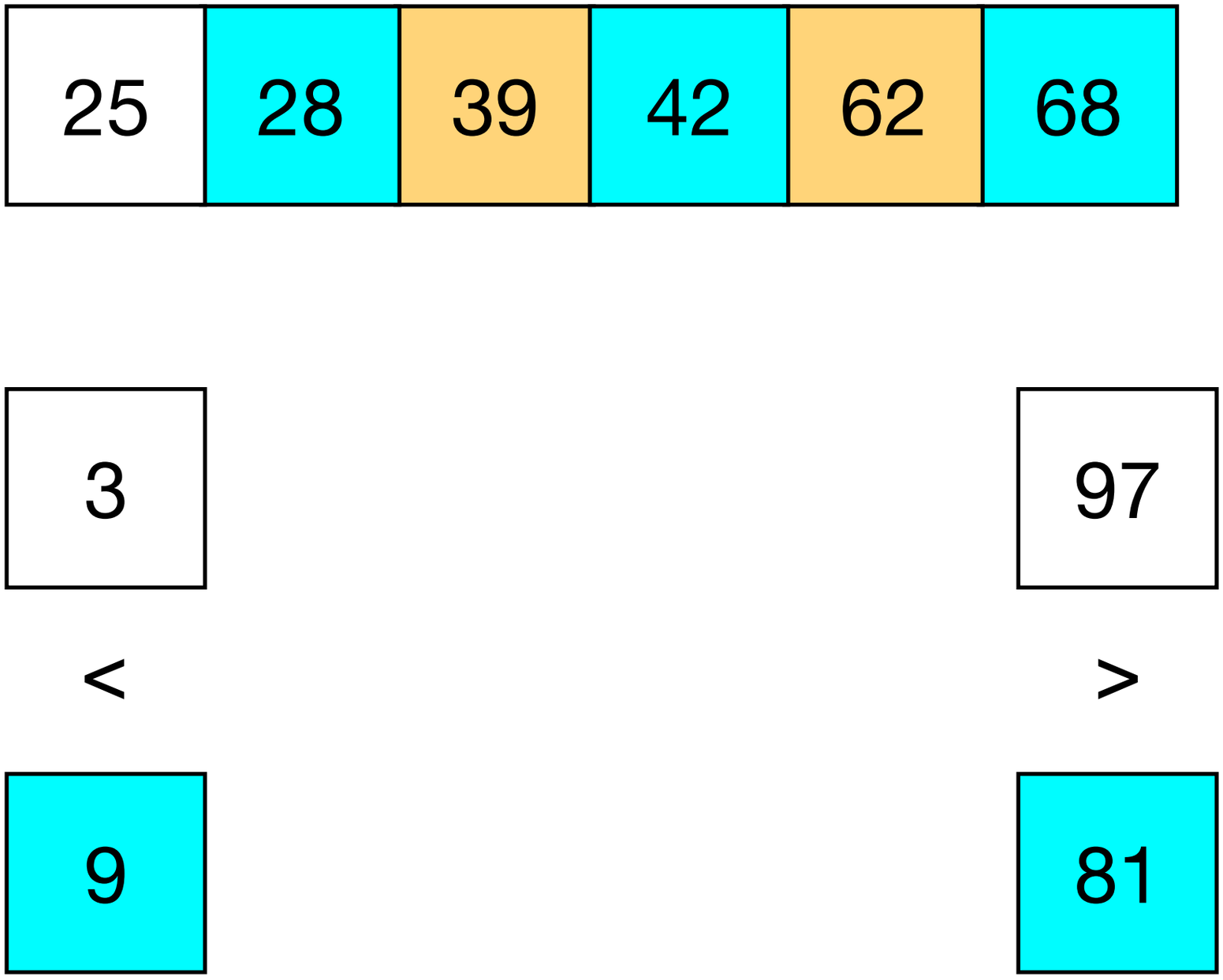
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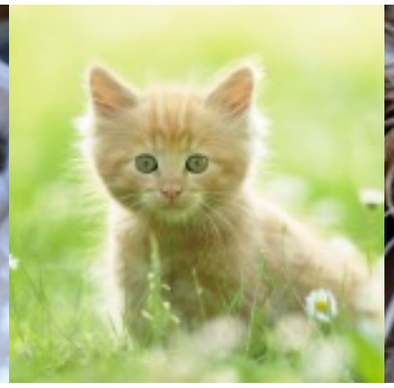
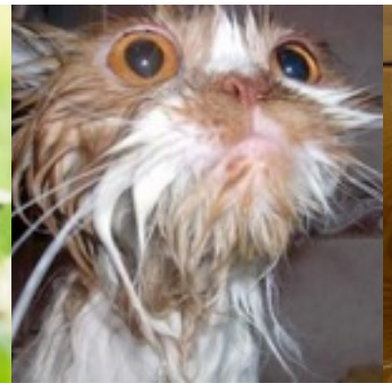
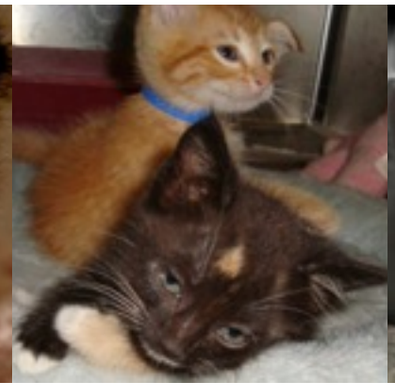
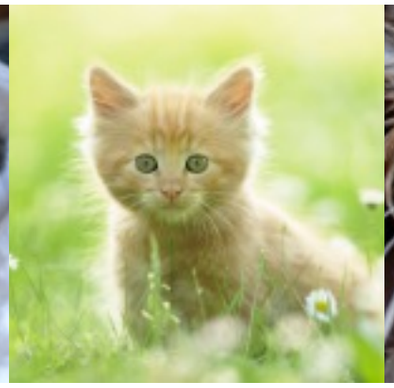
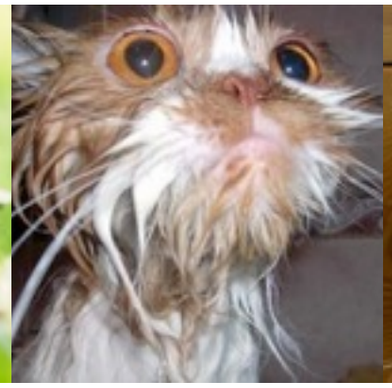
Quicksort on MTurk

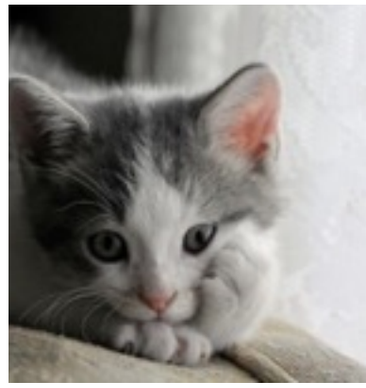
```
compare(a, b)
    hitId ← createHIT(...a...b...)
    result ← getHITResult(hitId)
    return (result says a < b)
```

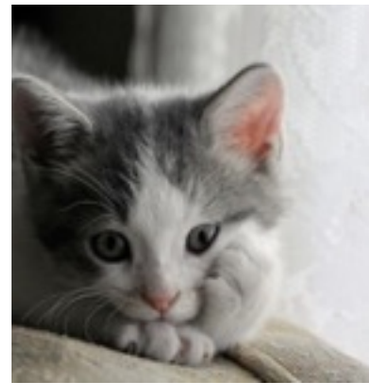







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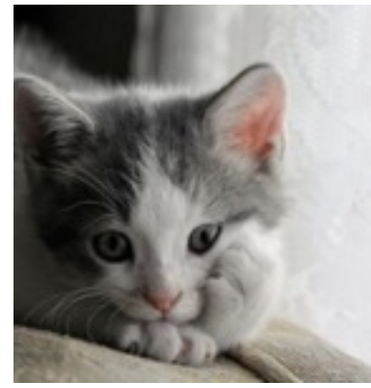

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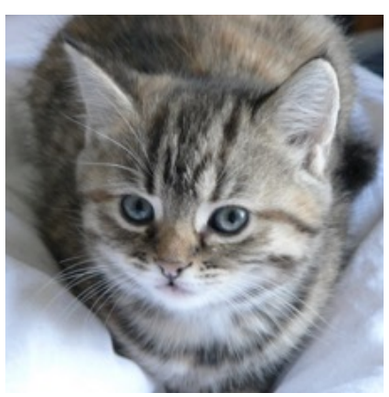



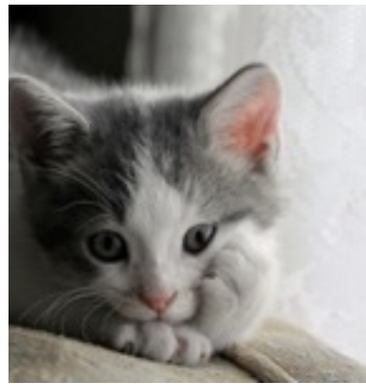


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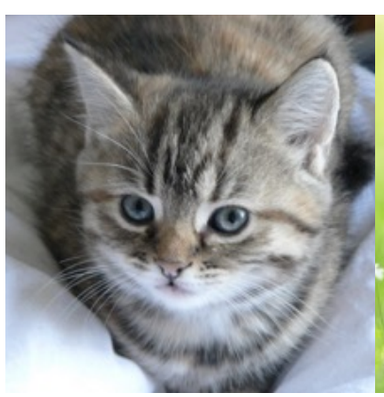
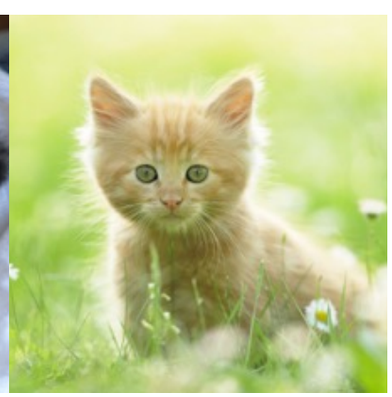

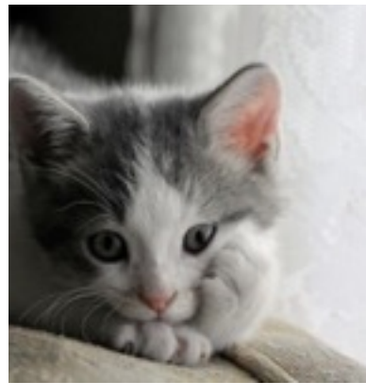

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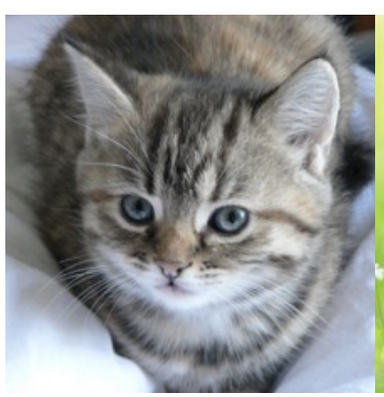

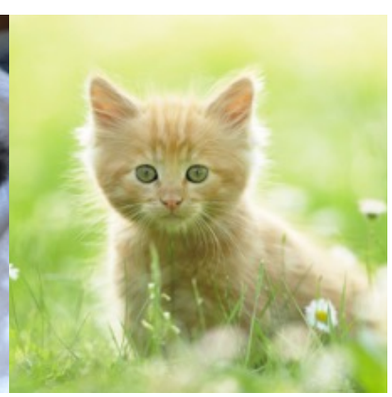

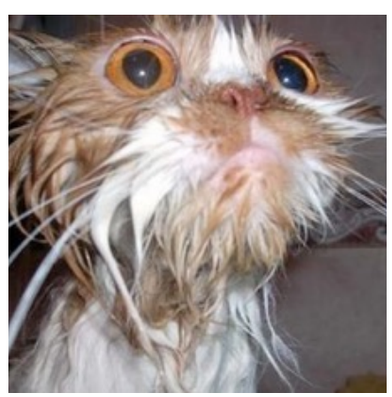

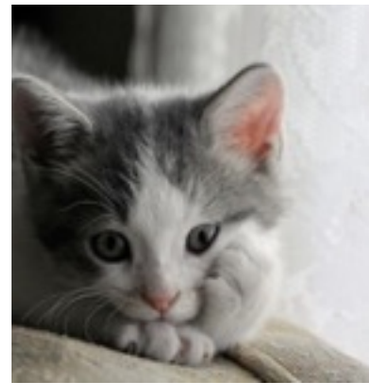

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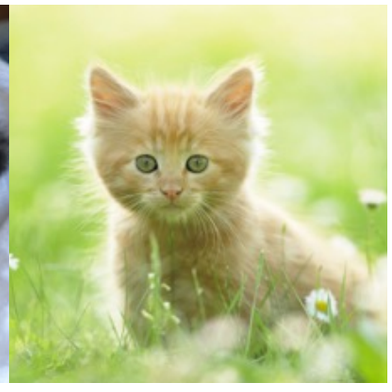

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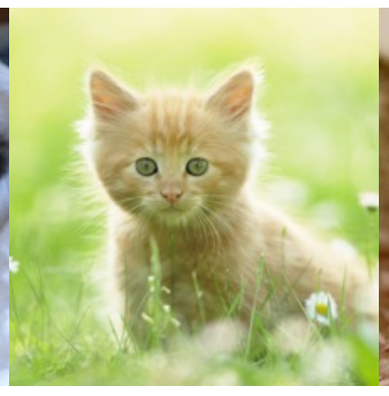

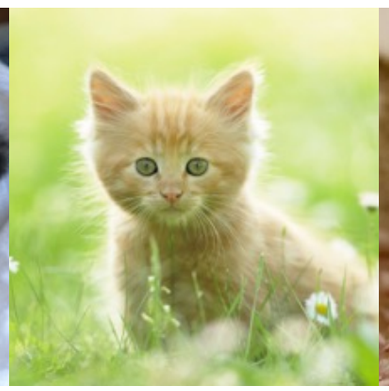

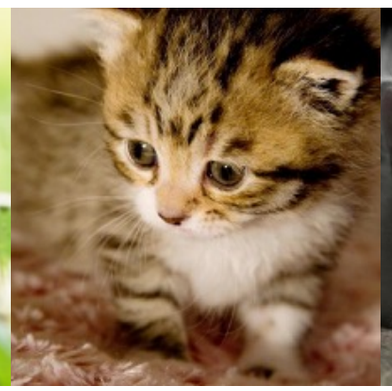


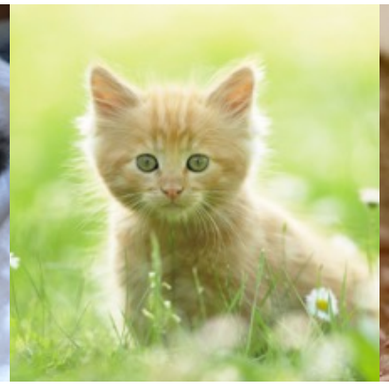




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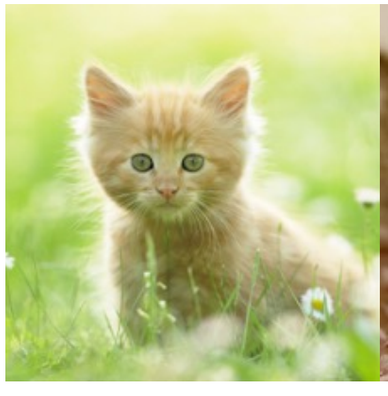
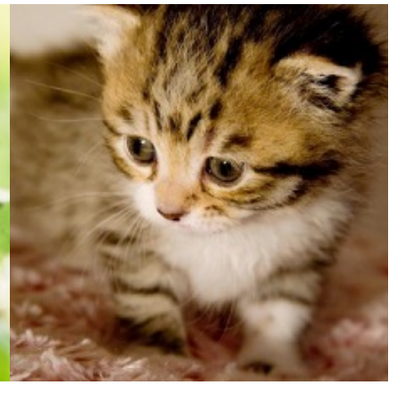

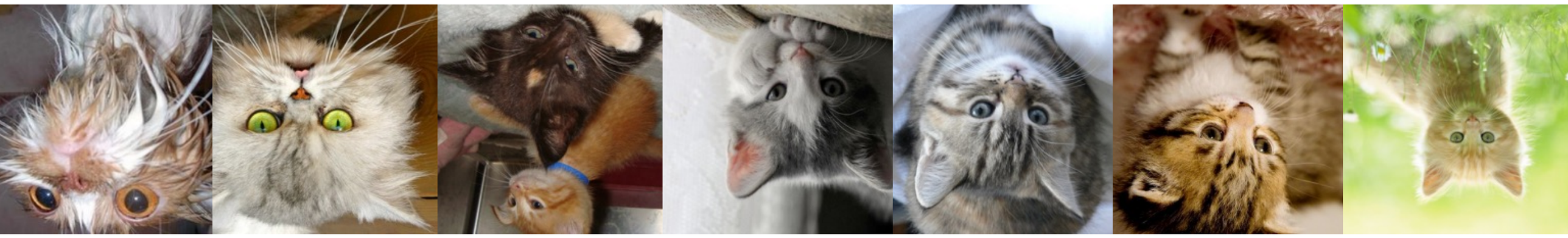






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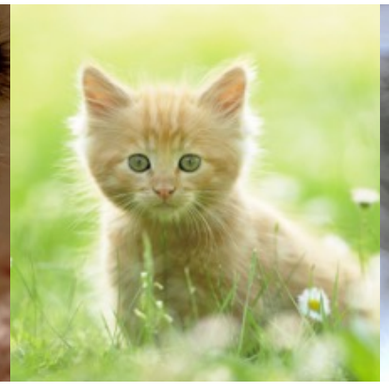





Quicksort as a Long-running process

- With this implementation we must wait for people to complete their judgments
- The algorithm may need to run for a very long time while waiting
- Challenge: how to maintain state

Quicksort as a Long-running process

- Normally quicksort maintains its state in the heap or the stack
- These are normally dynamically allocated in memory, and used by all of the programs running on a computer
- Memory isn't typically used for hours or days
- If the computer reboots, then our program's state would be lost and we would lose $$$

Store results in DB

- Insight of crash-and-rerun paradigm is that if the program crashes, it should be cheap to re-run
- Use a database to store all of the results up to the place that it crashed
- Since local computation is cheap, calling DB and re-executing code with store results is cheap

New keyword **once**

- Costly operations can be marked in a TurKit program with keyword **once**
- **once** denotes that an operation should only be executed once across all runs of a program

Quicksort on MTurk

```
compare(a, b)
    hitId ← once createHIT(...a...b...)
    result ← once getHITResult(hitId)
    return (result says a < b)
```

- Subsequent runs of the program will check the database before performing these operations

When should you mark a function with **once**?

- **High cost -** This is its main usage. Whenever a fn is high-cost in terms of money or time, **once** saves the day

When should you mark a function with **once**?

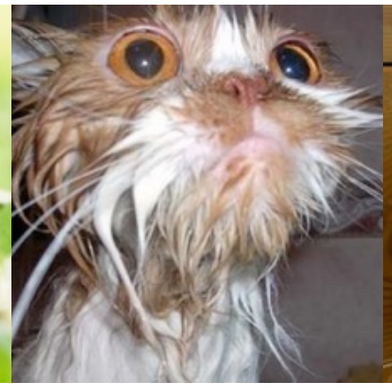
- **Non-determinism -** storing results in DB assumes that the program executes in a deterministic way

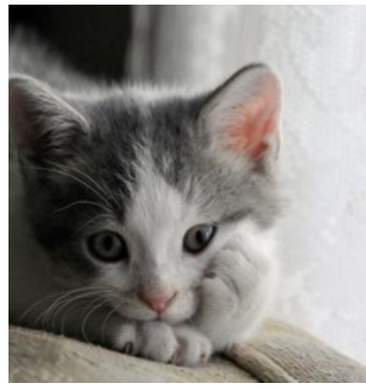














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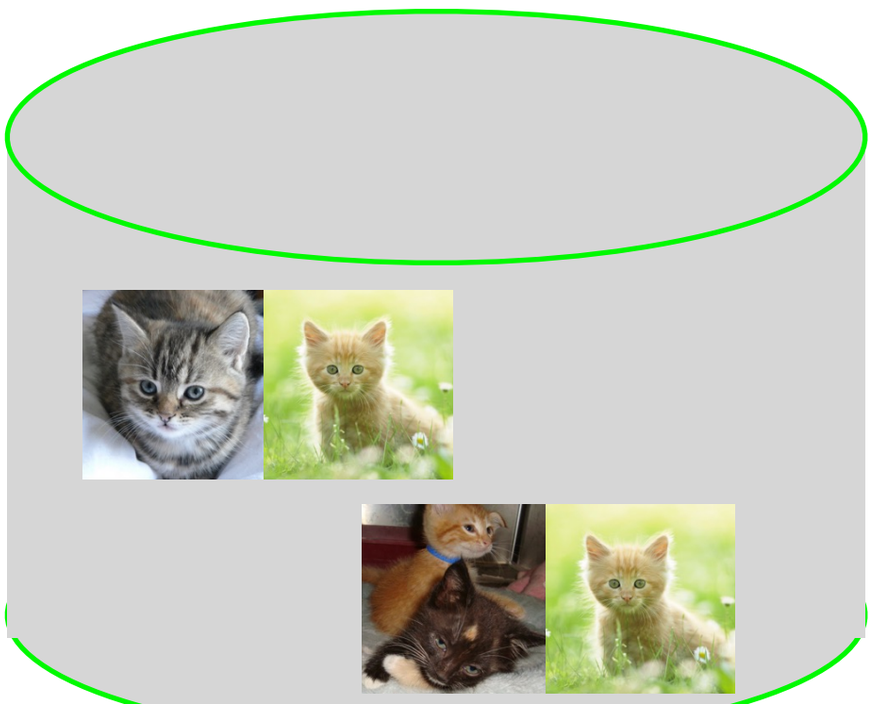

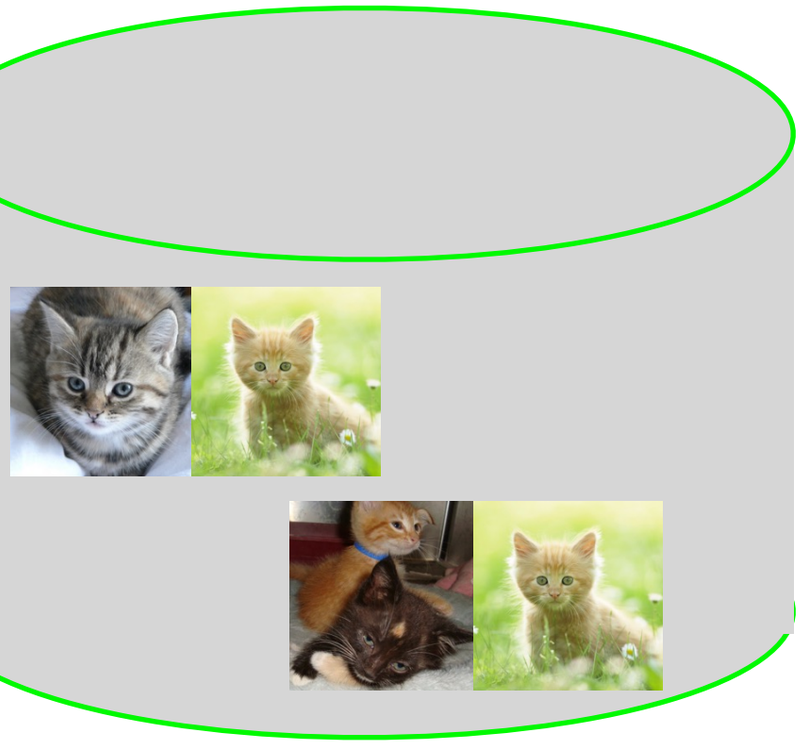

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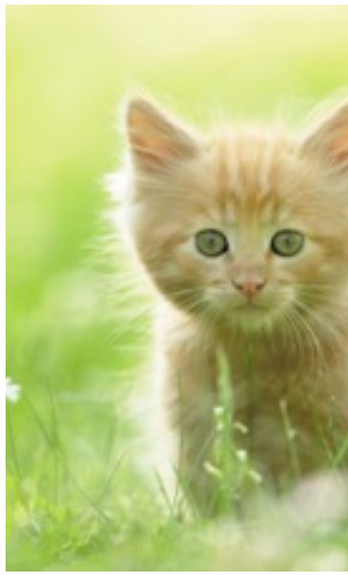

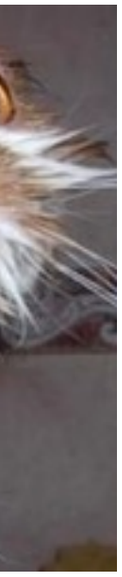

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Quicksort

```
quicksort(A)
 if A.length > 0
  pivot ← A.remove(once A.randomIndex())
  left ← new array; right ← new array
  for x in A
   if compare(x, pivot)
    left.add(x)
   else
        right.add(x)
quicksort(left)
quicksort(right)
A.set(left + pivot + right)
```

When should you mark a function with **once**?

- **Side-effects -** if a function has side effects during repeated calls, then wrap it in once.

Other benefits of **once**

- **Incremental programming** - you can write part of an algorithm, test it, view the results, modify it, and rerun.

Other benefits of **once**

- **Retroactive print-line debugging** - if your program behaves in an unexpected fashion, you can put in debugging print statements after the fact
- This also lets you print data to a file if you decide that you want to analyze it

TurKit Script

- TurKit is built on top of JavaScript
- Users have full access to JavaScript
- Plus a set of APIs built around MTurk and the crash-and-rerun programming paradigm

TurKit keywords

- once
- crash
- fork / join

The **crash** keyword

- Why in the hell would you want to tell your program to crash?
- Since we cache results in a DB, **crash** is an alternate to **wait**
- Most common use for **crash** is waiting for results to be returned from MTurk
- TurKit automatically re-runs program after a set interval

fork allows for parallel execution

- TurKit allows multiple branches to be run in parallel via **fork**
- Calling **crash** from within a **fork**ed branch resumes the execution of the former branch
- This allows you to post multiple jobs on MTurk simultaneously
- The script can make progress on whatever path gets a result first

One HIT at a time

```
a = createHITAndWait()          // HIT A
b = createHITAndWait(...a...) // HIT B
c = createHITAndWait()          // HIT C
d = createHITAndWait(...c...) // HIT D
```

- B depends on A
- D depends on C
- They don’t depend on each other. Why wait?

Multiple HITs at a time

```
fork(function() {
    a = createHITAndWait()          // HIT A
    b = createHITAndWait(...a...) // HIT B
})
fork(function() {
    c = createHITAndWait()          // HIT C
    d = createHITAndWait(...c...) // HIT D
})
```

The **join** keyword

```
fork(...b = ...)
fork(...d = ...)
join()
e = createHITAndWait(...b...d...)
```

- **join** waits for all previous forks for finish

Calling Mechanical Turk

- TurKit adds several simple commands for interacting with MTurk
  - prompt
  - vote
  - sort

Calling MTurk: **prompt**

```
print(mturk.prompt(“When did Colorado become a state?”))
```

- **prompt** optionally allows a second argument with the number of responses

```
a = mturk.prompt(“What is your favorite color?”), 100)
```

Calling MTurk: **vote**

```
v = mturk.vote("Which is better?", [a, b])
// returns the list item with the most votes
```

- Optional 3rd argument to specify many votes to collect

Calling MTurk: **vote**

```
function vote(message, options) {
    // create comparison HIT
    var h = mturk.createHITAndWait({
        ...message...options...
        assignments : 3})
    // get enough votes
    while (...votes for best option < 3...) {
        mturk.extendHIT(...add assignment...)
        h = mturk.waitForHIT(h)
    }
    return ...best option...
}
```

Calling MTurk: **sort**

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

- This version just uses JavaScripts built-in sorting function
- Defines a comparator using mturk.vote
- Negative: comparisons are done serially

Under the hood

- TurKit is handles the MTurk API
- It generates web pages and CSS and hosts them on Amazon's S3 server
- Nice additional features, like disabling of form elements while in preview mode
- Uses Java Rhino to interpret JavaScript
- DB is serialized using JSON

TurKit

- IDE for writing TurKit scripts, running them, and automatically rerunning them
- TurKit “crashes” after publishing a HIT; re-running polls MTurk to check for result
- Provides controls for switching from sandbox into normal MTurk, clearing DB

Amazon Web Service Credentials

User

Turkit

aws access key id: AKIAJWIROTA3QHKOG

aws secret access key: ••••••••••••••••••••

user@gmail.com
logout

Projects

new project

HelloWorld
- props
- **main.js**
- output
- db
- new file
- hit.html

reset

OtherProject

Run Controls

main.js

```
print("Hello World")
print("Your balance is: " + mturkBase.getAccountBalance())

var w = webpage.create(read("hit.html"))

for (var i = 0; i < 2; i++) {
    fork(function () {
        var hitId = mturk.createHIT({
            title : "Simple question",
            desc : "Answer a simple question.",
            reward : 0.01,
            url : w
        })
        var hit = mturk.waitForHIT(hitId)

        print("Answer = " + hit.assignments[0].answer.choice)

        mturk.approveAssignment(hit.assignments[0])
        mturk.deleteHIT(hit)
    })
}
join()

webpage.remove(w)
```

output

```
Hello World
Your balance is: 10000
Answer = 42

crashed - waiting on hit:
1QQJRV9TXEVEZQM7K62JHJREVJXTHA

crashed - ready to rerun
```

Output

execution trace

- create webpage
- fork
  - createHIT
  - waitForHIT
  - approveAssignment
  - deleteHIT
- fork
  - createHIT
  - waitForHIT

Execution Trace

Getting Started

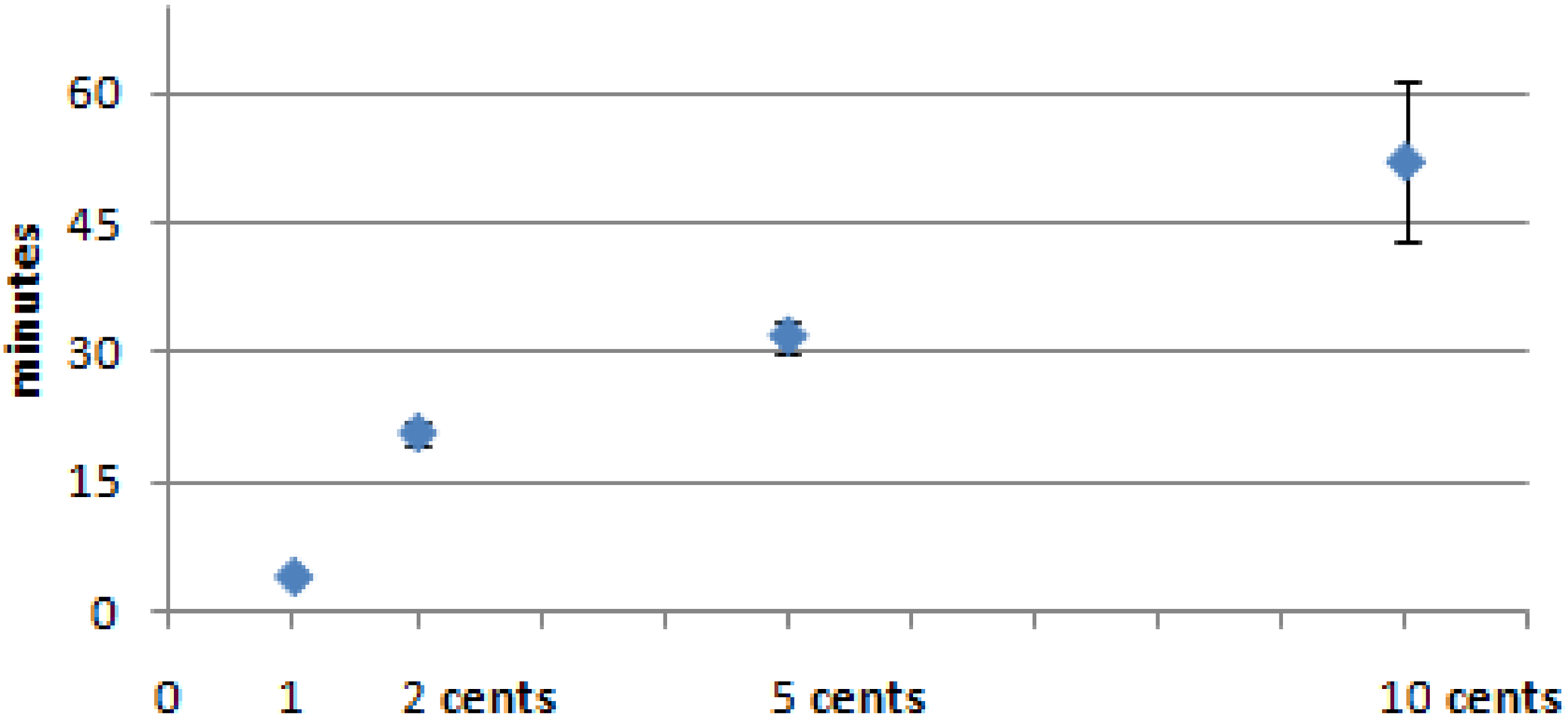
API reference

example projects

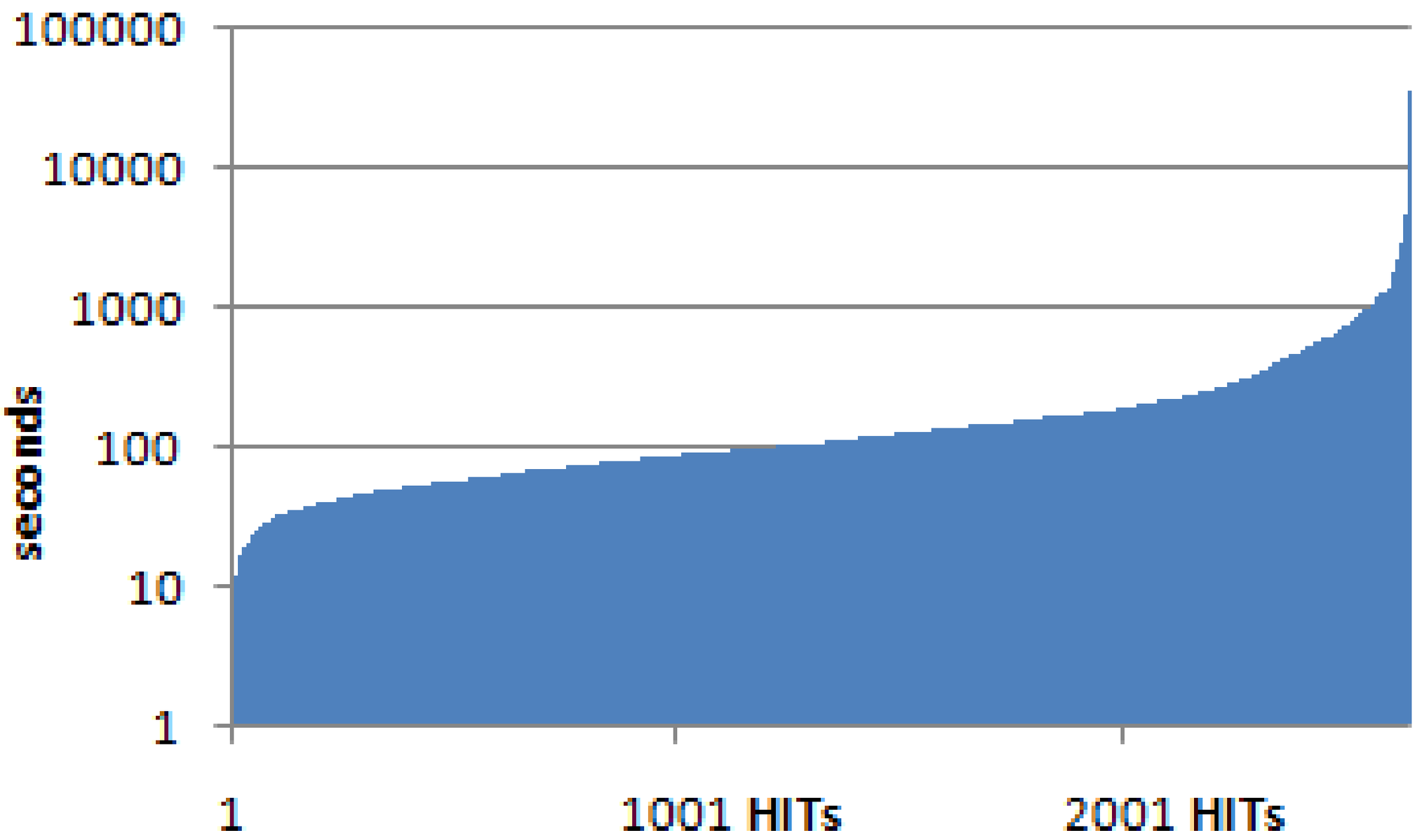
hello world	clone
iterative writing	clone
brainstorming	clone
sorting	clone

Editor

Time for results to come back, by reward amount

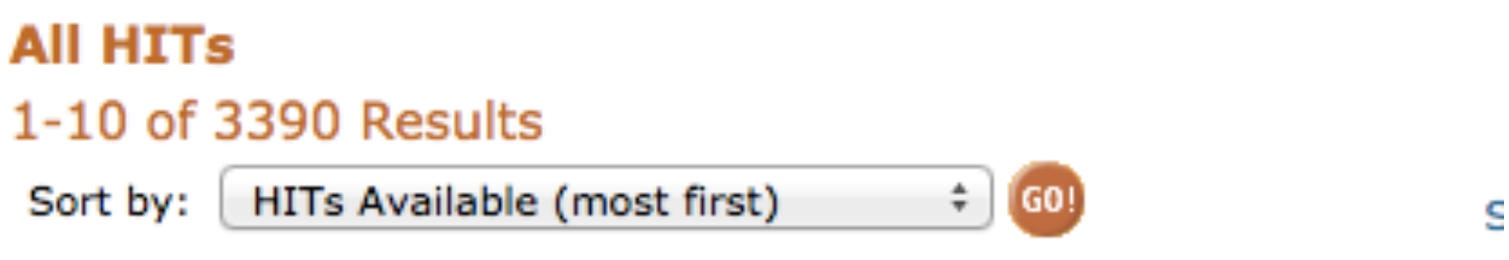


Time for first $0.01 assignment to complete

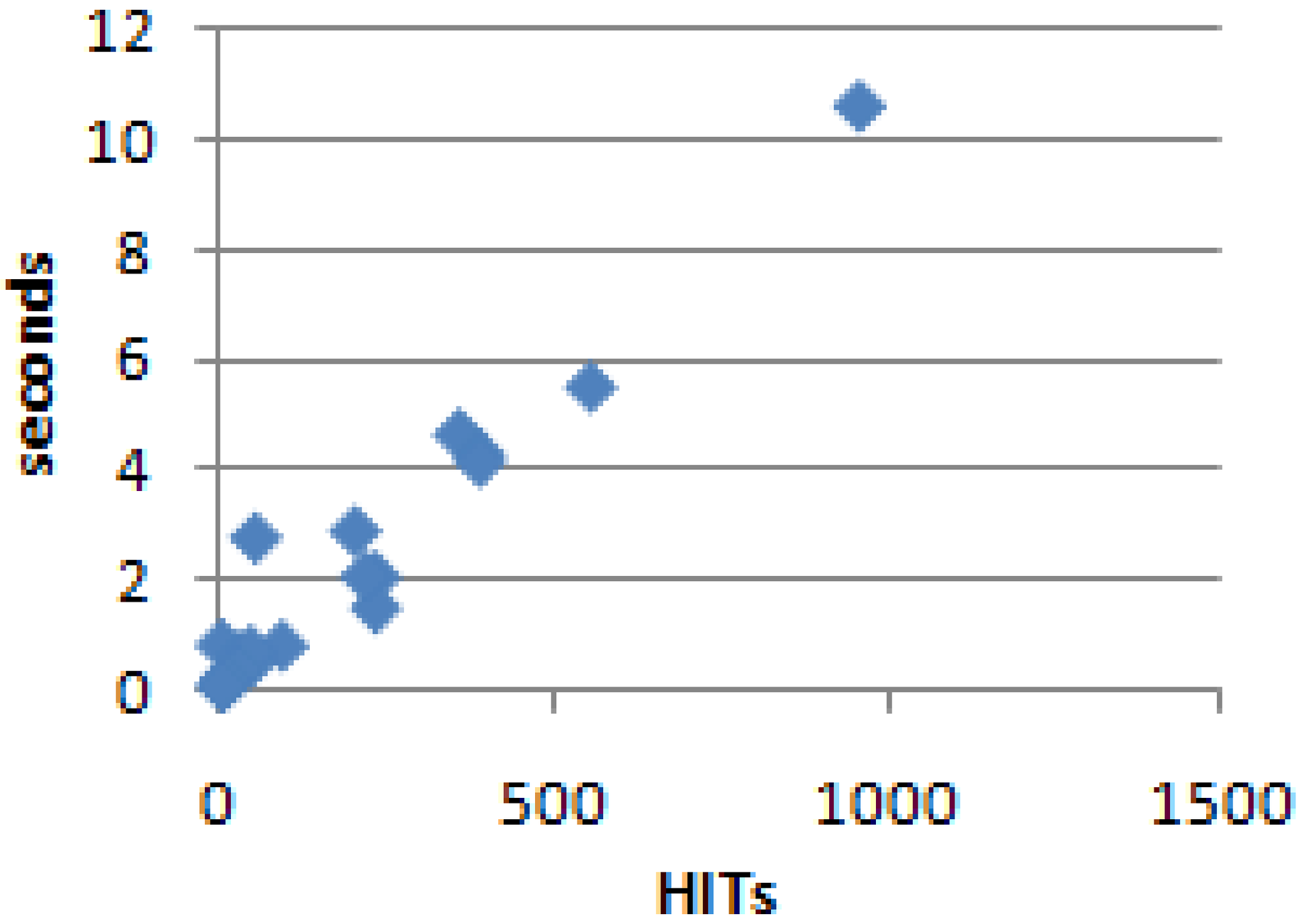


Dealing with Latency

- Build the programming language to deal with high-latency operations
- Do something to optimize throughput on MTurk
- One (nefarious) example: artificially inflate number of assignments in your HIT to get front-page placement



Time to execute once all HITs have been cached



Pros and Cons of TurKit?

Pros and Cons of TurKit

- **con:** Scalability - assumes local computation is minimal. Rerunning after each HIT might be tedious if task is large
- **con:** Parallel programming - not completely general in TurKit. **once, fork** and **join** do not give enough state.
- **pro:** Experimental replicability - usually one downside of human computation is that results with differ each time. Not so with TurKit!

What experiments would you run?

For Friday:
Finish HW5 "Become a Requester" (Warning: post your tasks to CrowdFlower EARLY)

Submit your Company Profile Video

http://crowdsourcing-class.org/