

Computational Environment Design

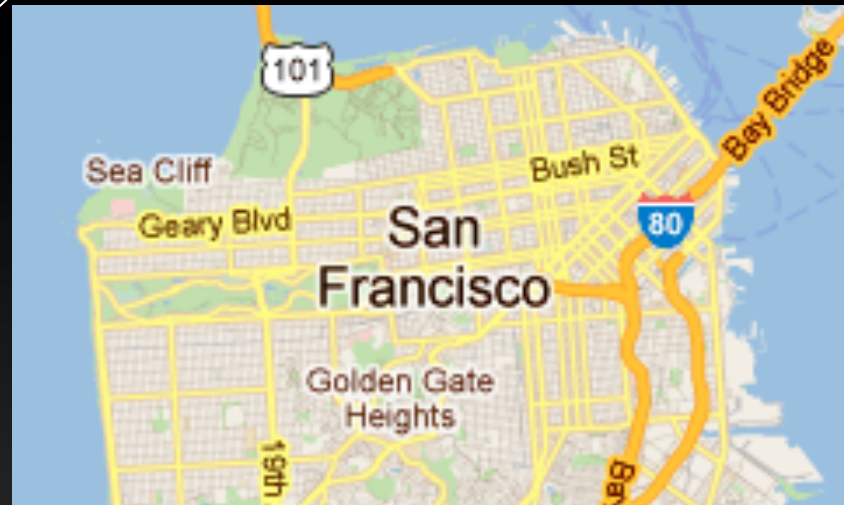


Haoqi Zhang

Harvard University

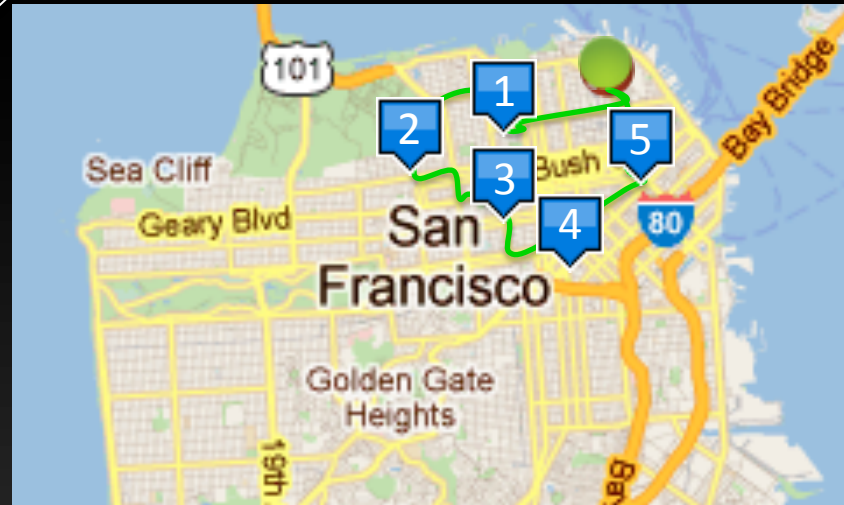
amazing cafes
cool art
somewhere to read

...

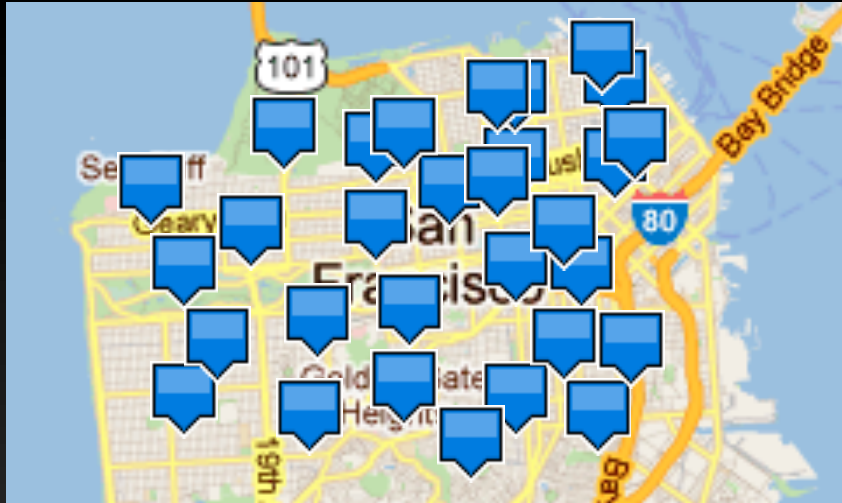


amazing cafes
cool art
somewhere to read

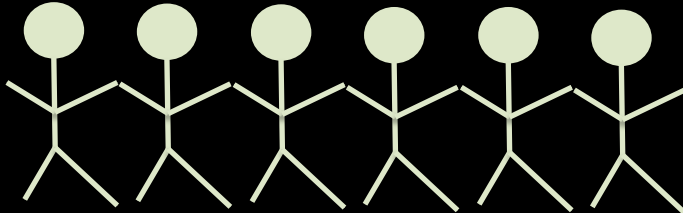
...



amazing cafes
cool art
somewhere to read
...



amazing cafes
cool art
somewhere to read
...



Computational Environment Design

the problem of constructing decision environments
on the Web that elicit effective user actions

Computational Environment Design

the problem of constructing decision environments on the Web that elicit effective user actions



decision
environment

interface or workflow
incentives
feedback to users
constraints on actions
.....

decision
environment



participants

interface or workflow
incentives
feedback to users
constraints on actions
.....

knowledge and abilities
interests and motivations
availability
.....

decision
environment



participants



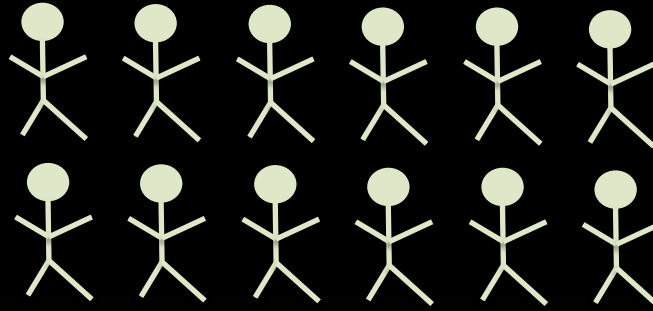
actions

interface or workflow
incentives
feedback to users
constraints on actions
.....

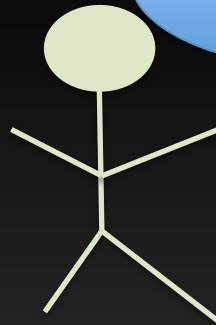
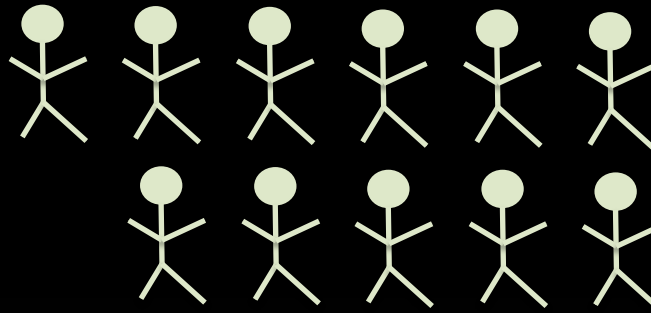
knowledge and abilities
interests and motivations
availability
.....

planning an itinerary
answering a question
routing a task to another user
.....

crowds



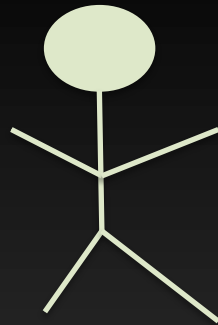
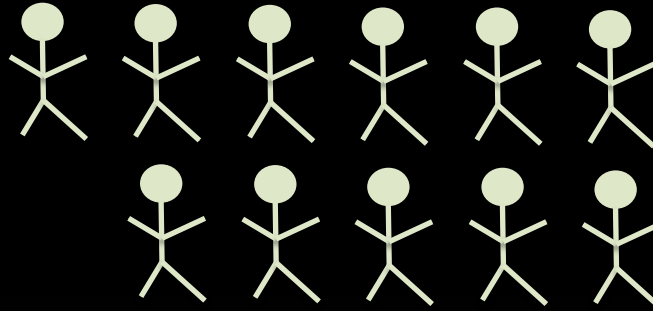
crowds



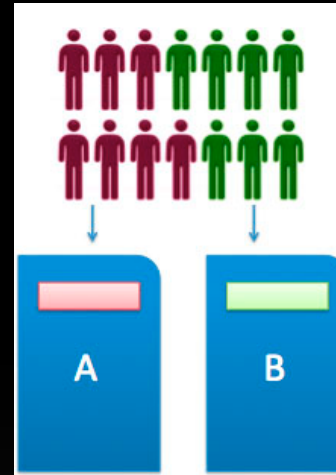
iPhone!



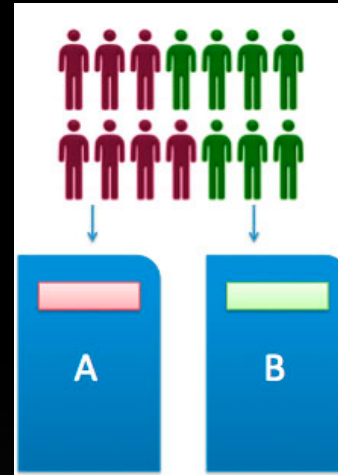
crowds



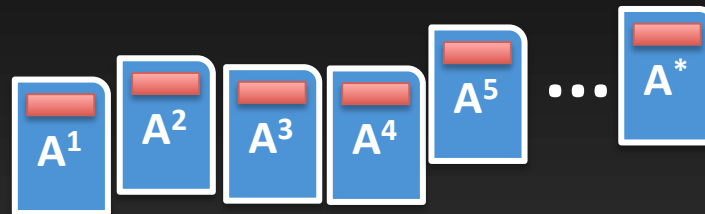
data-driven iterative design



data-driven iterative design

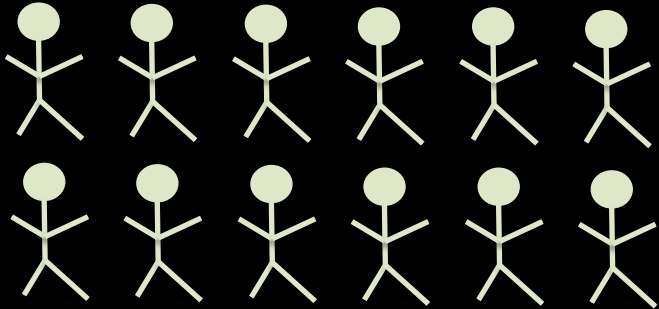


Performance



Experiments

my contributions



crowdsourcing
complex tasks



automated
environment design

my approach:
reason and **learn**
about participants

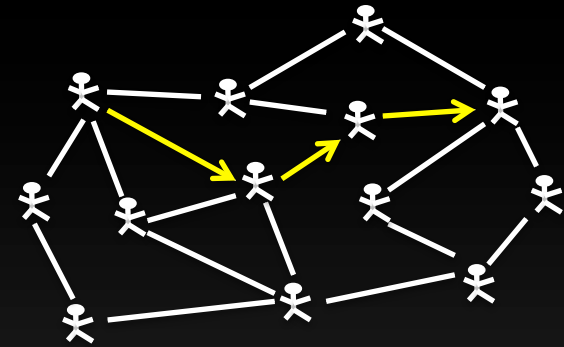


this talk

human computation tasks
with global constraints



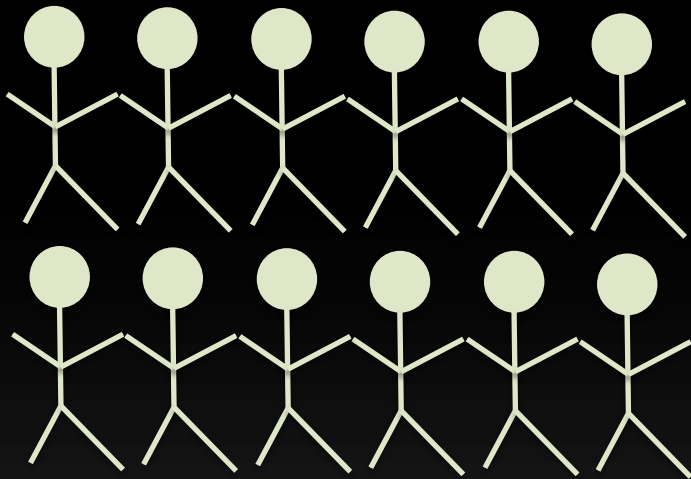
task routing



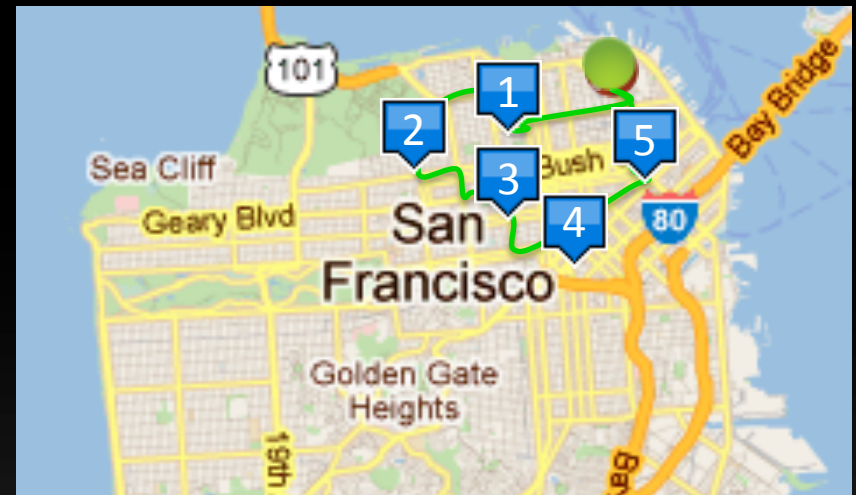
automated workflow synthesis



human computation with global constraints

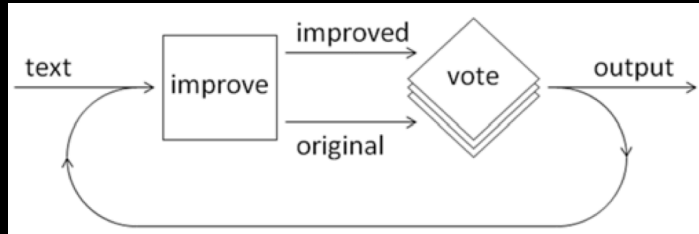


many small contributions

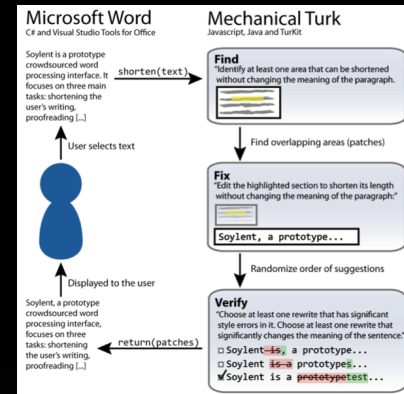


difficult to decompose

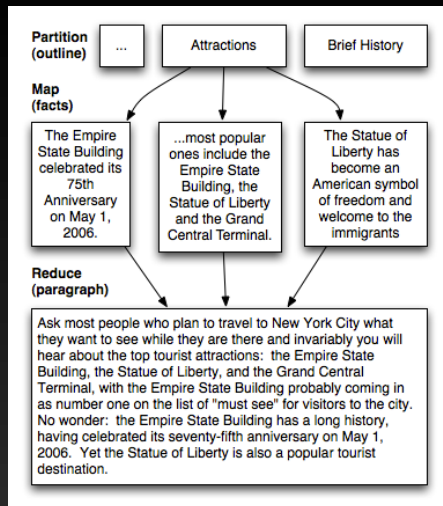
human computation algorithms



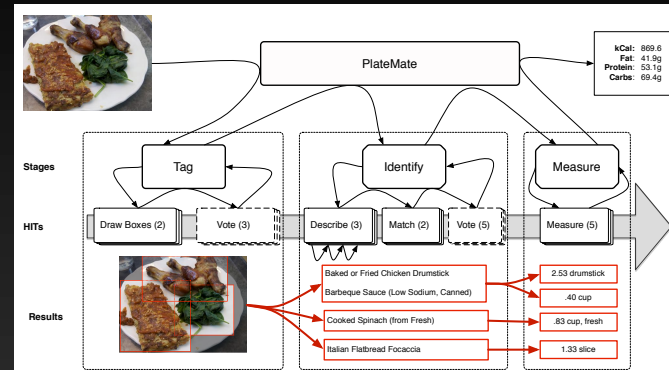
[Little et al., UIST 2010]



[Bernstein et al., UIST 2010]



[Kittur et al., UIST 2011]



[Noranha et al., UIST 2011]

Mobi

[Zhang, Law, Miller, Gajos, Parkes, Horvitz, CHI '12]

Going to San Francisco

Saturday, 11am to 10pm

What I am looking for:

I am going to San Francisco for a conference and have a day to explore the city before the conference starts. I'd love to go to some amazing cafes, check out some cool artsy things, and also just to relax and read a little.

Specific requirements:

- have at least 2 cool artsy things activities.
- have at least 1 place to read activity.
- have at least 1 amazing coffee/cafe activity.
- spend at least 3 hours on fresh local foods.

qualitative
constraints

quantitative
constraints

Going to San Francisco












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- have at least 2 cool artsy things activities
- have at least 1 place to read activity
- have at least 1 amazing coffee/cafe
- spend at least 3 hours on fresh local

	arrive at Hyatt Regency	(11:00am)
	Cool cafe + People watching	(11:15am–11:45am)
	place to read	(11:55am–12:25pm)
	Ferry Plaza Farmers Market	(12:35pm–2:05pm)
	San Fran Museum of Modern Art	(2:20pm–4:20pm)
	Art at Grace Cathedral	(4:35pm–5:05pm)
	Stop at Philz Coffee	(5:25pm–6:10pm)
	balmy alley murals	(6:40pm–7:10pm)
	Local food at unique Localvore restaurant	(7:25pm–8:55pm)
	Westin St. Francis glass elevators	(9:15pm–9:45pm)
	arrive at Hyatt Regency	(9:55pm)

Our brainstream

#fresh local food restaurants #cool artsy things
 #people watch #amazing coffee/cafes
 #somewhere to read #todo #activity #note

search or add an idea, or click on one below

Add more things to the itinerary !
 There is still 5 hours and 3 minutes left empty in the itinerary. The trip can go till 10:00pm.
 #todo #time

Add more 'amazing coffee/cafes' to the itinerary !
 We need at least 2 amazing coffee/cafes activities. The current itinerary contains 1 amazing coffee/cafes activities. [...]
 #todo #amazing coffee/cafes

Add more 'cool artsy things' to the itinerary !
 We need at least 2 cool artsy things activities. The current itinerary contains 1 cool artsy things activities. The [...]
 #todo #cool artsy things

Cool cafe + People watching 1
 Check out this North Beach cafe for great coffee and even better people watching!
 #activity #people watch #amazing coffee/cafes

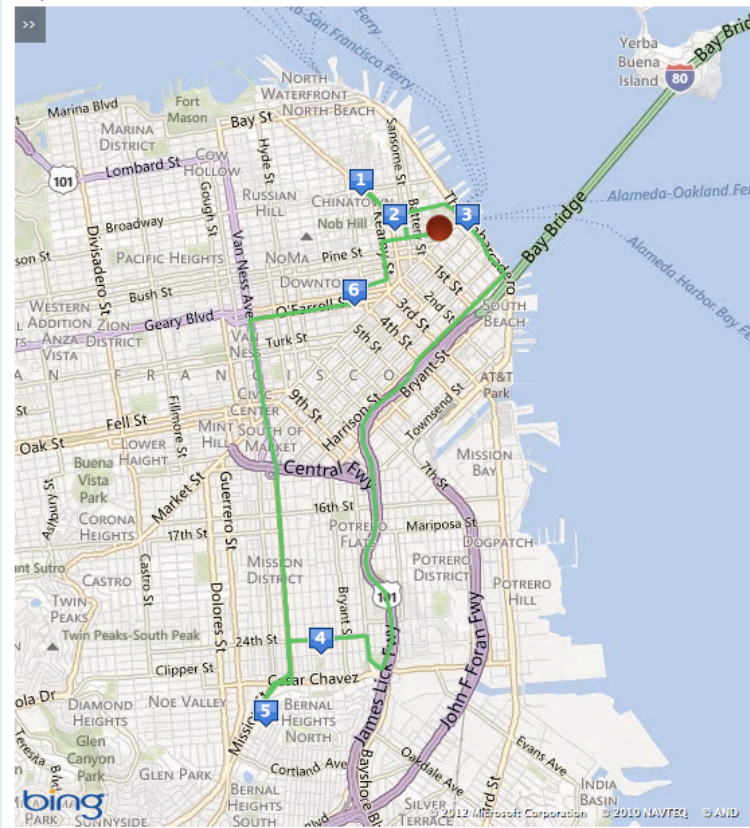
Art at Grace Cathedral
 See the triptych created by world famous artist Keith Haring, marvel at the murals and the beautiful stained glass [...]
 #activity #cool artsy things

Starbucks for coffee
 get some coffee
 #activity #amazing coffee/cafes

Ferry Plaza Farmers Market 3
 Fresh local food. The back walkway, which has views of the bay and the coming and going of the ferries, is also a great [...]
 #activity #fresh local food restaurants #people watch #somewhere to read

Map

Trip time: 5 hours and 57 minutes



Itinerary

drag activities to reorder, click to edit/remove

- arrive at Hyatt Regency (11:00am)
- 1 Cool cafe + People watching (11:05am-11:35am)
- 2 place to read (11:45am-12:15pm)
- 3 Ferry Plaza Farmers Market (12:25pm-1:55pm)
- 4 balmy alley murals (2:05pm-2:35pm)
- 5 Local food at unique Localvore restaurant (2:40pm-4:10pm)
- 6 Westin St. Francis glass elevators (4:25pm-4:55pm)
- arrive at Hyatt Regency (5:00pm)

Our brainstorm

#fresh local food restaurants #cool artsy things
#people watch #amazing coffee/cafes
#somewhere to read #todo #activity #note

Add more things to the itinerary

There is still 5 hours and 3 minutes left empty in the itinerary. The trip can go till 10:00pm.

[#todo](#) [#time](#)

Add more 'amazing coffee/cafes' to the itinerary

We need at least 2 amazing coffee/cafes activities. The current itinerary contains 1 amazing coffee/cafes activities. [...]

[#todo](#) [#amazing coffee/cafes](#)

Add more 'cool artsy things' to the itinerary

We need at least 2 cool artsy things activities. The current itinerary contains 1 cool artsy things activities. The [...]

[#todo](#) [#cool artsy things](#)

Cool cafe + People watching

Check out this North Beach cafe for great coffee and even better people watching!

[#activity](#) [#people watch](#)

[#amazing coffee/cafes](#)

Art at Grace Cathedral

See the triptych created by world famous artist Keith Haring, marvel at the murals and the beautiful stained glass [...]

video demo

crowdware

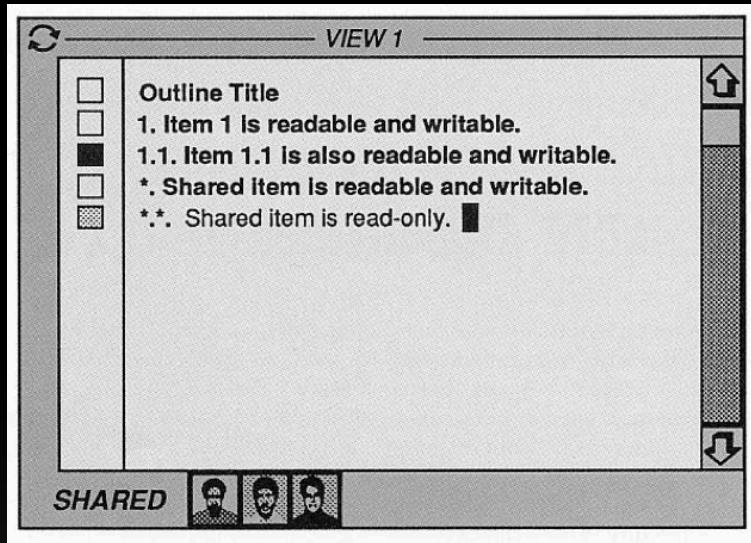
(a) the crowd contributes opportunistically given the current solution context

The screenshot shows a web interface titled "visiting harvard in the summer". It features a "Map" section with a street view of Harvard University and a "Itinerary" section with a list of activities. The itinerary includes:

- arrive at MBTA-HARVARD (9:30am)
- Explore Harvard Yard (9:32am-9:47am)
- Take pictures with the John Harvard Statue (9:47am-10:02am)
- Visit Memorial Church and Widener Library (10:05am-10:10am)
- See Annenberg (10:15am-10:20am)
- Visit the Science Center (10:26am-10:41am)
- greenhouse cafe (10:44am-10:54am)
- Visit the Museum of Natural History (10:57am-12:12pm)
- get a sandwich at Darwin's (12:24pm-1:24pm)
- Walk along the Charles River (1:32pm-2:17pm)
- Check out the Boathouse (2:17pm-2:32pm)
- Get Bubble Tea at the Boston Tea Stop (2:36pm-2:41pm)
- Shop at Berk's Clothing and Shoes (2:41pm-3:11pm)
- shop at Urban Outfitters bargain basement (3:12pm-3:42pm)
- buy harvard stuff at coop (3:43pm-4:28pm)
- arrive at MBTA-HARVARD (4:28pm)

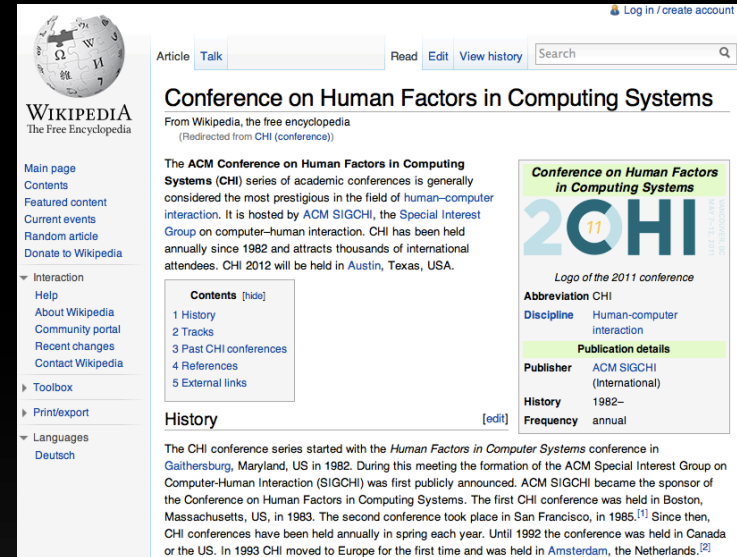
(b) the system indirectly coordinates the problem solving effort

Add more 'shopping' to the itinerary
We need at least 1 hour of shopping. The current itinerary contains no shopping.
#todo #shopping



Groupware

[Ellis et al., CACM 1991]



Wikipedia

[Cosley et al., UII '07]
[Hoffman et al., CHI '09]

experiment

Our brainstream
#shopping #lunch #non-touristy
#museum #campus must-sees #todo
#activity #note

search or add an idea, or click on one below Add

Add to the itinerary or spend more time on existing activities !
There is still 2 hours and 49 minutes left empty in the itinerary. The trip can go till 4:30pm.
#todo #time

Add more 'shopping' to the itinerary !
We need at least 1 hour of shopping. The current itinerary contains no shopping.
#todo #shopping

Add more 'campus must-sees' to the itinerary !
We need at least 2 hours of campus must-sees. The current itinerary contains 45 minutes of campus [...]
#todo #campus must-sees

Check out Glass Flowers
the glass flowers
#activity #museum

Cambridge 1
the potato pizza is delicious
#activity #lunch

TODO

Our brainstream
#shopping #lunch #non-touristy
#museum #campus must-sees #todo
#activity #note

search or add an idea, or click on one below Add

Check out Glass Flowers
the glass flowers
#activity #museum

Cambridge 1
the potato pizza is delicious
#activity #lunch

Take a pic where Good Will Hunting was born!
Matt Damon and Ben Affleck wrote their movie here. How you like them apples?
#activity

walk by the river 3
Might be a little cold..
#activity #non-touristy

bartley's burgers 2
Have any of their burgers. It's great.
#activity #lunch

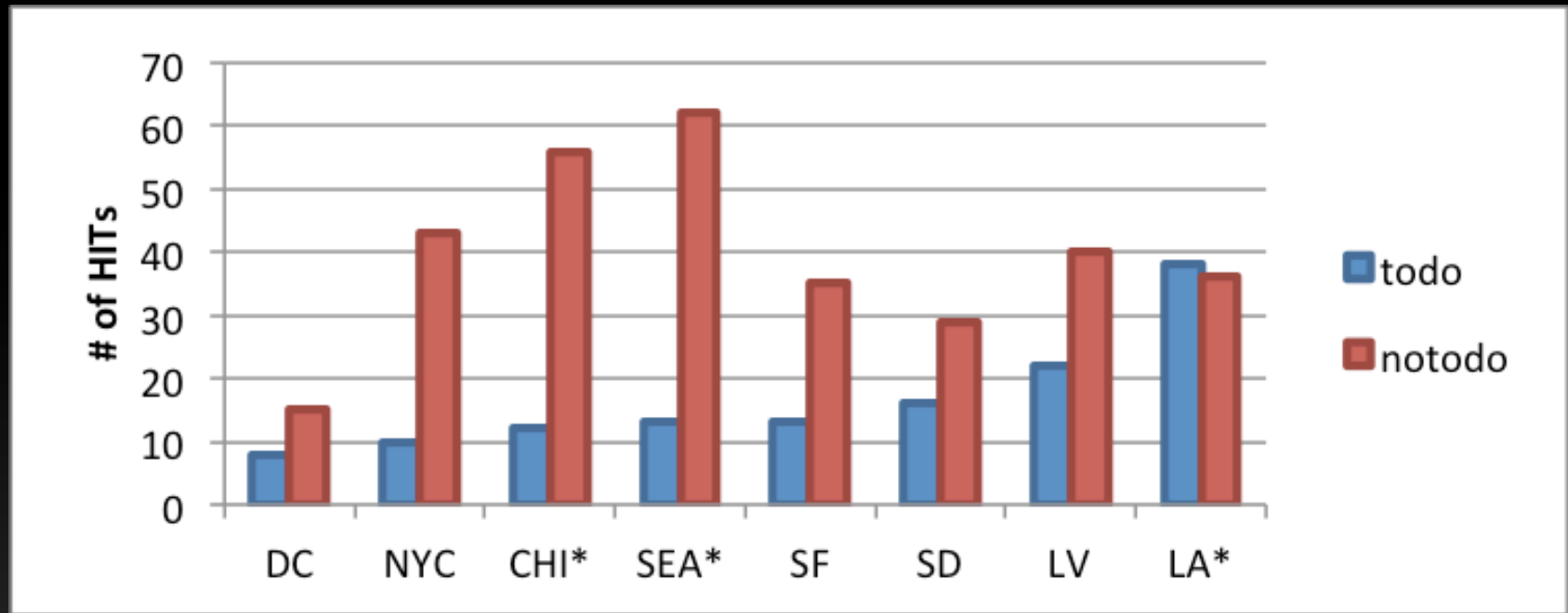
Sneak into Annenburg
Don't get caught
#activity #campus must-sees

visit the geological museum
glass flower exhibit

NO TODO

Mechanical Turk workers
paid \$0.15 for any micro-contribution

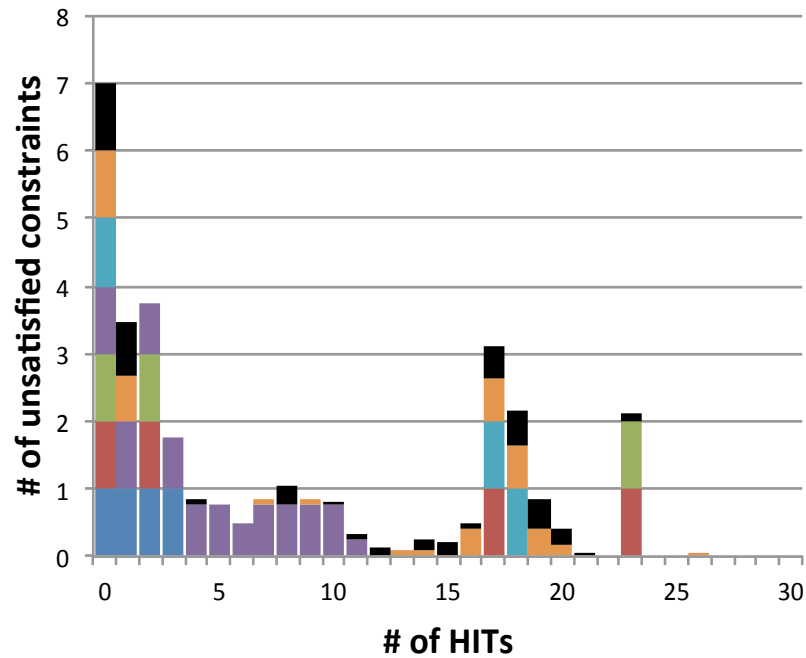
TODO condition resolves quantitative constraints quicker



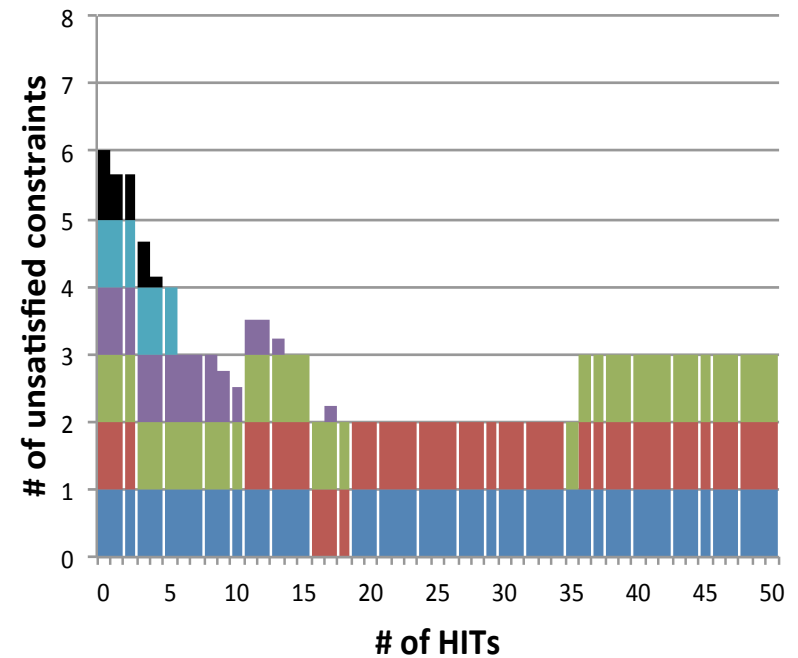
[*] the notodo condition never satisfied all the constraints

Chicago

TODO



NO TODO



- breakfast (=1)
- lunch (=1)
- dinner (=1)
- break (≥4)
- architecture (≥1)
- kid-friendly (≥6h)
- total time (≈12h)

end-to-end user study

Study: 10 subjects enter missions into Mobi

Result: All subjects found crowd-generated itineraries to satisfy their mission, and would use them in real life.

human computation tasks with global constraints

task routing

automated workflow synthesis

visiting harvard in the summer

Our brainstream

- campus tour sites #shopping #lunch #non-touristy #solo #activity #photo
- Check out the Boathouse
- Classic Harvard
- Activity: #campus tour sites
- Shop at Berk's Clothing and Shoes
- Clothing and Shoe Store
- activity: #shopping
- Shop at the Harvard Student Agencies
- Shop
- Activity: #campus tour sites
- greenhouse cafe
- eat lovely snack food (such as amazing garlic knots)
- activity: #non-touristy
- Explore Harvard Yard
- Activity: #campus tour sites
- mbi admin: shopping requirement reduced
- Good point - 2 hours is too long if a requirement for shopping.
- Activity: #shopping
- The much required shopping time
- Not all tour need it to some high to large percentage of their trip
- shopping: I can't do it anymore
- Activity: #shopping
- Walk Cambridge Commons
- Cambridge Commons

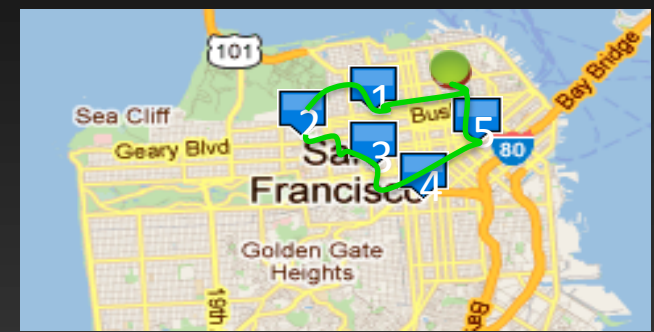
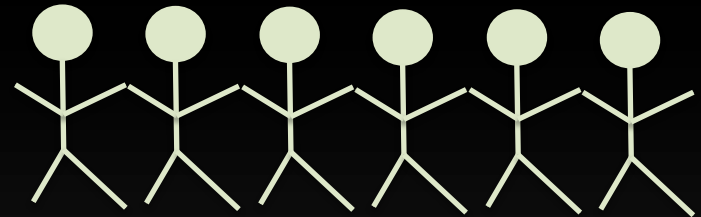
Map

Top time: 5 hours and 58 minutes

Itinerary

- arrive at MITA-JANUARD (9:30am)
- Explore Harvard Yard (9:32am-9:47am)
- Take pictures with the John Harvard Statue (9:47am-10:02am)
- Visit Memorial Church and Widener Library (10:05am-10:20am)
- See Annenberg (10:15am-10:20am)
- Visit the Science Center (10:26am-10:41am)
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Add more 'shopping' to the itinerary
We need at least 1 hour of shopping. The current itinerary contains no shopping.
#todo #shopping



human computation tasks
with global constraints

task routing

automated workflow synthesis

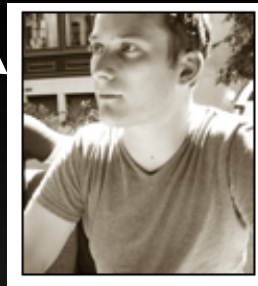
How do I prove
this theorem?



How do I prove
this theorem?



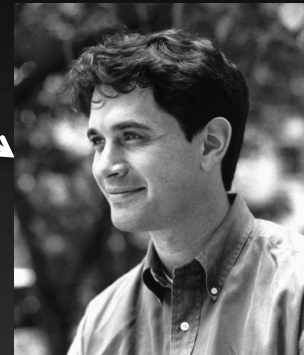
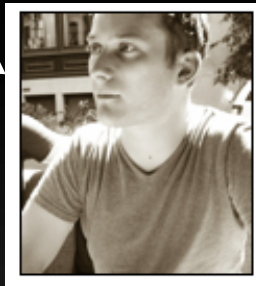
You need to reduce
it to something...



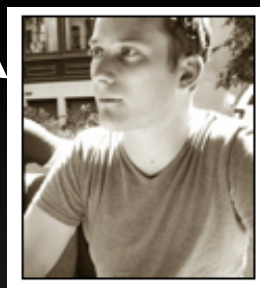
How do I prove
this theorem?



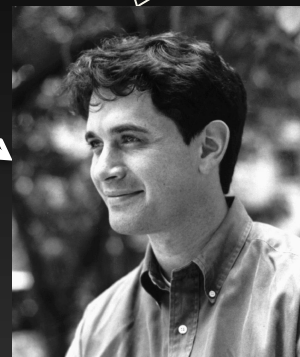
try Michael.
He might know.



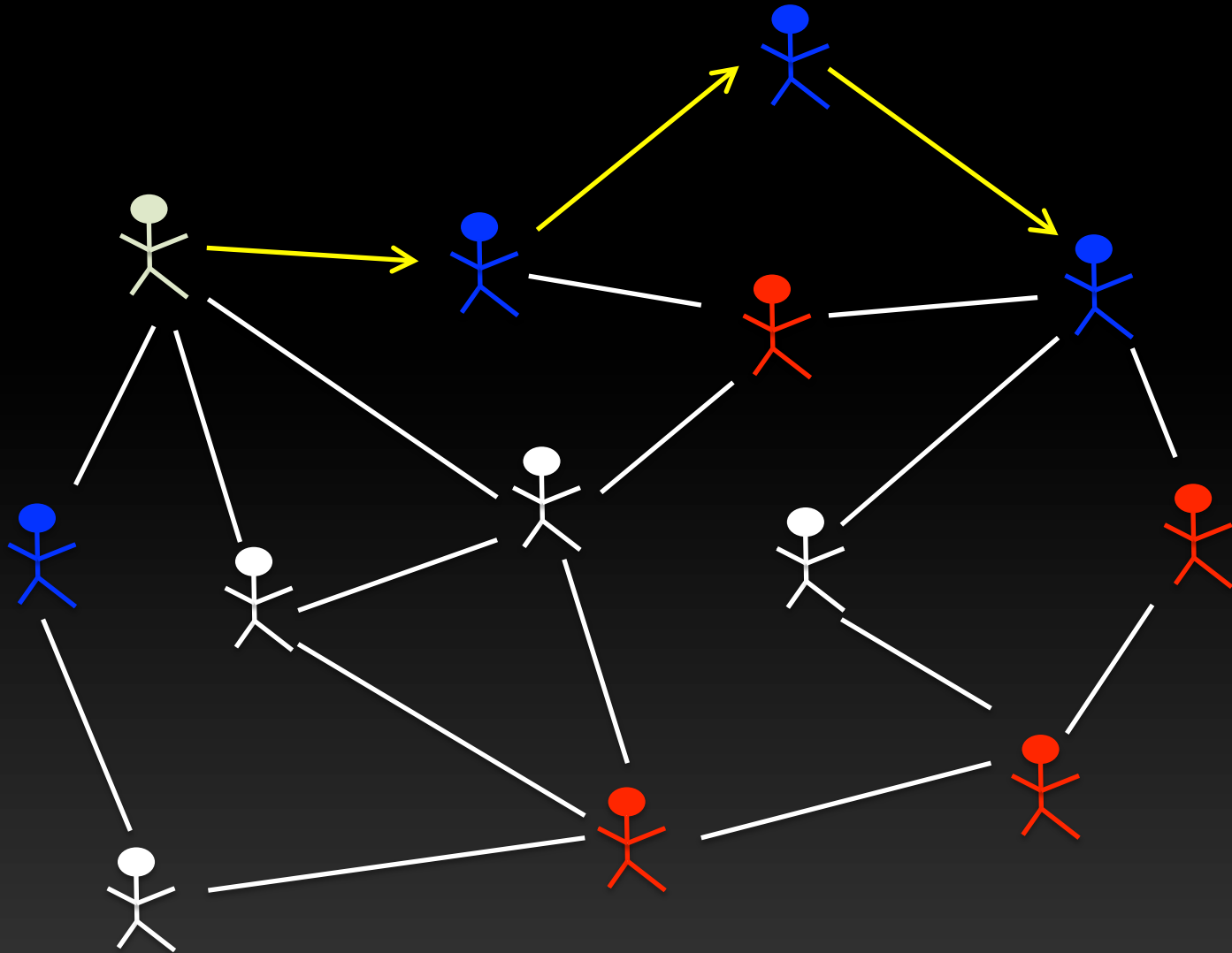
How do I prove
this theorem?



sometimes when you
can't prove A or B, you
need to prove C.



task routing over social networks



task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

- ✧ will Obama win in 2012?
- ✧ will the iPhone 5 be taller than the iPhone 4S?

task routing for prediction tasks

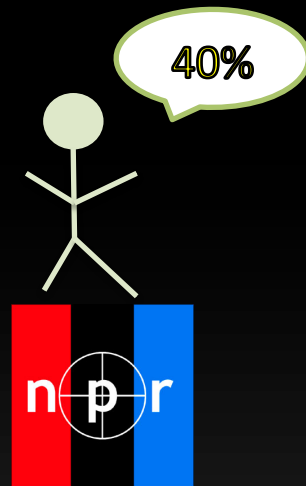
[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

Will Obama
win in 2012?

task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

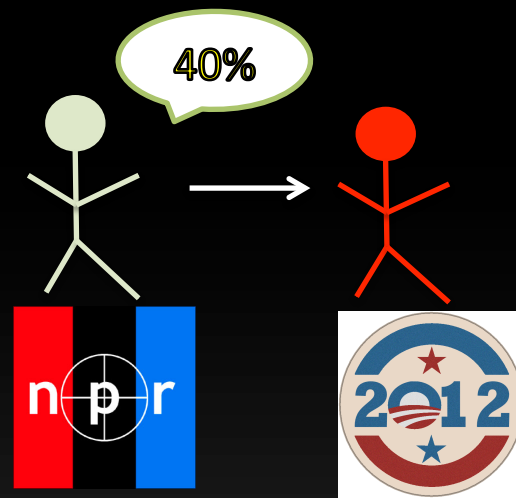
Will Obama
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task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

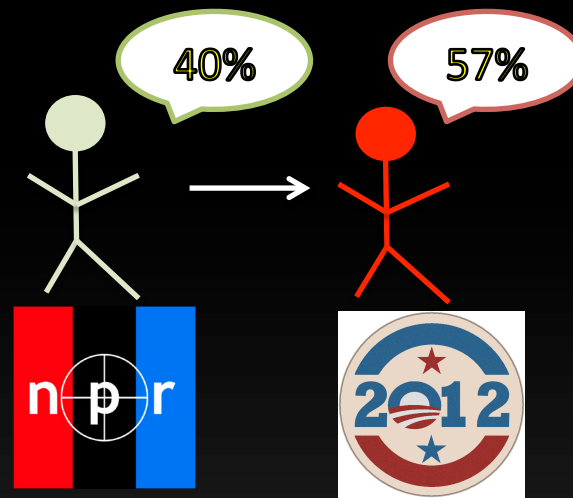
Will Obama
win in 2012?



task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

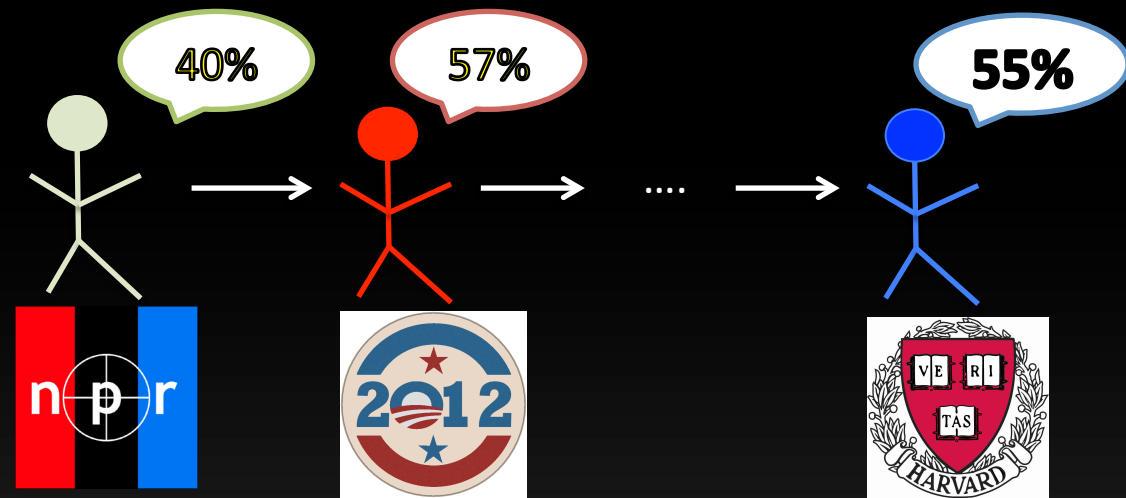
Will Obama
win in 2012?



task routing for prediction tasks

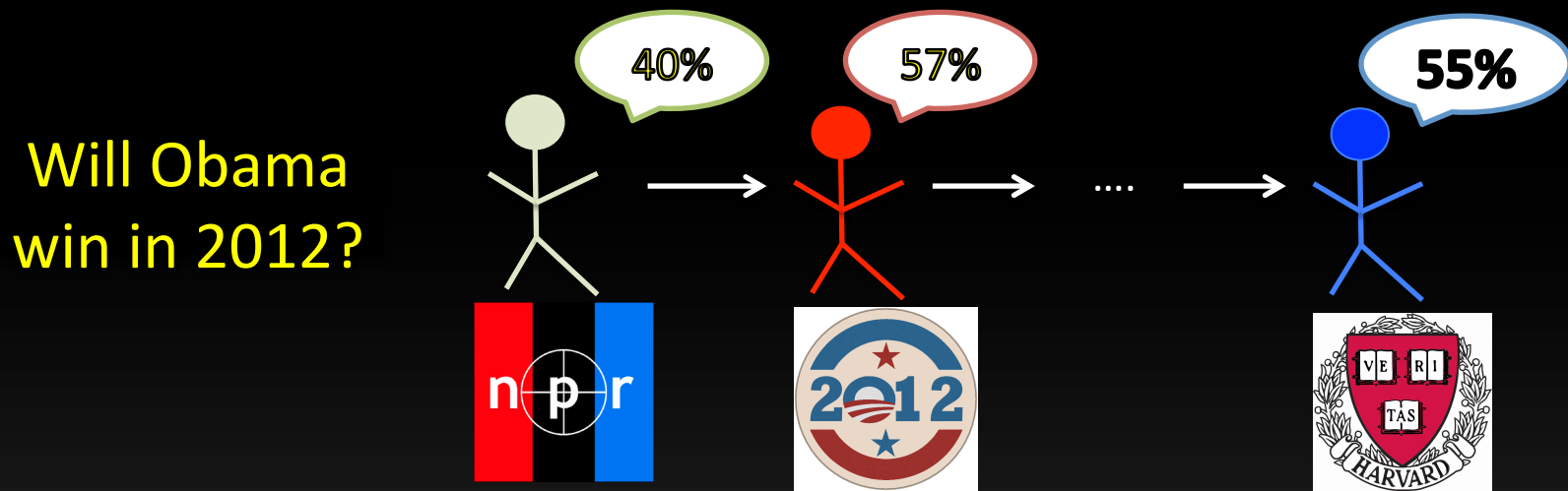
[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

Will Obama
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task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]



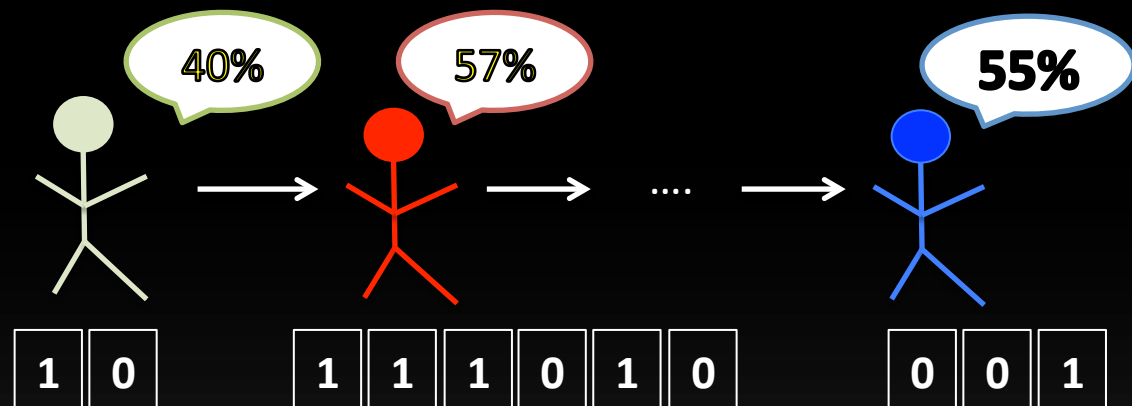
Design incentives such that in equilibrium:

- ✧ people report honestly
- ✧ people make good routing decisions

task routing for prediction tasks

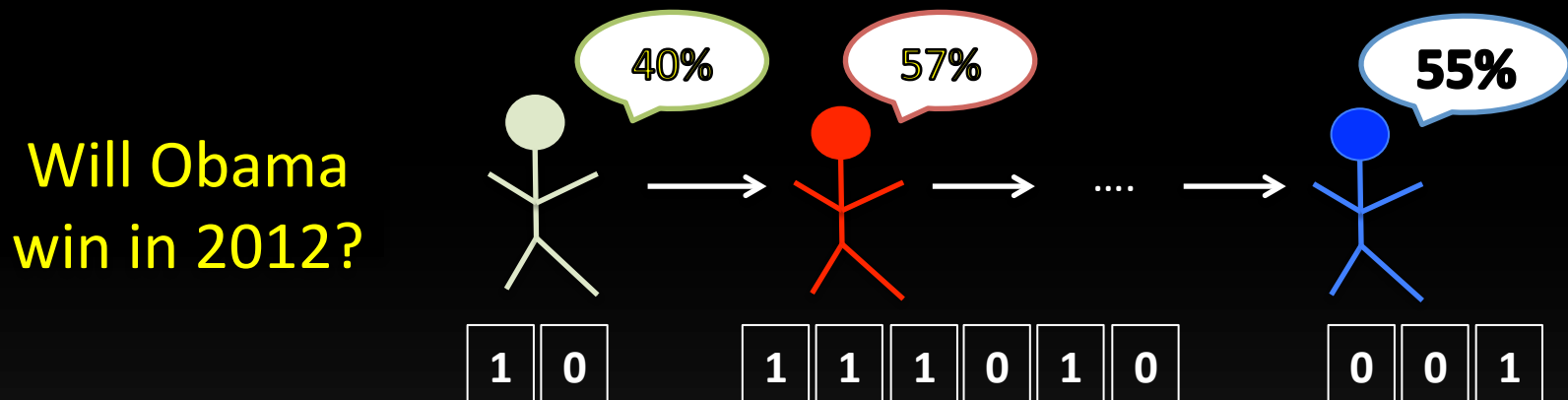
[Zhang, Horvitz, Chen, Parkes, AAMAS '12]

Will Obama
win in 2012?



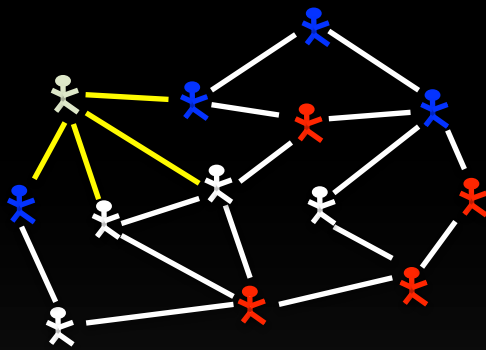
task routing for prediction tasks

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]



- ✧ players observe conditionally independent bits of signal based on true state
- ✧ Bayesian model; assume common prior and known signal distribution

incentives

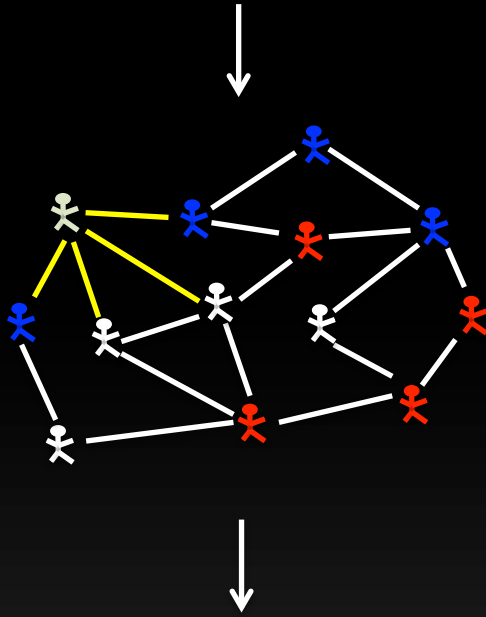


local knowledge of
others' expertise



report honestly,
route effectively

incentives



Local common knowledge

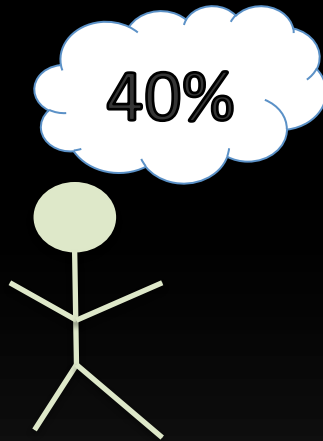
everyone knows how many bits of information people within m -hops hold, and this is common knowledge.

report honestly,
route effectively

strictly proper scoring rules

[Good '52, Winkler '69, Savage '71]

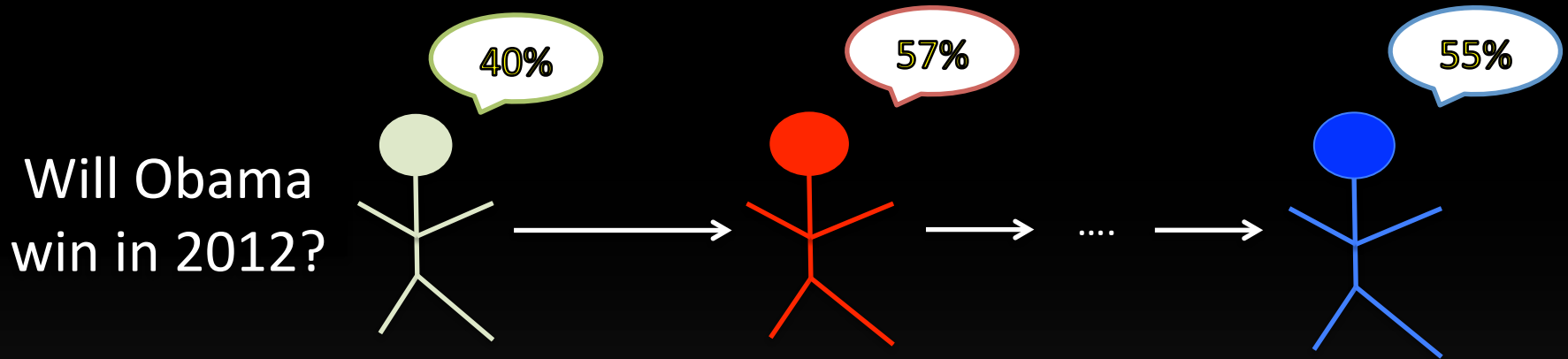
Will Obama
win in 2012?



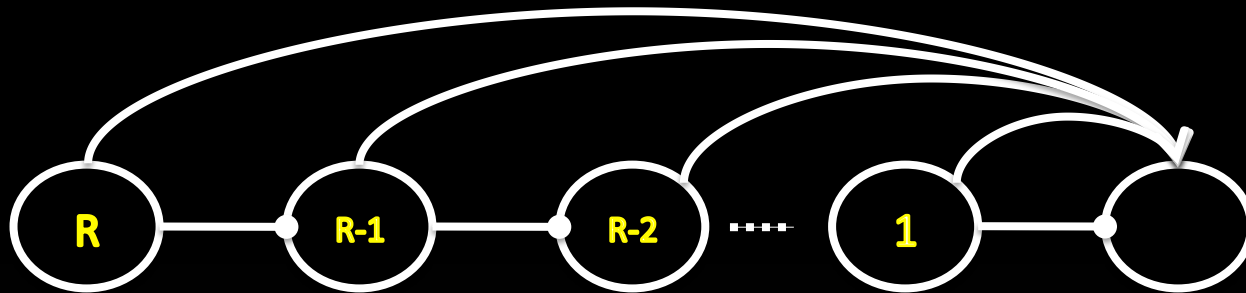
$$S(q) = \begin{cases} 1 - (1 - q)^2 & \text{if win} \\ 1 - q^2 & \text{if lose} \end{cases}$$

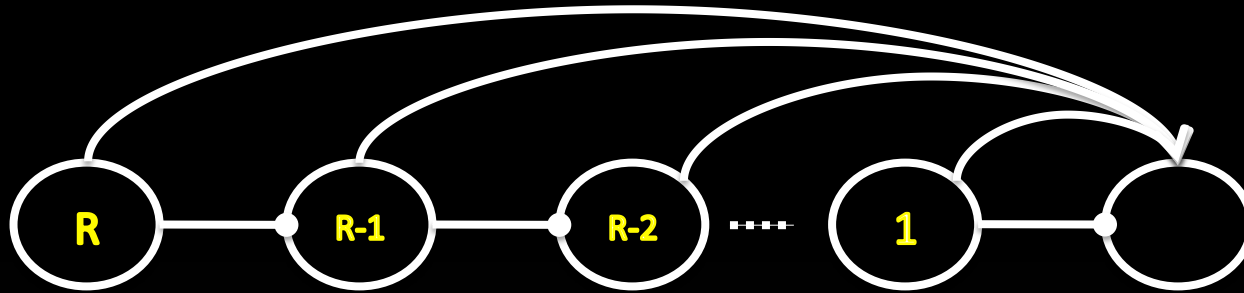
routing scoring rules

[Zhang, Horvitz, Chen, Parkes, AAMAS '12]



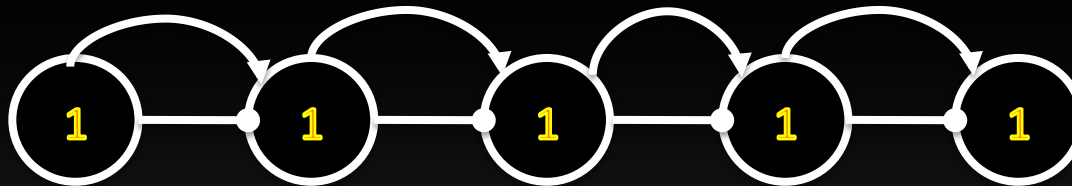
$$S(q_i) + S(q_{i+k})$$



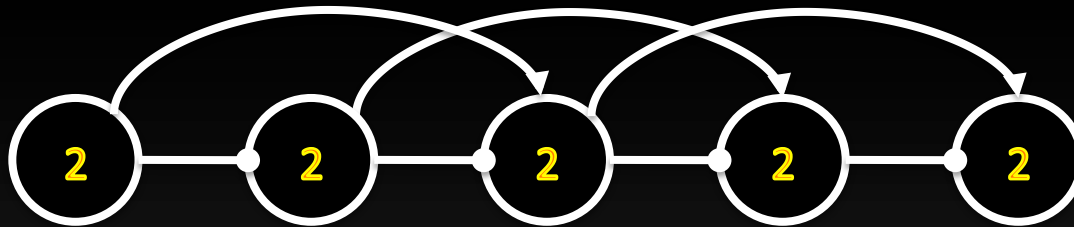


✧ people may only know others' expertise within a local neighborhood.

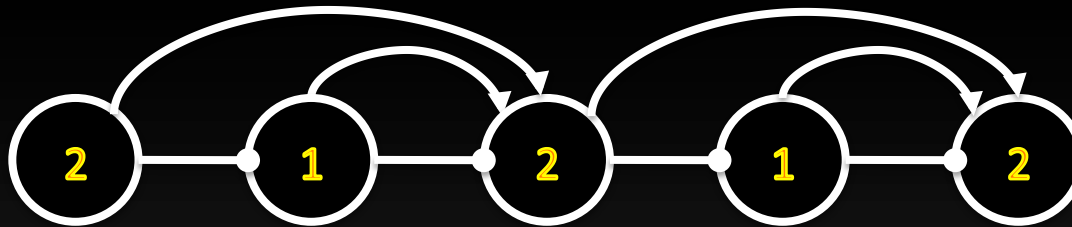
myopic routing rule



2-2-2-2



2-1-2-1



local routing rules

routing payment for player i must:

- (a) stay within m -hops

local routing rules

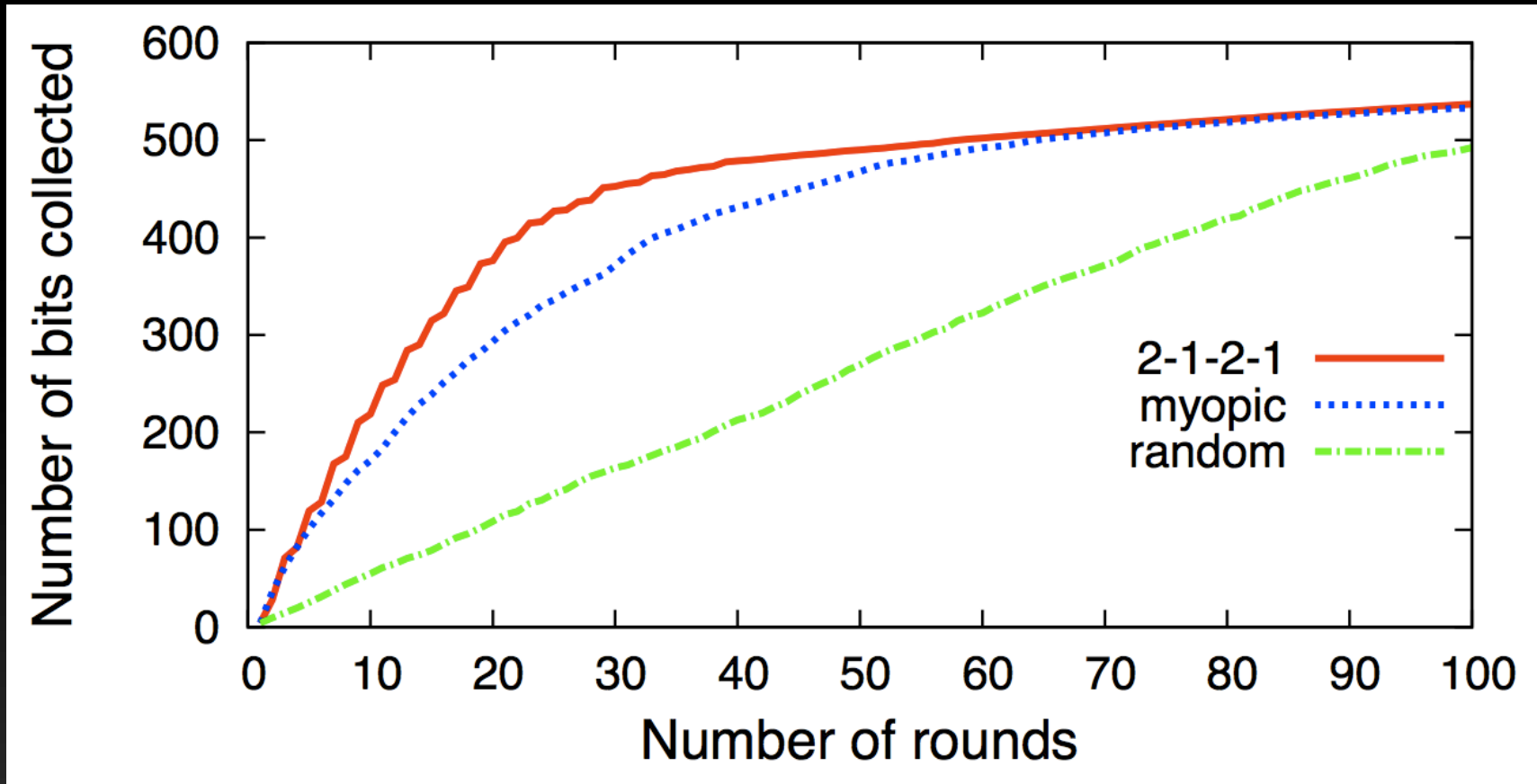
routing payment for player i must:

- (a) stay within m -hops
- (b) only reach players whose routing payment stays within m -hops of player i

theorem

Local routing rules induce equilibrium in which players **report honestly** and **route based on local information**.

benefit of local routing scoring rules

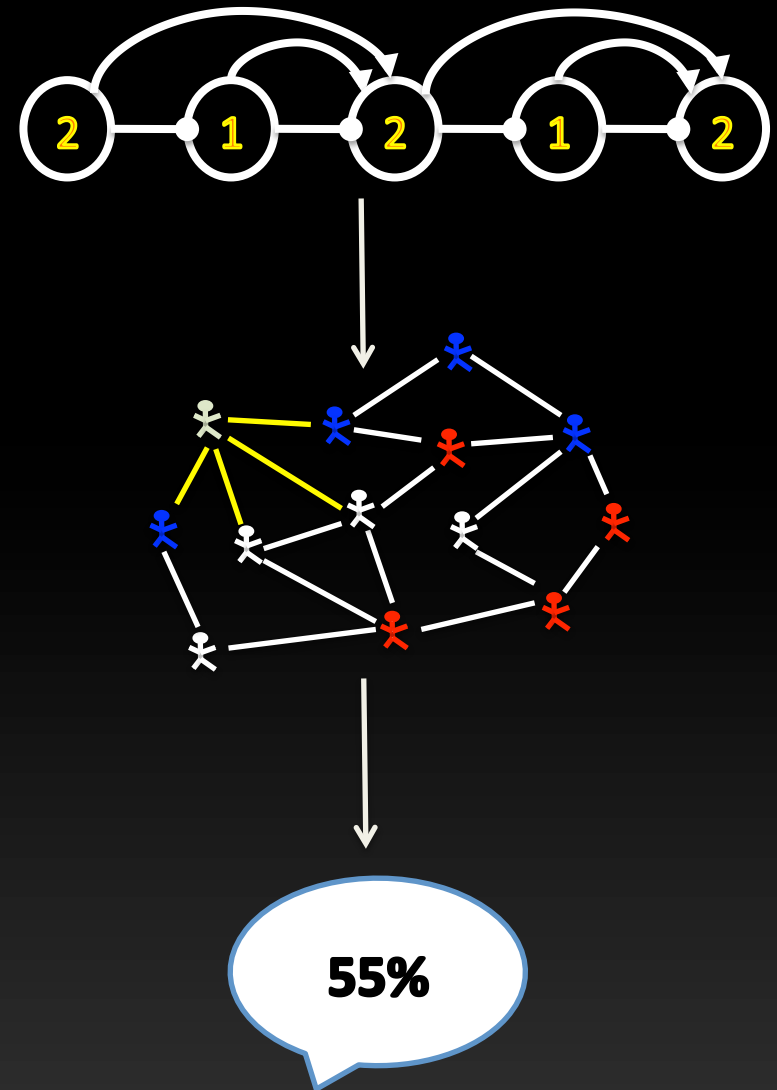


[graphs generated using the Watts-Strogatz model, with $\beta = 0.1$, $n = 100$, $d = 10$]

human computation tasks
with global constraints

task routing

automated workflow synthesis

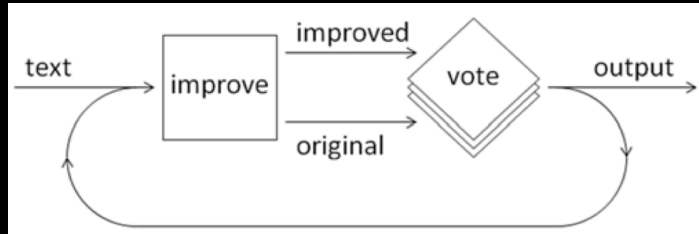


human computation tasks
with global constraints

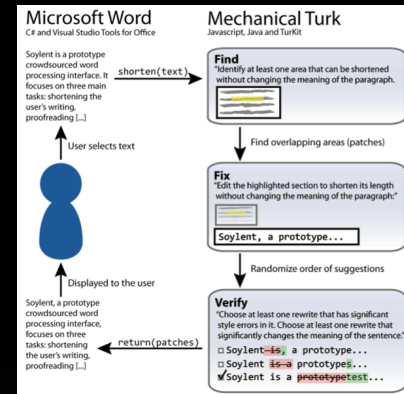
task routing

automated workflow synthesis

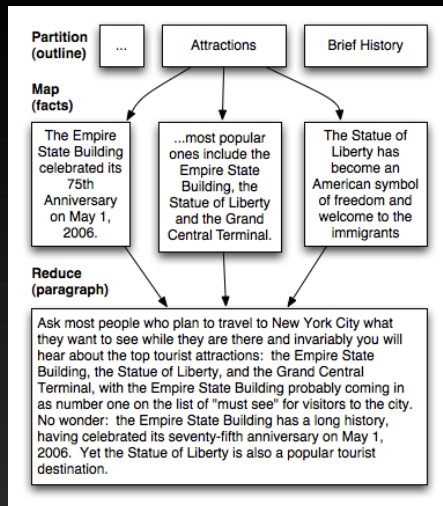
human computation algorithms



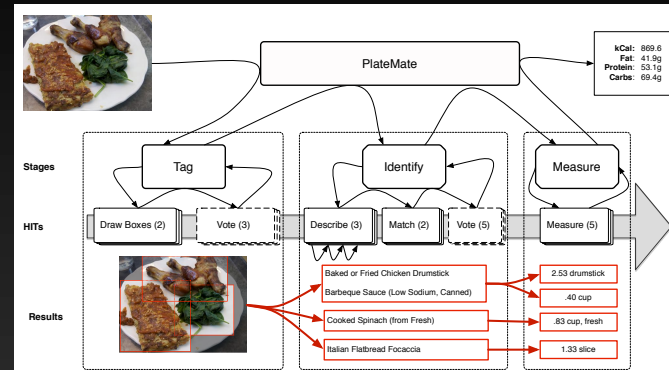
[Little et al., UIST 2010]



[Bernstein et al., UIST 2010]



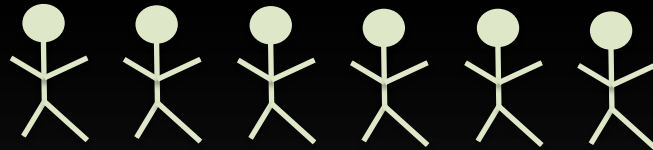
[Kittur et al., UIST 2011]



[Noranha et al., UIST 2011]

many ways to solve a problem

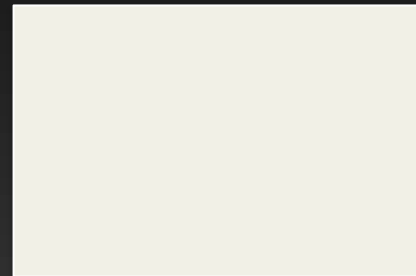
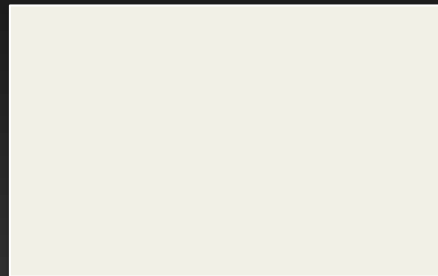
(many possible tasks)



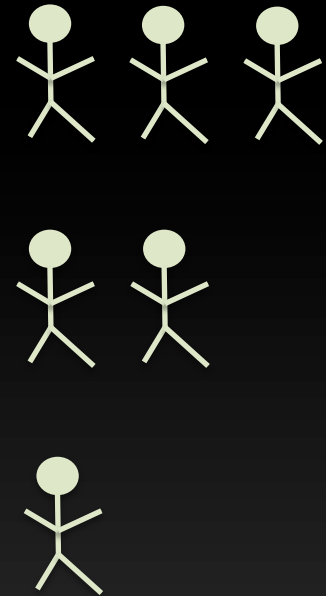
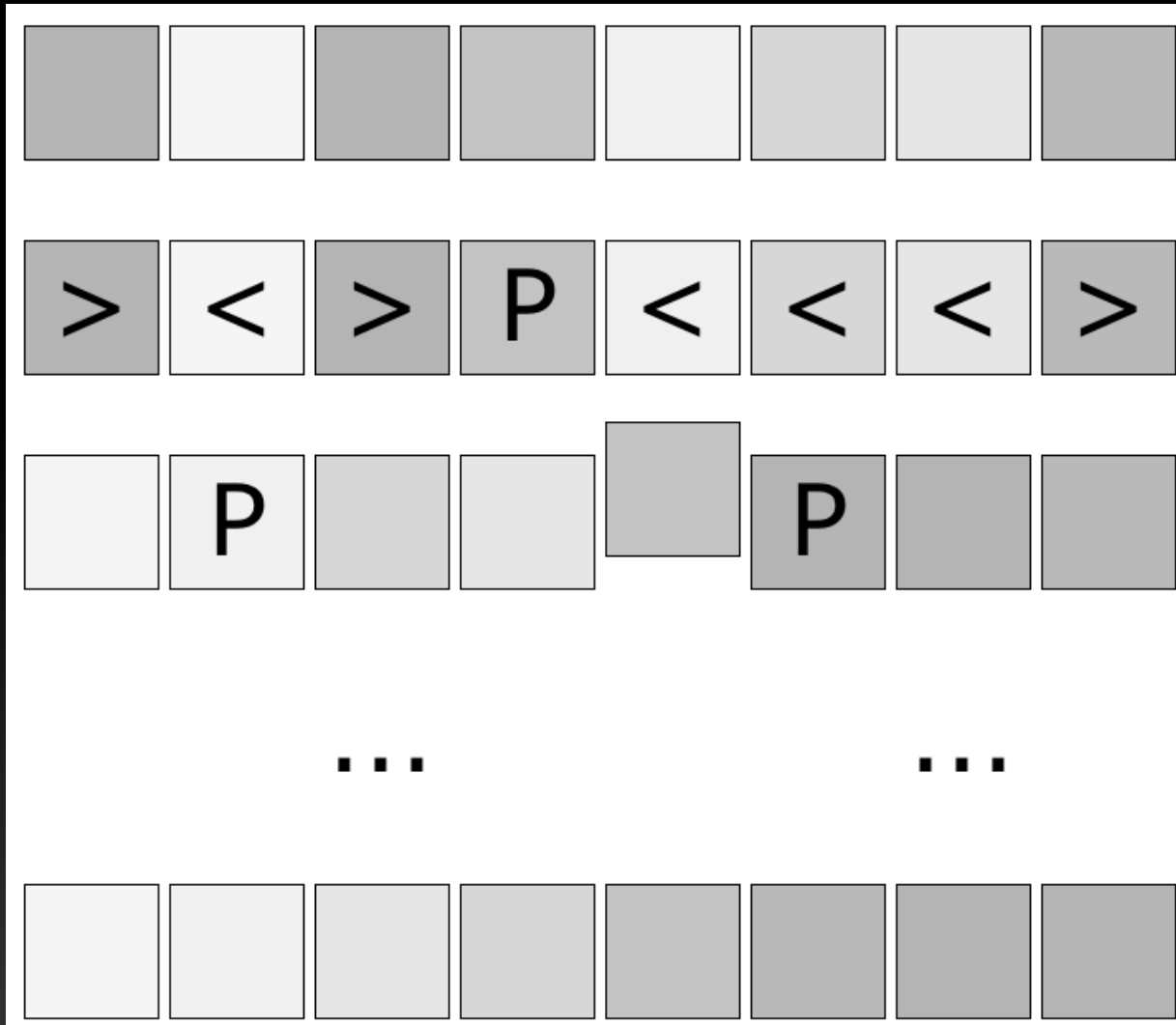
humans can make mistakes

(need to allocate effort across tasks)

example: **human sorting tasks**



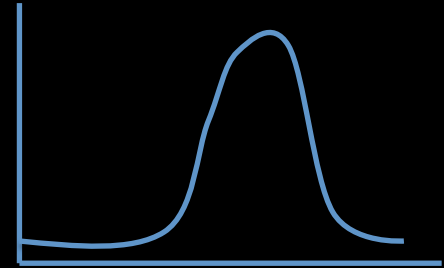
human quicksort



automated workflow synthesis

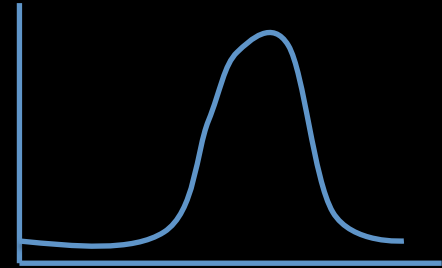
automated workflow synthesis

models of task
performance



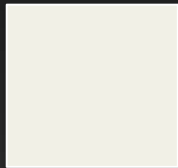
automated workflow synthesis

models of task performance



experiment
on task/input

Which is darker,

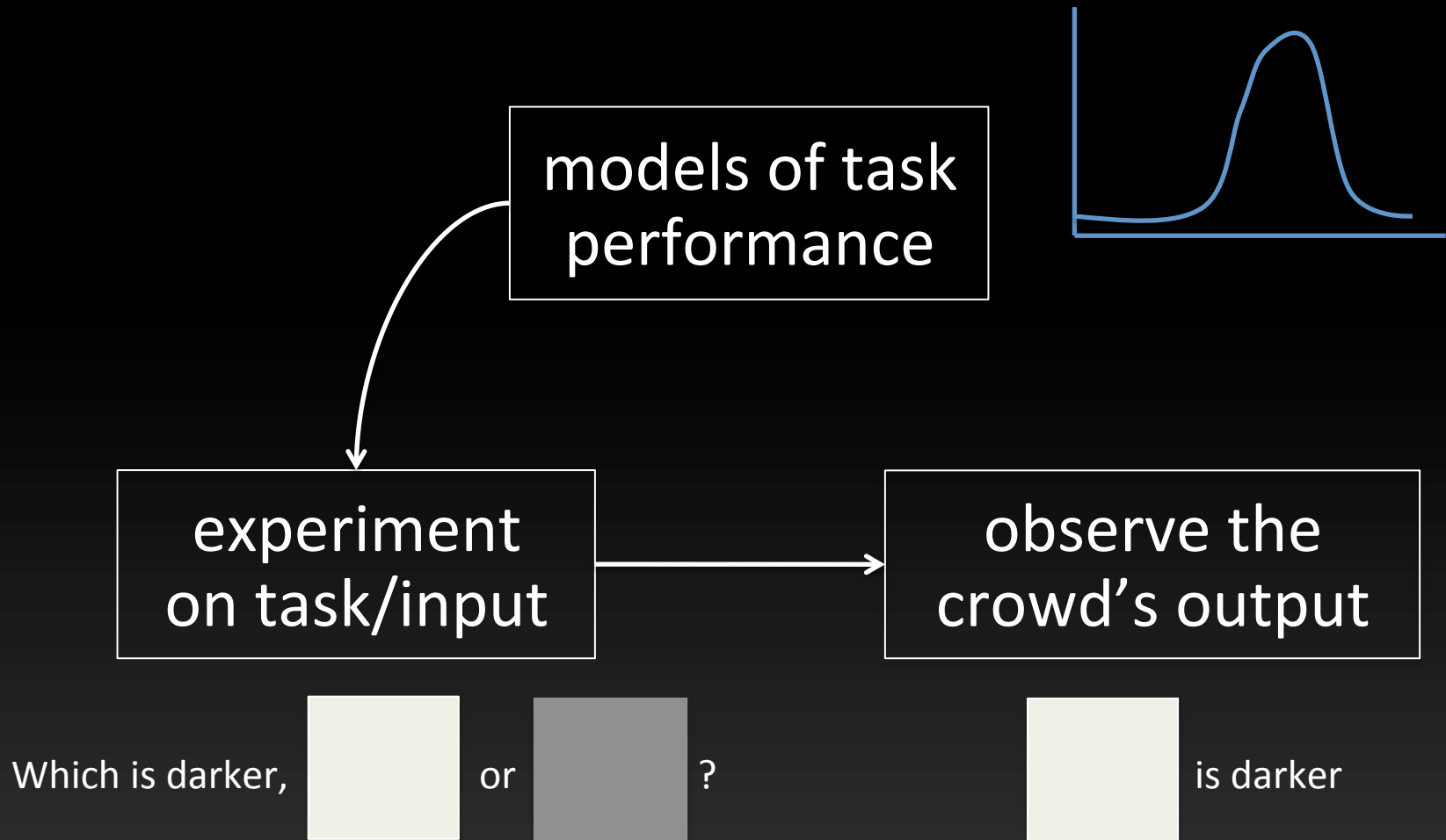


or

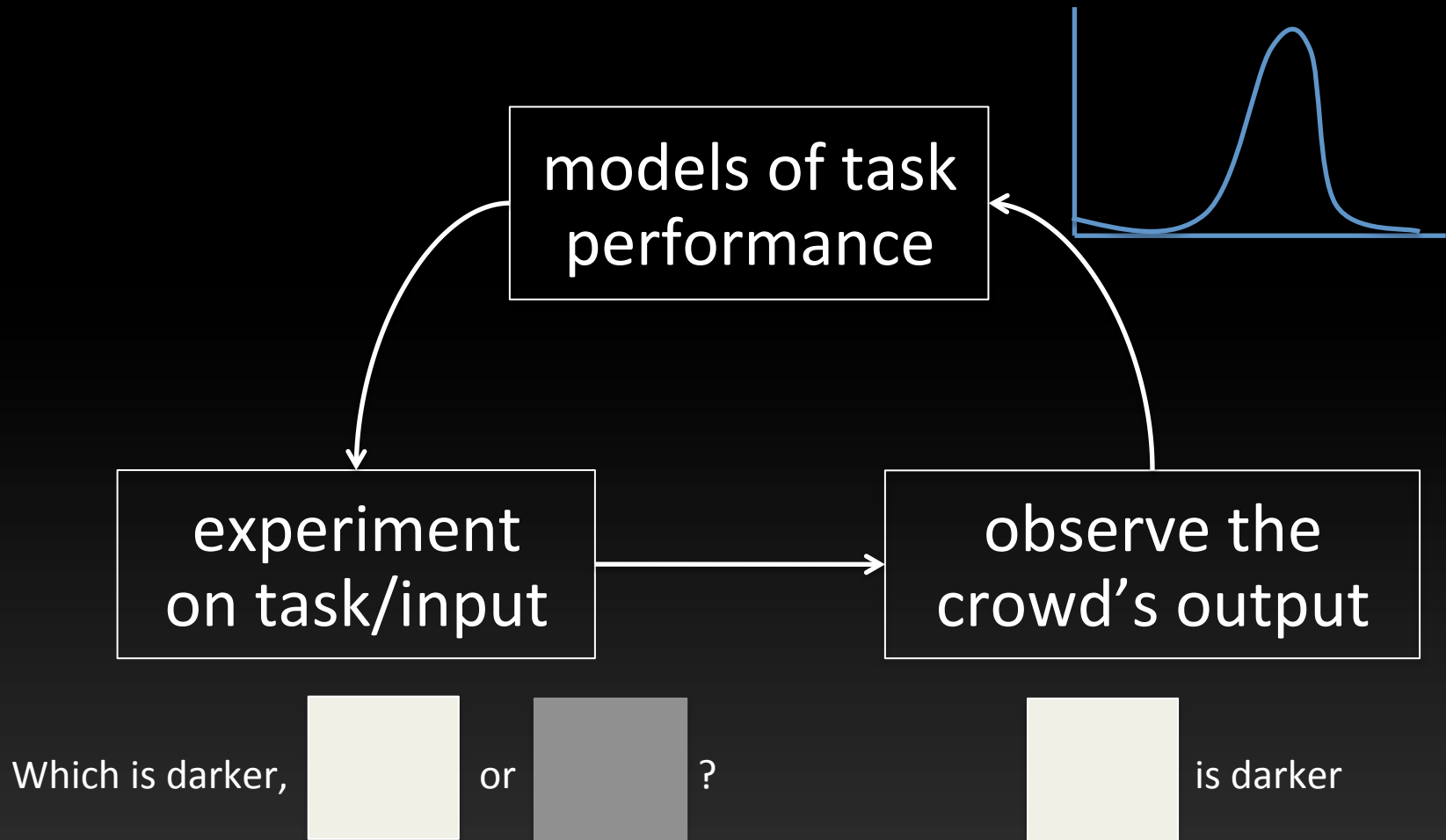


?

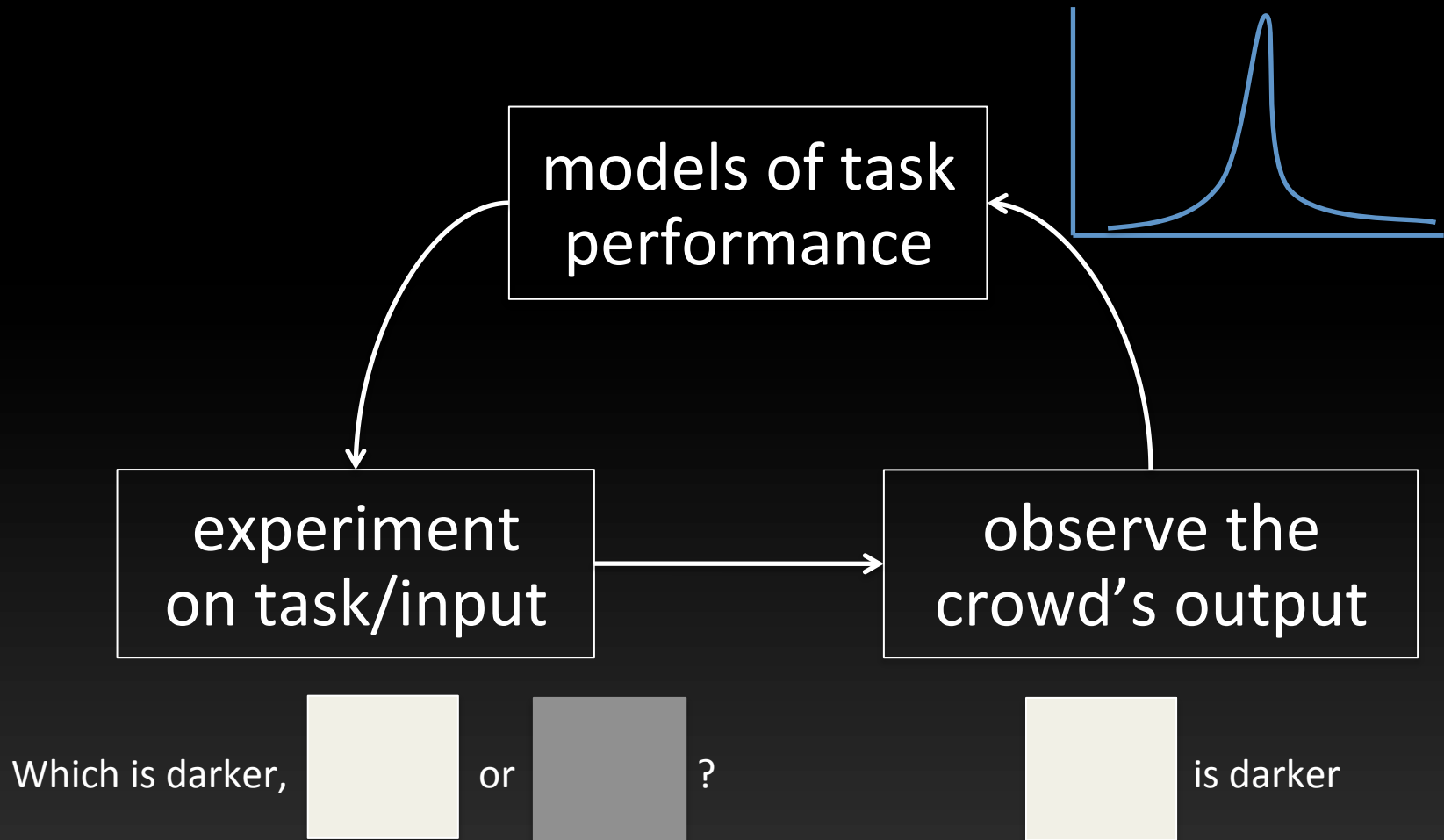
automated workflow synthesis



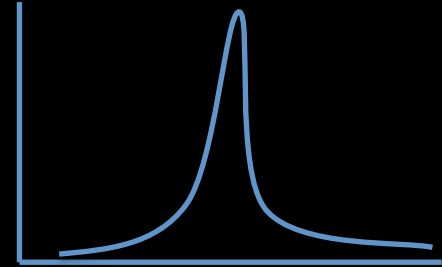
automated workflow synthesis



automated workflow synthesis

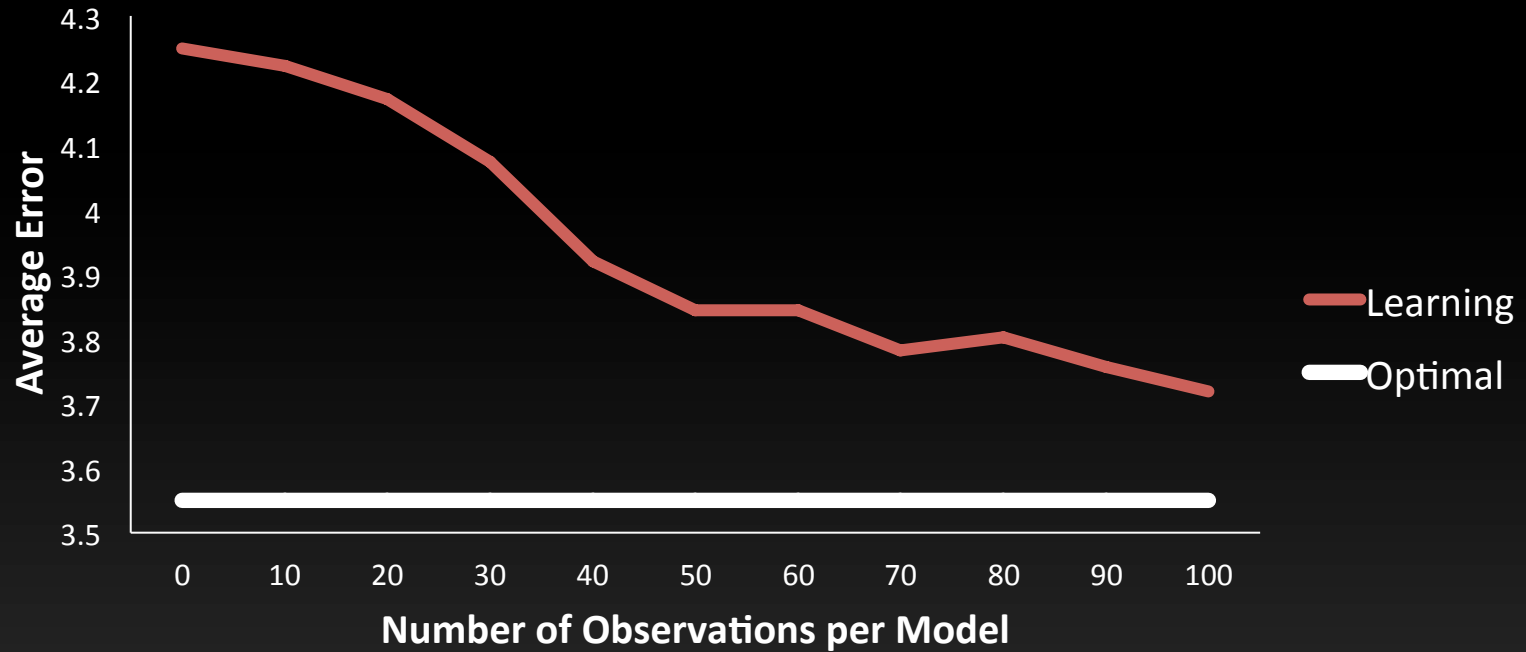


models of task
performance

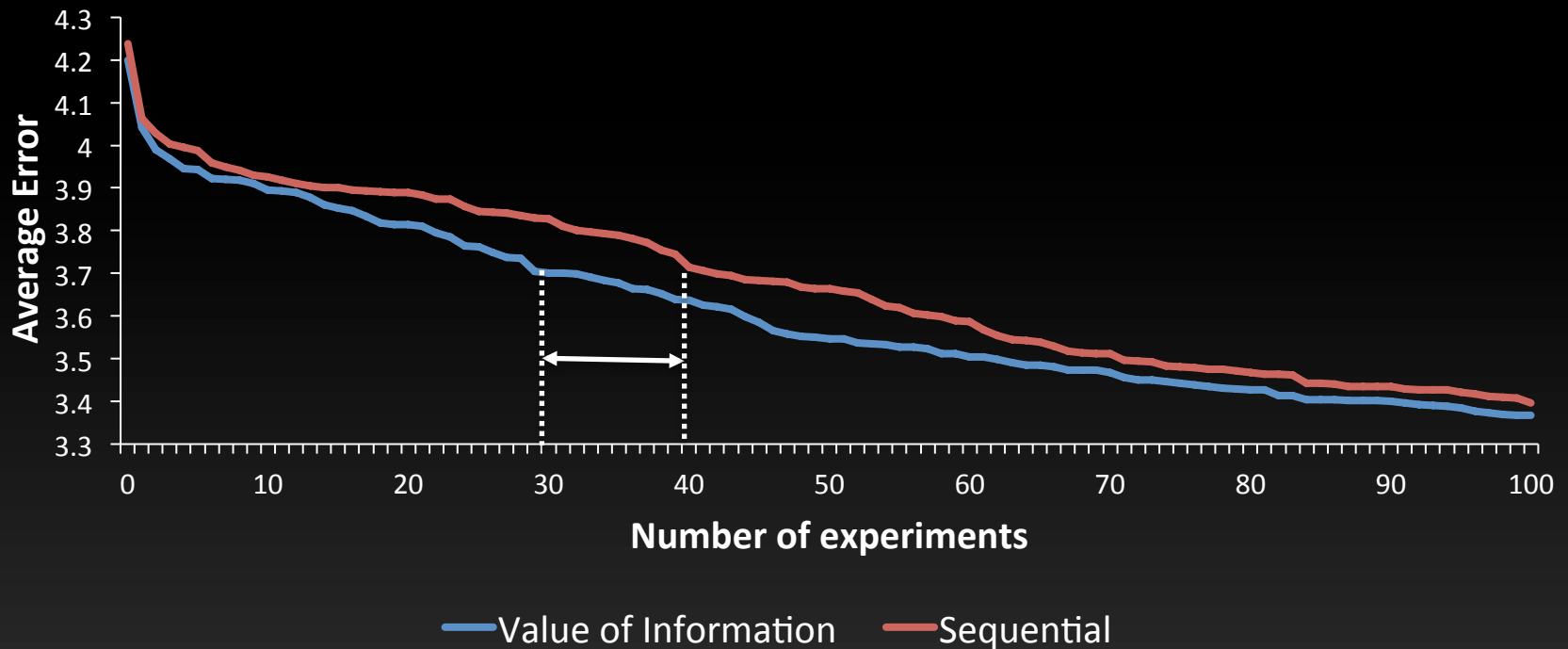


**synthesize efficient algorithms
that are tailored to the crowd**

learning leads to better algorithms

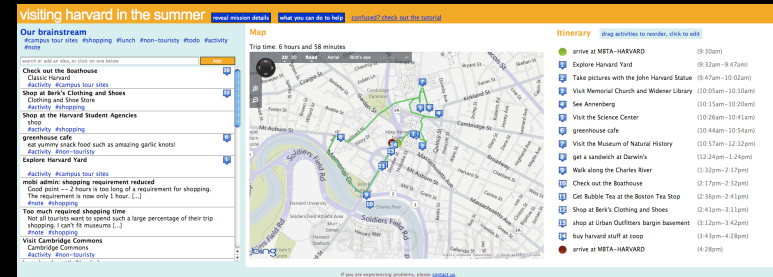


learning smart leads to better algorithms sooner



summary

human computation tasks
with global constraints



task routing



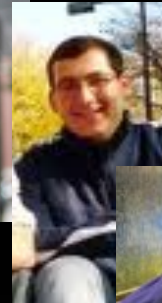
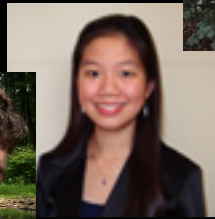
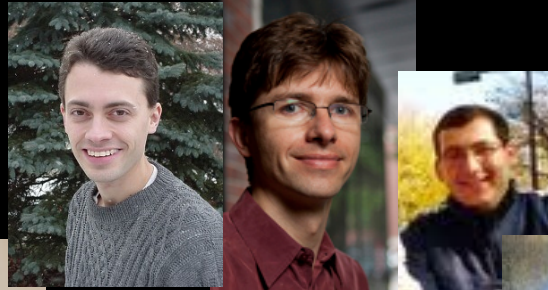
automated workflow synthesis



reason and **learn**
about participants



HCI



Computational
Environment Design



EconCS



AI





Thank you.

reason and learn about participants

