

Human Computation Tasks with Global Constraints

Haoqi Zhang★

Edith Law☑

Rob Miller★

Krzysztof Gajos★

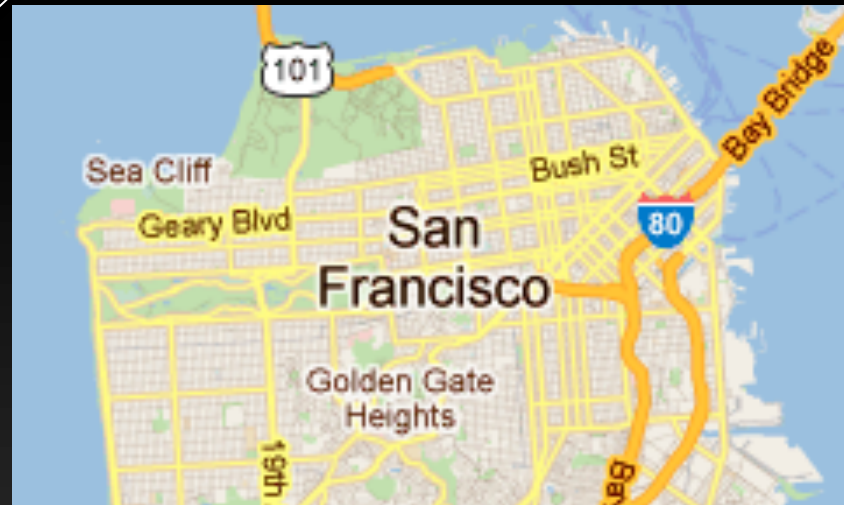
David Parkes★

Eric Horvitz✓

a day in San Francisco

amazing cafes
cool artsy things
somewhere to read

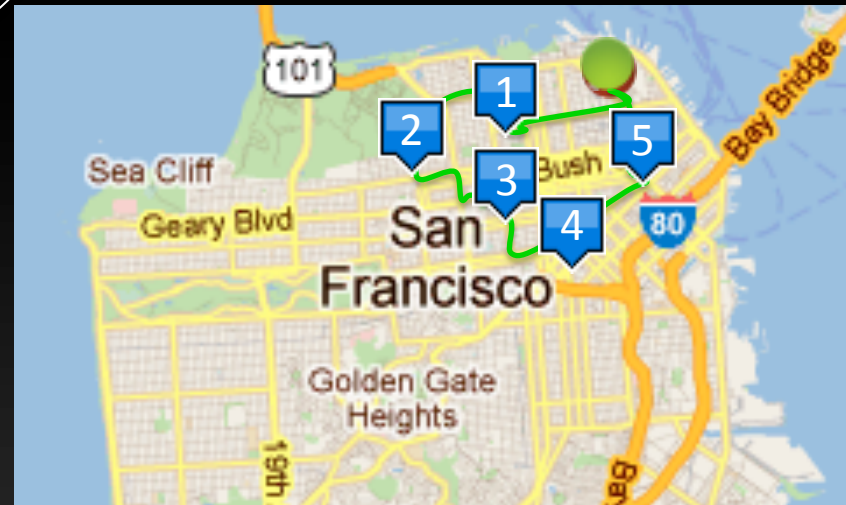
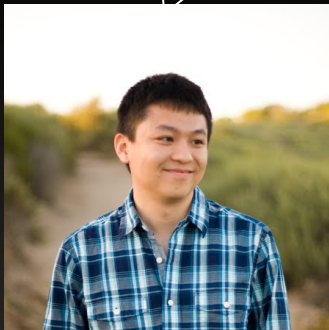
...



a day in San Francisco

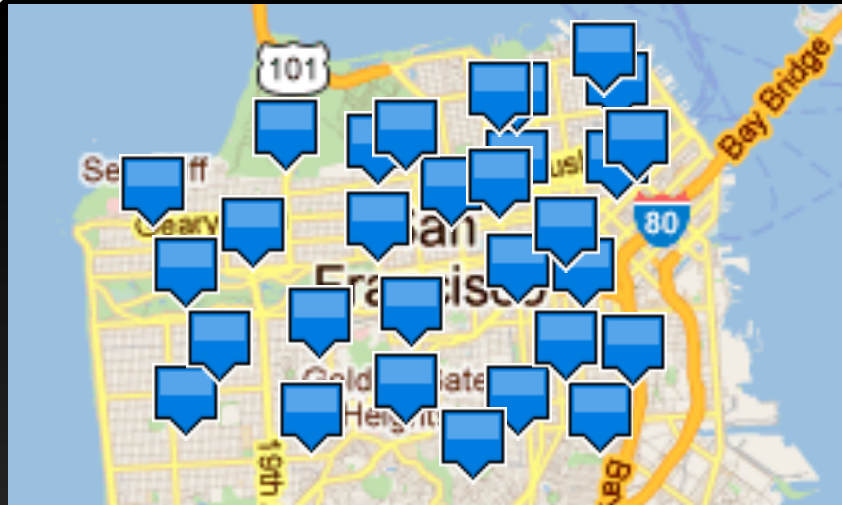
amazing cafes
cool artsy things
somewhere to read

...



a day in San Francisco

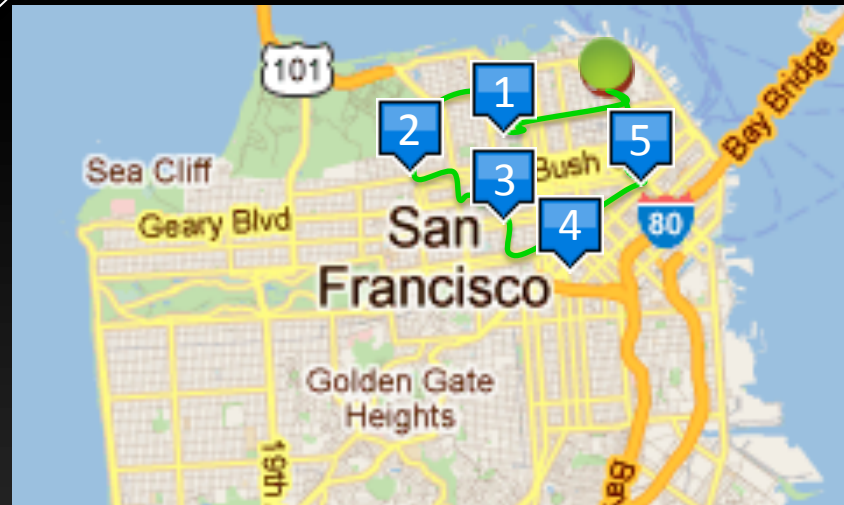
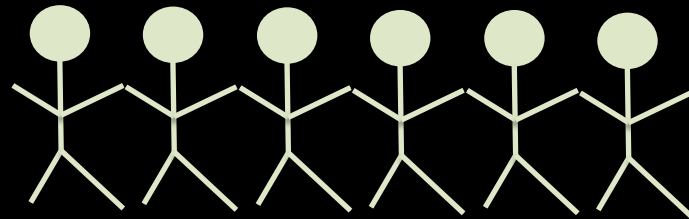
amazing cafes
cool artsy things
somewhere to read
...



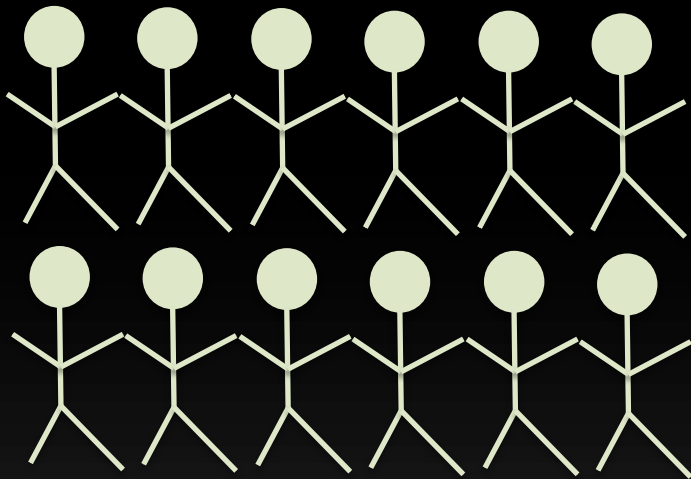
a day in San Francisco

amazing cafes
cool artsy things
somewhere to read

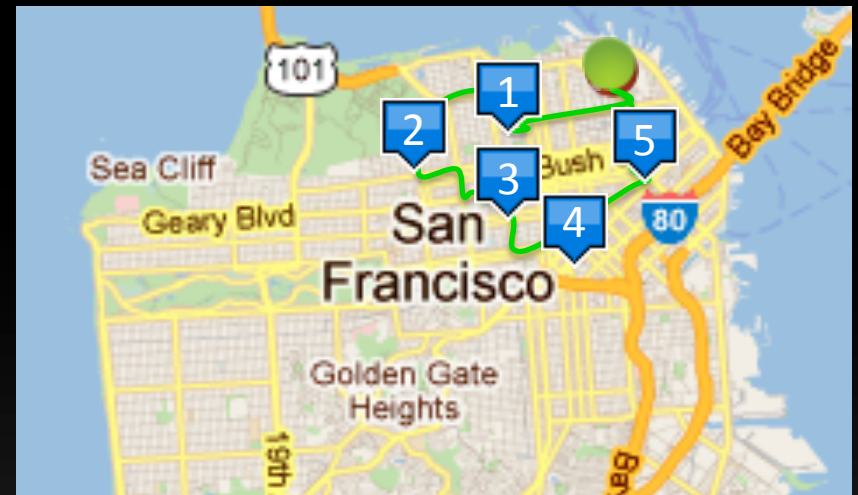
...



human computation with global constraints

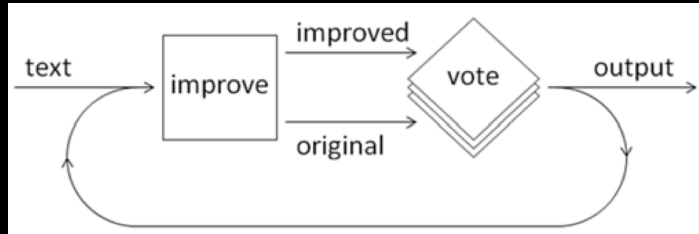


many small contributions

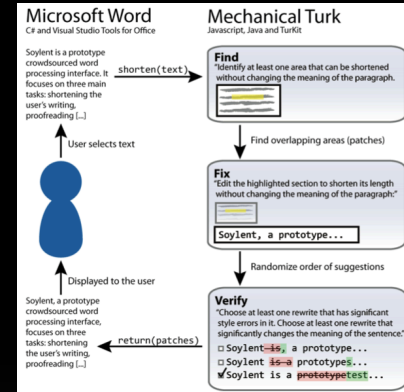


difficult to decompose

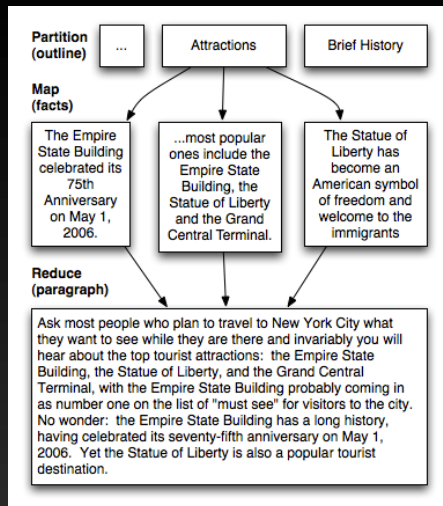
human computation algorithms



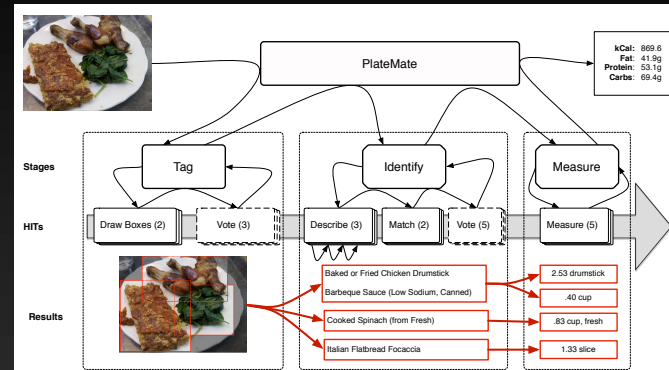
[Little et al., UIST 2010]



[Bernstein et al., UIST 2010]



[Kittur et al., UIST 2011]



[Noronha et al., UIST 2011]

Mobi

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












Saturday, 11am to 10pm

What I am looking for:

I am going to San Francisco for a conference. I have a day to explore the city before the conference starts. I'd love to go to some cool cafes, check out some cool artsy things, 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
- 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

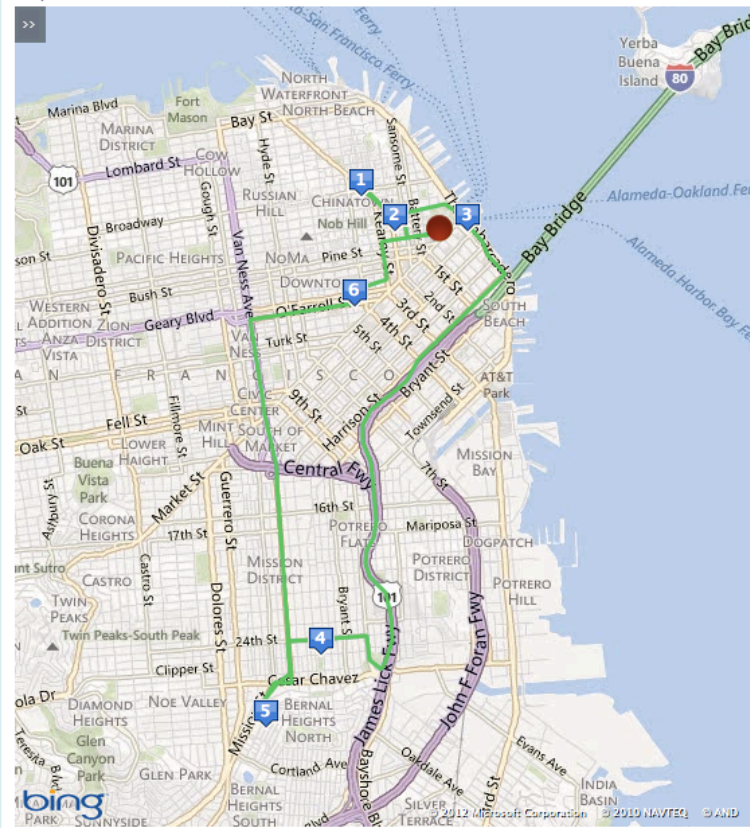
Art at Grace Cathedral
 See the triptych created by world famous artist Keith Haring, marvel at the murals and the beautiful stained glass [...]
 #activity #cool artsy things

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 [...]

Mobi

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:

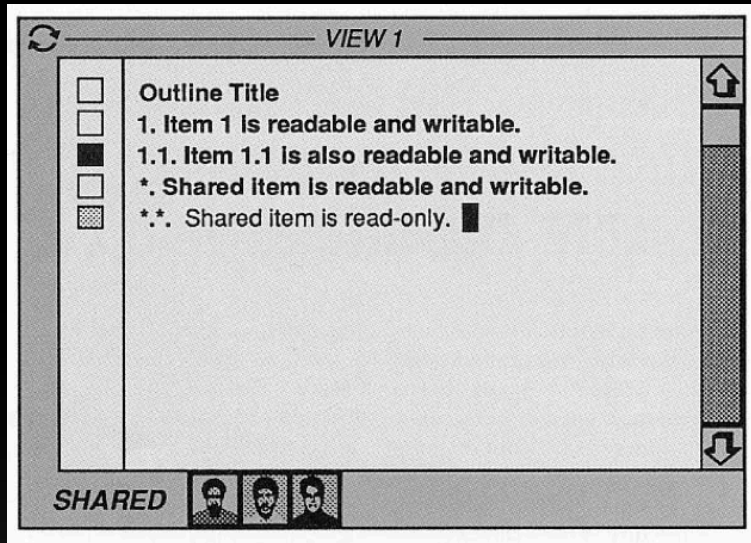
- arrive at MBTA-HARVARD (9:30am)
- Explore Harvard Yard (9:32am-9:47am)
- Take pictures with the John Harvard Statue (9:47am-10:02am)
- Visit Memorial Church and Widener Library (10:05am-10:10am)
- See Annenberg (10:15am-10:20am)
- Visit the Science Center (10:26am-10:41am)
- greenhouse cafe (10:44am-10:54am)
- 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)

The interface also includes a "Map" section with a street view of Harvard University and a "Itinerary" section with a list of activities. The itinerary includes:

(b) the system indirectly coordinates the problem solving effort

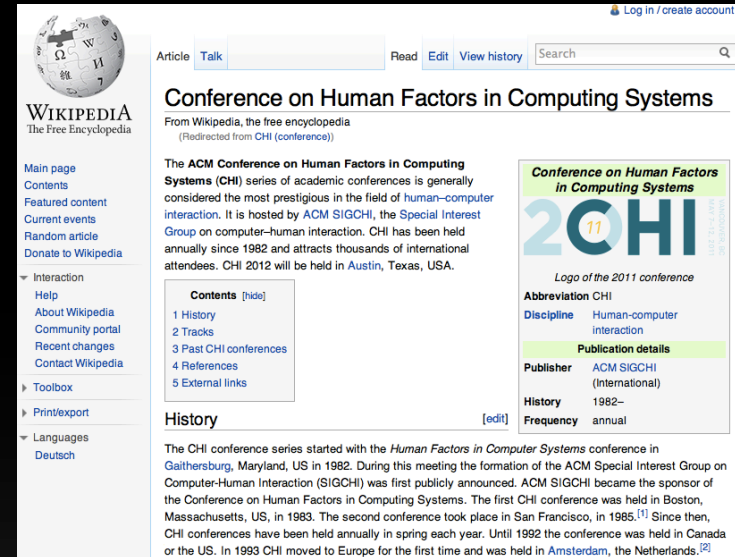
Add more 'shopping' to the itinerary
We need at least 1 hour of shopping. The current itinerary contains no shopping.
#todo #shopping





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

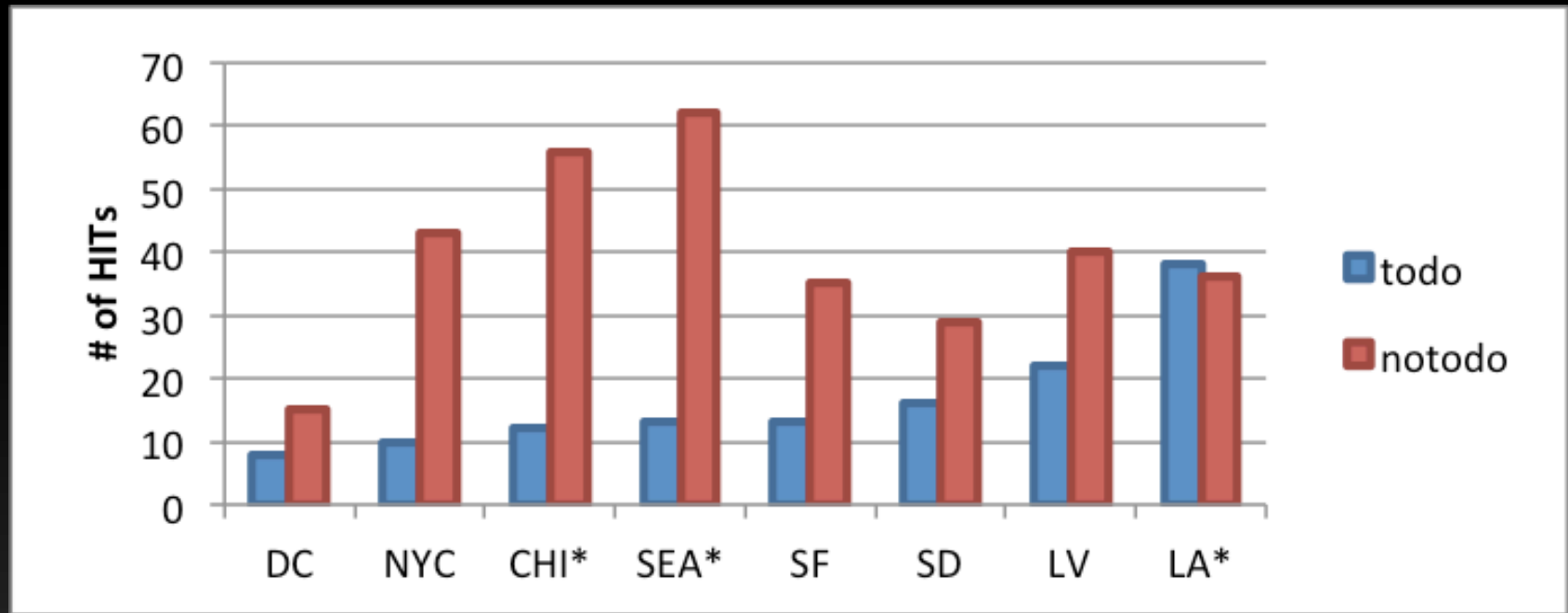
Sneak into Annenburg
Don't get caught
#activity #campus must-sees

visit the geological museum
glass flower exhibit

NO TODO

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

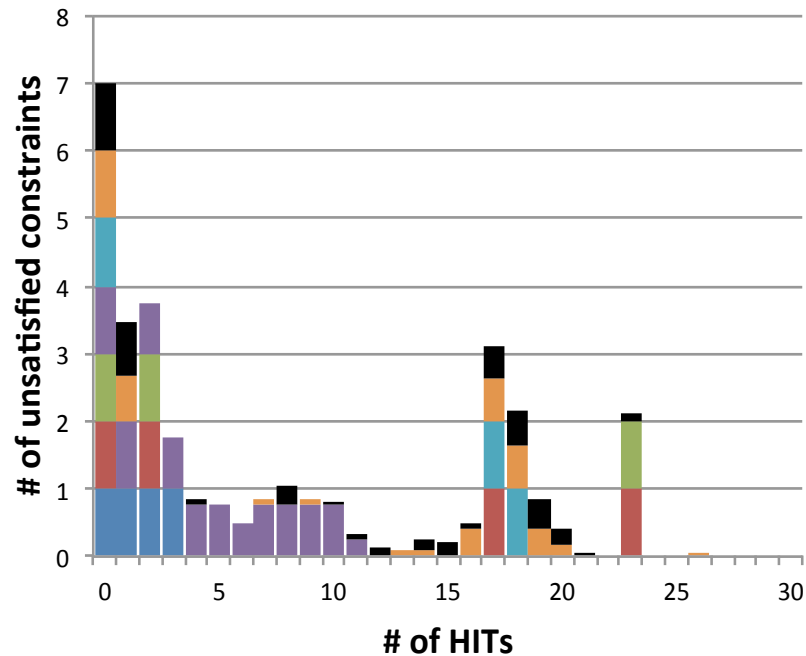
TODO condition resolves quantitative constraints quicker



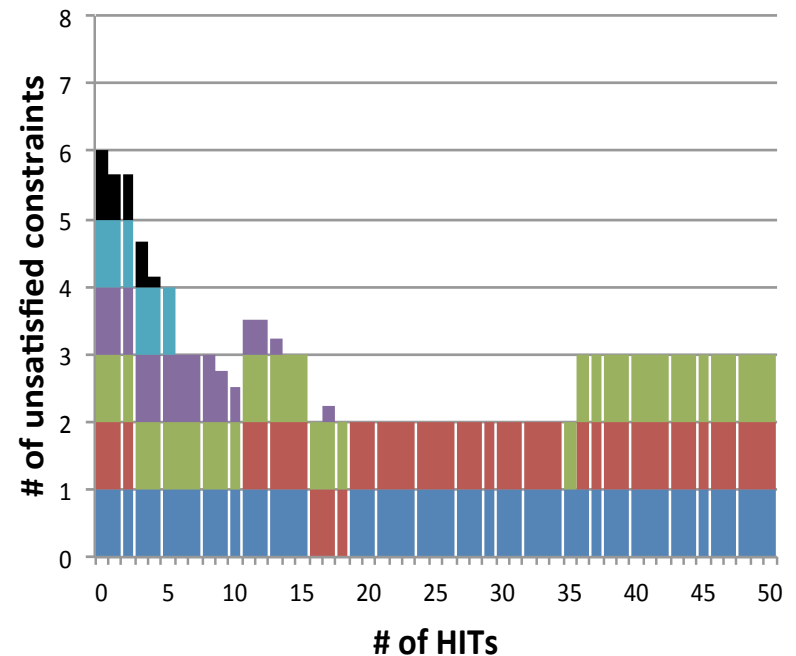
[*] the notodo condition never satisfied all the constraints

Chicago

TODO



NO TODO












- breakfast (=1)
- lunch (=1)
- dinner (=1)
- break (≥ 4)
- architecture (≥ 1)
- kid-friendly ($\geq 6h$)
- total time ($\approx 12h$)











end-to-end user study

Study: 10 subjects enter missions into Mobi











Result: All 10 subjects find crowd itineraries satisfy their mission, and would use it in real life.

-  arrive at Central Square, Cambridge
-  1 Spectacle Island
-  2 Urban Interactive
-  3 Peddocks Island
-  4 Hingham Harbor Kayaking Tour
-  5 Boston Harbor Cruises – Whale Watching
-  6 Ginza
-  7 Skywalk
-  arrive at Central Square, Cambridge

Partner's birthday

-  arrive at downtown
-  1 Breakfast at Sarabeth's
-  2 walk through central park
-  3 Shopping at Saks 5th Avenue
-  4 Wicked
-  5 Bombay Palace
-  6 Dirt Candy
-  7 Shopping in SoHo
-  8 Tribeca Performing Arts Center
-  arrive at downtown

NYC with family

-  arrive at 8442 Palm Pkwy, Orlando, FL
-  1 Travel to Sea World
-  2 Pets Ahoy
-  3 Sharks Underwater Grill
-  4 Clyde and Seamore Take Pirate Island
-  5 Blue Horizons
-  6 One Ocean
-  7 A'Lure the Call of the Ocean
-  8 Eat at The Ravenous Pig
-  arrive at 8442 Palm Pkwy, Orlando, FL










SeaWorld with pregnant wife

My partner's birthday

What I am looking for:

There are 2 of us (33-year-old man and woman) and it's my partner's birthday so I want to do something fun and different. We will have a car and are happy to drive out of the city to do something fun. We love hiking, the beach, the woods, and other outdoor things. We like seeing/experiencing things that are novel and uniquely that area. We don't like tourist-y things but can put up with some tourists if the situation is neat. The more off-the-beaten-path though, the better. We'd also be open to leaving on Friday and camping somewhere if there's a good option. Or be interested in exploring things that are out in the water. I always see these island off the coast whenever I get in a plane and I always wonder what they're about. Are there fun things that might involve a boat? Or visiting little islands off the coast? We've never done that and I have no idea what's out there... Heck, we've never tried kayaking or any water-based activities around Boston and that might be neat, especially if we can get to fun places for like a picnic or something?

We also love eating yummy food (from quirky street vendors to Michelin starred restaurants). We'll probably want a nice meal (probably dinner). We love Japanese and French and Italian. We've been to many of the fanciest places in Boston, but don't know anything about the Italian places in the North End. (We don't want an old stuffy person's restaurant... young, hip is much better. Funkified non-traditional food is best. So think more like Uni and less like Clio in terms of Boston restaurants.)

-  arrive at Central Square, Cambridge
-  1 Spectacle Island
-  2 Urban Interactive
-  3 Peddocks Island
-  4 Hingham Harbor Kayaking Tour
-  5 Boston Harbor Cruises – Whale Watching
-  6 Ginza
-  7 Skywalk
-  arrive at Central Square, Cambridge

hidden constraints

“I just happen to be afraid of bungee jumping because it seems so unsafe”

“I am under age so the wine thing would not be great for me but everything else sounds great.”

“I was not expecting to travel so much uptown/downtown in one day.”

conclusion

crowdware enables the crowd to tackle complex tasks with global constraints

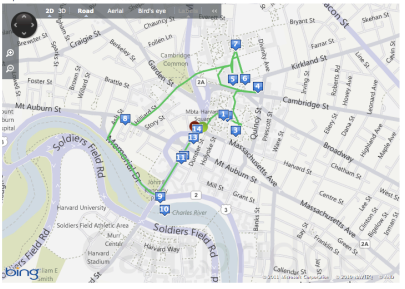
visiting harvard in the summer [reveal mission details](#) [what you can do to help](#) [confused? check out the tutorial](#)

Our brainstream
#campus tour sites #shopping #lunch #non-touristy #todo #activity #note

Search for add an item, or click on one below

- 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 #shopping
- greenhouse cafe**
eat yummy snack food such as amazing garlic knots!
#activity #non-touristy
- Explore Harvard Yard**
#activity #campus tour sites
- mobi admin: shopping requirement reduced**
Good point -- 2 hours is too long of a requirement for shopping. The requirement is now only 1 hour. [...]
- Too much required shopping time**
Not all tourists want to spend such a large percentage of their trip shopping. I can't fit museums [...]
- Visit Cambridge Commons**
Cambridge Commons
#activity #non-touristy

Map
Trip time: 6 hours and 58 minutes



Itinerary [drag activities to reorder, click to edit](#)

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

If you are experiencing problems, please [contact us](#).

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



Thanks!

Please ask a question.

We'd appreciate some questions, currently no questions has been asked.

[#todo](#)



Get in touch with me.

My email is hq@eecs.harvard.edu

[#todo](#)



Help us improve mobi.

Please share your thoughts; all comments are welcomed.

[#todo](#)

