



AI-MIX

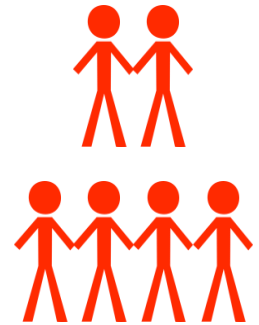
Using **Automated Planning** to Steer **Human Workers** Towards Better **Crowdsourced Plans**



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Arizona State University



CROWDSOURCING

- Process of obtaining ideas or a needed service from a crowd of people
 - Crowd + OutSourcing
- Example: Travel Planning



Who's going:



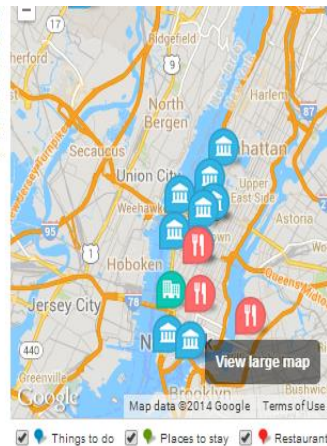
Linda Byrns

Questions

Exciting things to do in New York City

Art & Design Lovers Foodies Luxury Travelers Nightlife Lovers Trendsters

Like • 17 responses • Add a Recommendation • about 1 month ago •



Sync your Gogobot Trip Plans with



Top of the Rock

West 50th Street, New York, NY 10112

Elvira Vanag recommended Top of the Rock

★★★★★

The views from the Top of The Rock are a majestic of this amazing city. It's better than you can see far-far away. My favorite view

Like · Comment · about 1 month ago · 1 person likes this.

Brooklyn Bridge

Brooklyn, NY, USA

James Nelson recommended Brooklyn Bridge

★★★★★

A great way of getting an awesome view of NYC is by very little time and its free. I'd recommend going on a very crowded on the weekend.

Like · Comment · about 1 month ago · Report

Times Square

43rd Street and 7th Avenue, New York, NY 10036

James Nelson recommended Times Square

★★★★☆

Unless your going to a musical production I really don't see the point. I guess massive advertisements for M&Ms, tgi fridays, and aeropostle stores don't really do it for me. I can think of a lot ... [read more](#)

Like · Comment · about 1 month ago · Report

Yogic Traveler recommended Times Square

★★★★★

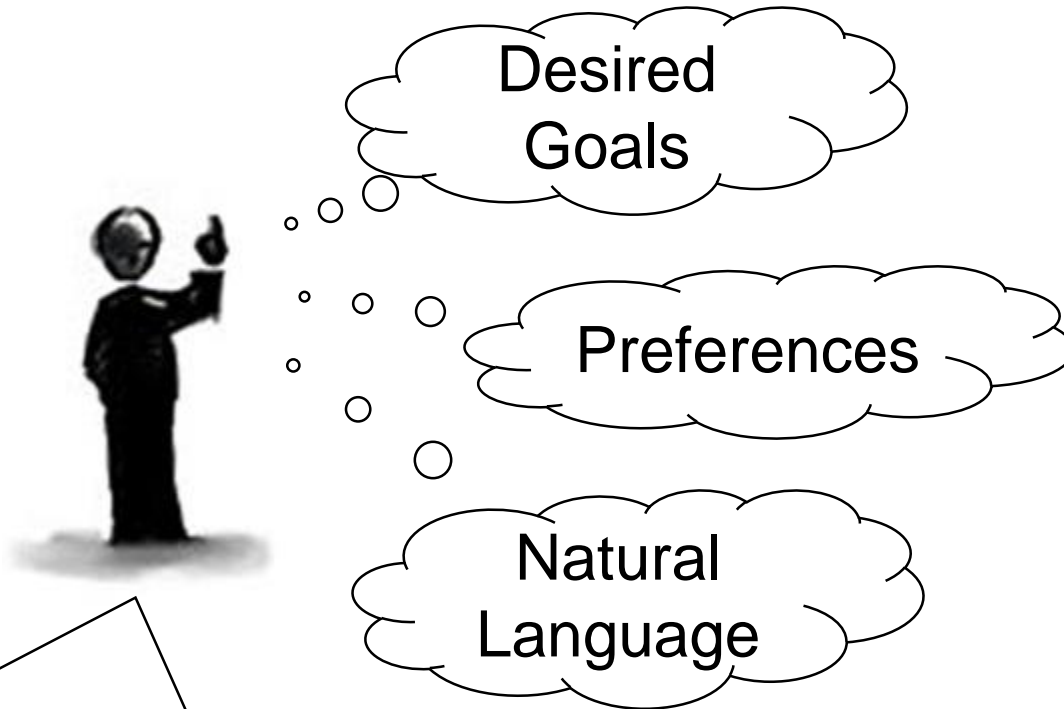
Top of the Rock

Brooklyn Bridge

Times Square



ROLES: REQUESTER (HUMAN)



What must I do, eat and see in NYC? I've been to NYC before, so suggestions on new speakeasies, restaurants and nightlife recommendations would be awesome.



ROLES: CROWD (HUMAN)

BREAK TASK INTO ACTION ITEMS

- Restaurants
- Nightlife Suggestions
- Museums

GENERATE AN ACTIONABLE PLAN

- Katz's Deli
- Times Square
- Central Park
- Magnolia Bakery
- Brooklyn Bridge
- Statue of Liberty
- The Village Underground



PROVIDE SUGGESTIONS

- Magnolia Bakery: If you haven't tasted a Magnolia cupcake, your NYC visit doesn't count.
- Katz's Deli has certainly kept its status as the best deli in New York City serving the Lower East Side. Best pastrami sandwich in town.

CRITIQUE EXISTING ACTIONS

- Katz's Deli: It's overhyped and over priced. I did not like it. Other places nearby are much better.
- Magnolia Bakery: It's too crowded at most times. Impossible lines.



THE CROWDSOURCED PLANNING PROBLEM

REQUESTER
(Human)



COLLABORATIVE
BLACKBOARD

*Task
specification*

FORM/MENU
SCHEDULES

Is it possible to improve the effectiveness of this process using automated planning?



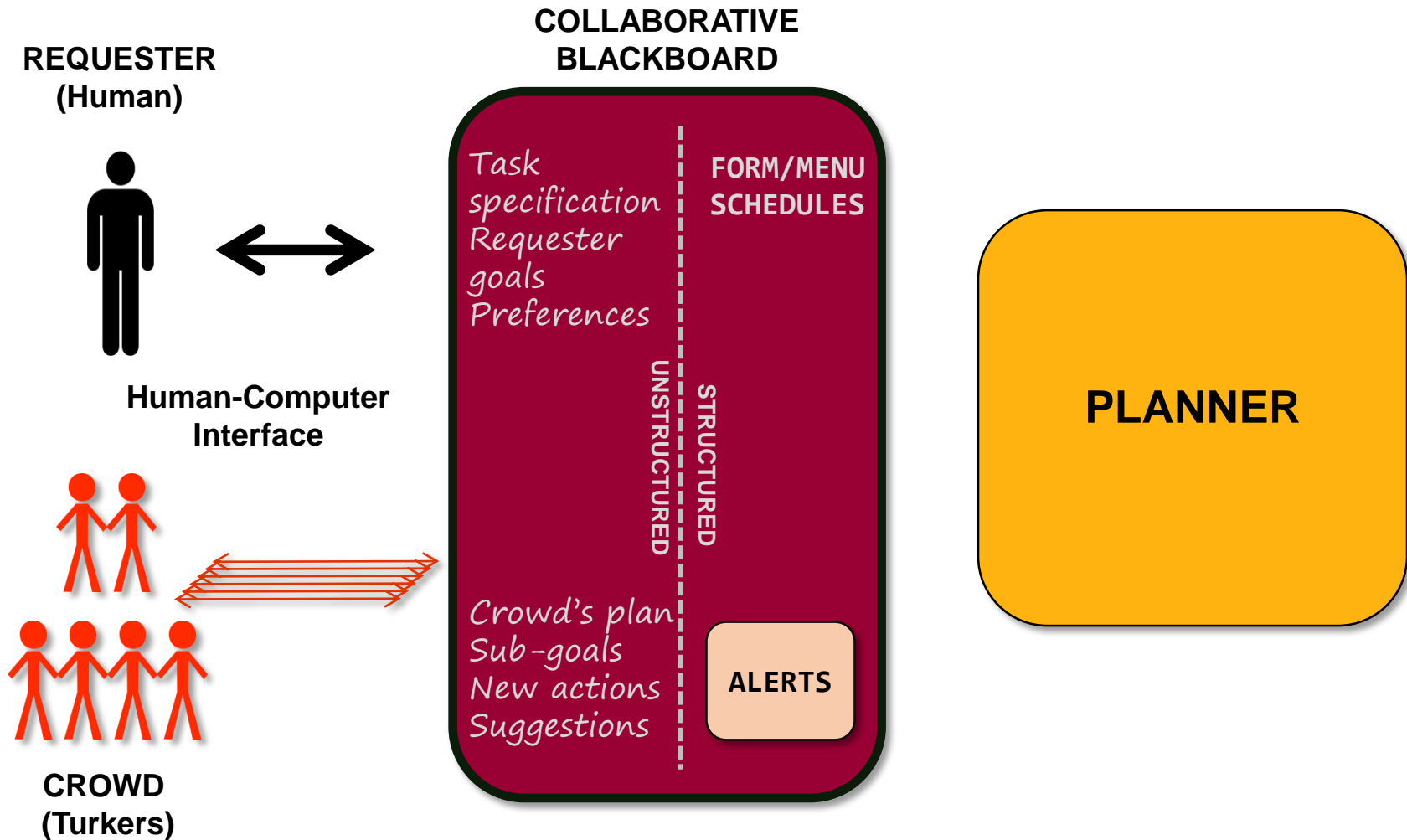
CROWD
(Turkers)

*Crowd's plan
Sub-goals
New actions
Suggestions*

ALERTS



THE CROWDSOURCED “PLANNING” PROBLEM





ROLES: PLANNER (MACHINE)

STEER THE CROWD: SUB-GOALS

- How to get to Magnolia Bakery?
- What are the hours of Katz's Deli?

CONSTRAINT CHECKING

- Duration of 'Statue of Liberty' exceeds requested time of 2 hours
- Cost of The Village Underground exceeds threshold of \$20

PLANNER

SCHEDULE THE PLAN

- 08:00 – 10:30 Statue of Liberty
- 11:00 – 12:00 Katz's Deli
- 12:30 – 14:00 Times Square
- 14:30 – 16:00 Central Park
- 16:30 – 17:00 Magnolia Bakery
- 17:30 – 19:30 Brooklyn Bridge
- 20:00 – 23:00 The Village Underground



... BUT AUTOMATED PLANNERS NEED MODELS

- Domain Dynamics
- Preferences

UNSTRUCTURED

STRUCTURED

SHALLOW MODEL

APPROXIMATE MODEL

1.Full Model

Planner can generate plans by itself

Crowd is too expensive and cumbersome

2.No Model

Zero knowledge – Planner cannot engage at all

3.Partial Model **Model-lite Planning**

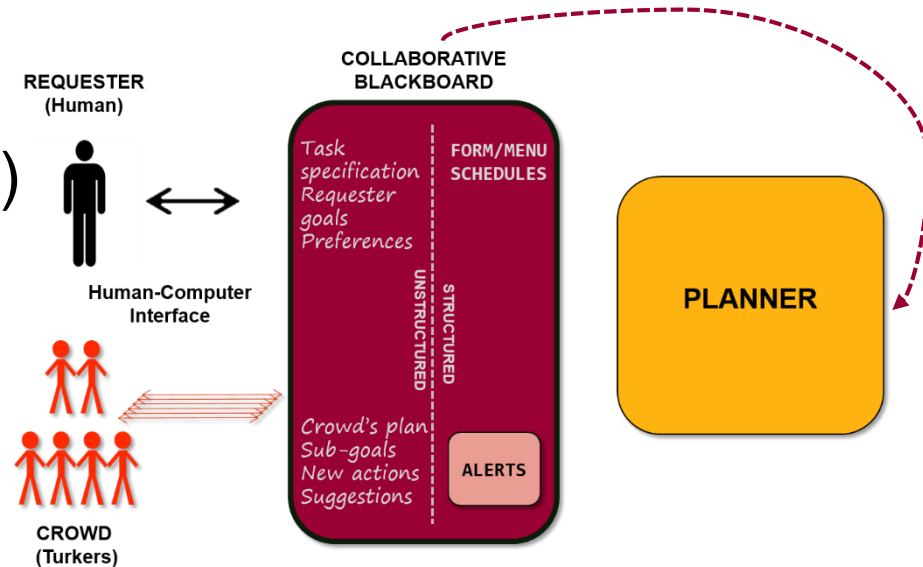
Planner can help in iterative refinement of plan

Most likely scenario in real-world problems (travel planning)



CHALLENGE: INTERPRETATION

- Understanding the goals and plans of the **humans** (requester + crowd) from **semi-structured** or **unstructured** text
- Impedance Mismatch



Extract from Plain Text

Impose structure

[Ling & Weld, 2010]

[Kim, Chacha & Shah, 2013]



UNSTRUCTURED

Full Plan Recognition

[Kautz & Allen, 1986]

[Ramirez & Geffner, 2010]



STRUCTURED



Plan Recognition from Noisy Traces

Extract noisy traces first

[Zhuo, Yang & Kambhampati, 2012]



DEALING WITH INTERPRETATION

- **Force Structure**

- Use forms to constrain human input
- Easier to match to planner's expectation of structured input
- Restricts flexibility of humans; less knowledge specified

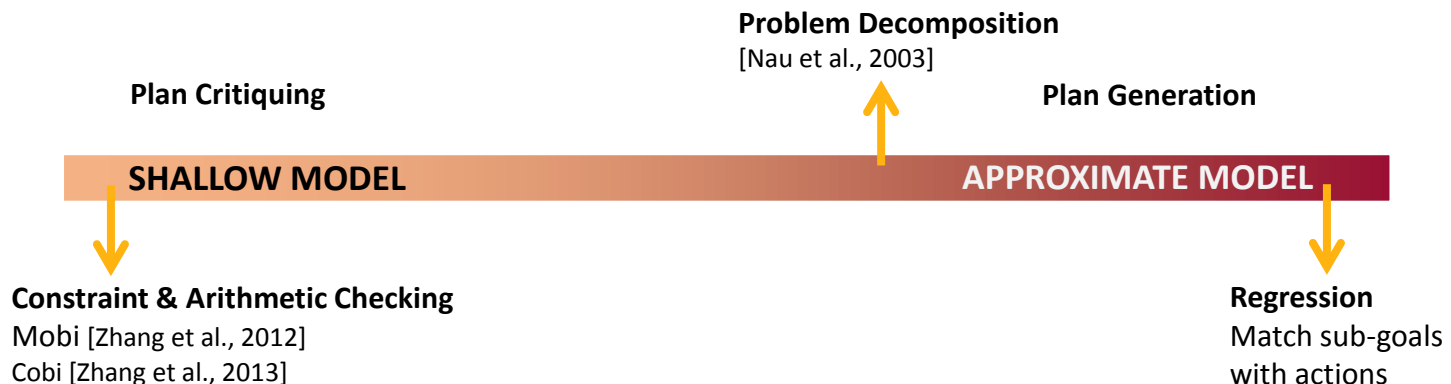
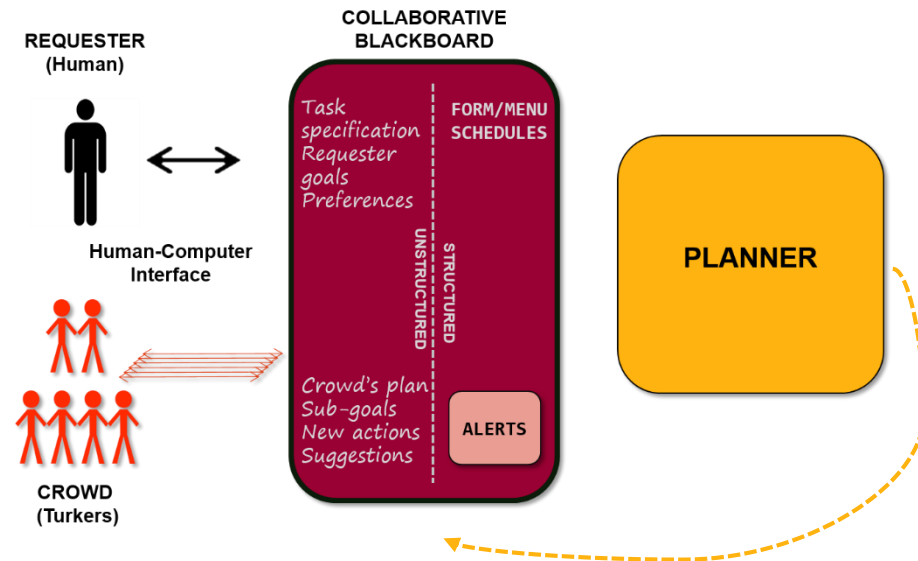
- **Extract Structure**

- Allow humans to use full natural language
 - Semi-structured and unstructured text
- Extract actions and goals from human-generated input
- Validate against partial model
- Iteratively refine recognized goals and plan



CHALLENGE: STEERING

- Steering the crowd workers towards **producing a plan collaboratively**
 - Partial domain dynamics
 - Incomplete preferences
- Iterative** Process





DEALING WITH STEERING

- **Constructive Critiques**

- Actively participate in refinement of plan
- Generate sub-goals for suggested activities
- Highlight unfulfilled requester goals
- Create actionable schedule / plan

- **Constraint Checking**

- Check quantitative constraints
 - Travel Planning: Cost, Duration
- Choose best set of activities fulfilling requester constraints

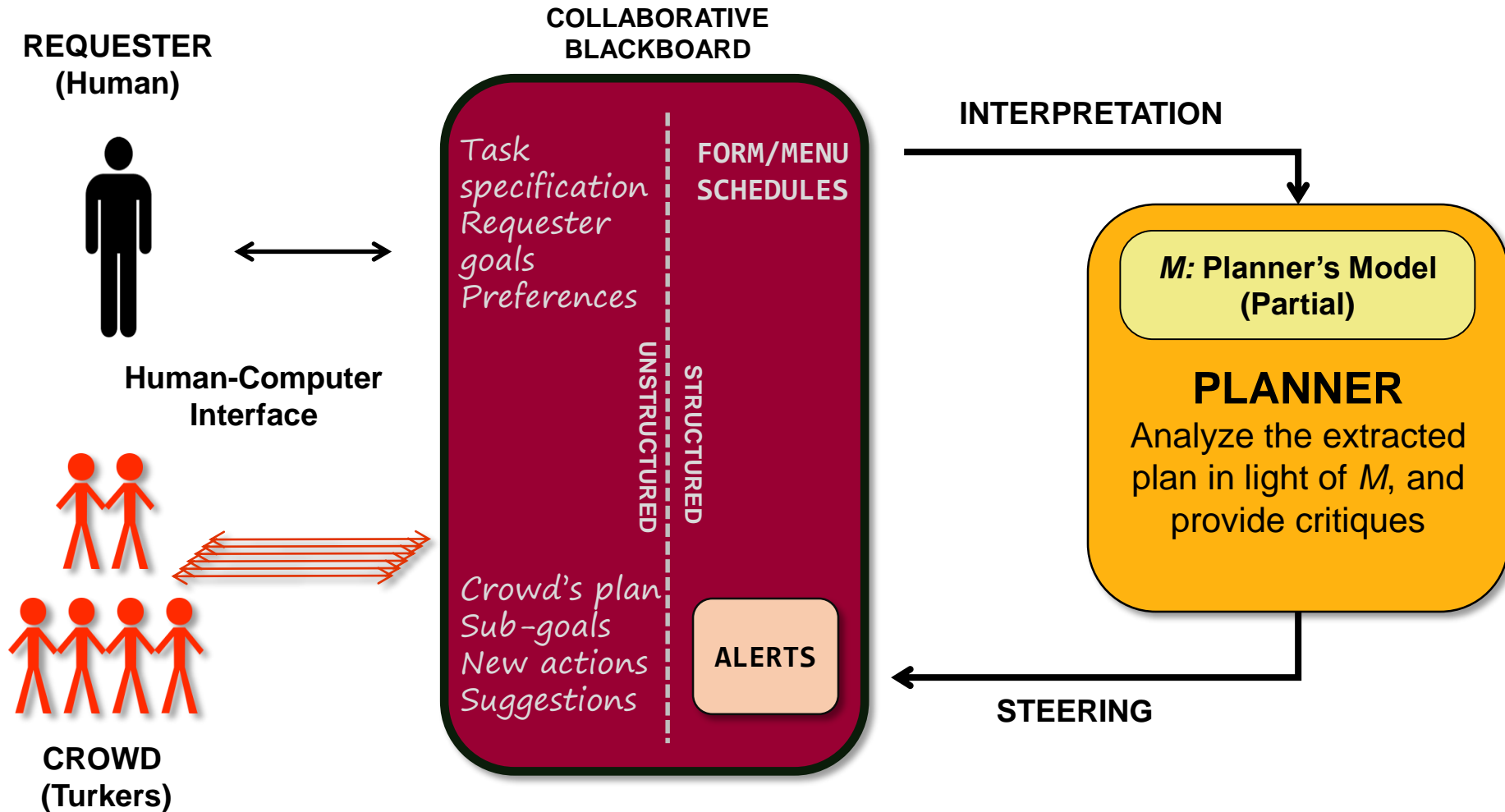


AI-MIX: A DEPLOYED SYSTEM

- Automated Improvement of Mixed Initiative eXperiences
- Works on multiple platforms
 - Amazon's Mechanical Turk (mTurk)
 - Google App Engine
- Input
 - High level task description by requester
- Output: Two kinds
 - Set of activity suggestions from crowd
 - Scheduled plan that can be executed



AI-MIX: SYSTEM SCHEMATIC



Find HITS containing

that pay at least \$ 0.00

☐ for which you are qualified☐ require Master Qualification

GO

Timer: 00:00:00 of 10 minutes

Want to work on this HIT?

Want to see other HITS?

Accept HIT

Skip HIT

Total Earned: Unavailable
Total HITS Submitted: 0

Tour to Chicago

Requester: Lydia

Reward: \$0.20 per HIT

HITS Available: 10

Duration: 10 minutes

Qualifications Required: HIT approval rate (%) is greater than 50, Location is US

TourPlanner Instructions

TOUR REQUEST

Going to New York City for only a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are some things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be great. Thanks!

- Have a breakfast at a good local restaurant. #breakfast
- Maybe a museum to visit for around 2 hours maximum. #museum
- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30\$. #lunch
- Do some shopping for a maximum of 1 hour.
- Take a walk in some touristy place.
- Have dinner and drinks at a good place.

HOW TO SUBMIT A HIT

You can contribute by

- Suggesting a new activity
- Critiquing an existing activity

The "TO DO Tags" column contains information about the **requester demands**, and **plan critiques** that are yet to be satisfied.

- To add a new activity, click on the "Add new activity" button, fill out the title, description and approximate duration, attach the tag corresponding to this activity and click "Submit".
- To critique an existing activity, click on the "Critique existing activity" button, click on the activity that you want to critique, enter your note, attach an appropriate tag (which will then be added to the list of TO DO Tags) and click "Submit".

For each option you may add more than one suggestion if you wish. Activities with existing suggestions appear in green; otherwise, they are red.

TO DO Tags:

macys_whattobuyin

macys_gettingto

manhattan_gettingto

museum

Add new activity

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

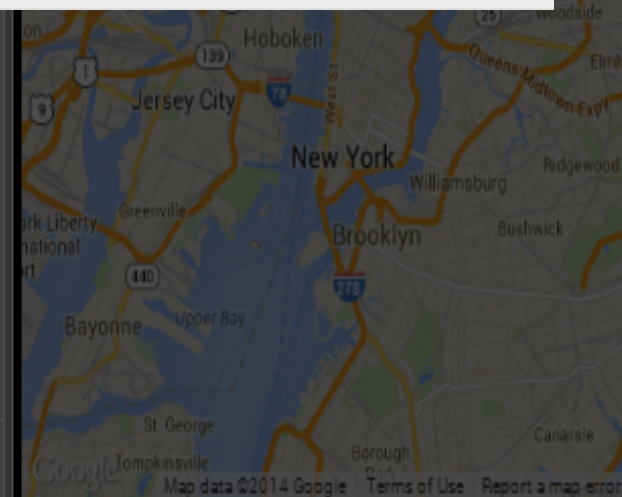
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- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30\$. #lunch
- Do some shopping for a maximum of 2 hours. I can spend upto 300\$ on shopping. #shop
- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to spend a maximum time of 3 hours here. #dinner

#shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk



Add new activity ▸

Critique existing activity ▸

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

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- Take a walk in some touristy place. #walk #touristy
- Have dinner and drinks at a good local restaurant. I want to

TO DO Tags:

macys_whattobuyin

macys_gettingto

manhattan_gettingto

museum

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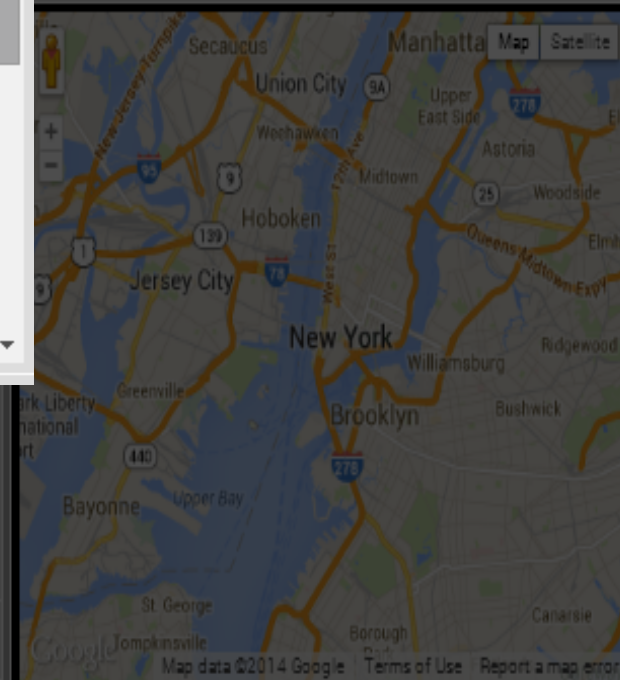
Existing Activities

Macys: Awesome shopping
#shop

Manhattan: Walking (2 hrs)
#walk

Add new activity »

Critique existing activity »



TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

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- Visit some iconic places with rich architecture. #architecture
- Have a quick light lunch. Budget is 30\$. #lunch
- Do some shopping for a maximum of 2 hours. I can't wait for hours to get seated/get food.
- Take a walk in some touristy place. #walk #tourist
- Have dinner and drinks at a good local restaurant.

TO DO Tags:

macys_whattobuyin

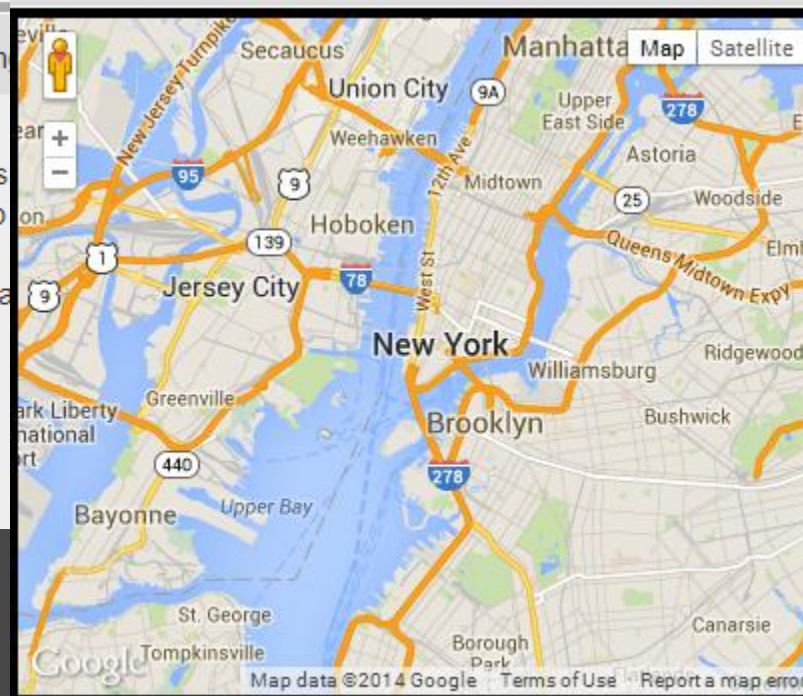
macys_gettingto

manhattan_gettingto

museum

Add new activity »

Critique existing activity »





ADDING AN ACTIVITY

- Crowd workers can **provide** any number of **activity suggestions**
- Both **unstructured and semi-structured input** handled
- Each **activity** is **in service of a “to-do” tag**
 - An activity *satisfies* a to-do tag
- After submission:
 - Planner checks for constraint violations
 - Planner generates sub-goals if applicable
 - Crowd workers critique the activity submission

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

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TO DO Tags:

macys_whattobuyin

macys_gettingto

manhattan_gettingto

museum

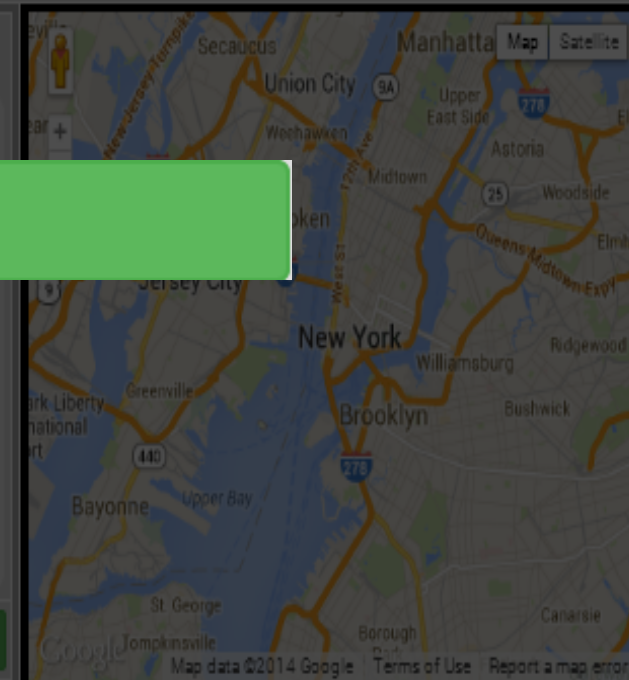
Add new activity »

Existing Activities:

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Critique existing activity »

Add new activity »





Add a New Suggestion

TO DO Tags:

museum

lunch

dinner

architecture

Add new activity »

Tag	Location	Comments/Description	Time	Duration	Cost
<p>*Select appropriate option from the dropdown list. Click the yellow option to type in your own tag.</p> <p>*All times must be in 24-hr format.</p> <div><div>walk</div><div>Manhattan</div><div>Walk near the NY public library and the ch</div><div>14:00</div><div></div><div>hours</div><div></div><div>\$</div><div>-add-</div></div>					

Click 'add' to enter new suggestions or 'remove' to delete one of your entries. Duration and cost is optional. Hit Submit after completing all your suggestions.

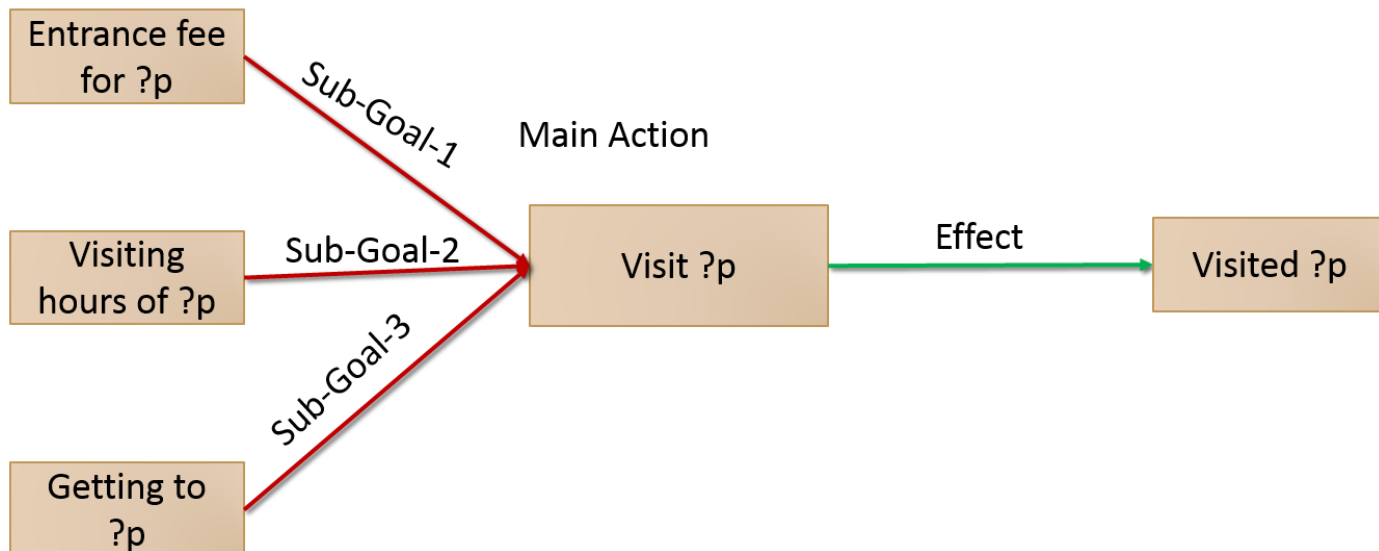
Submit

Go Back



SUB-GOAL GENERATION

- Planner uses a **high level PDDL action model**
- Action examples: visit, lunch, shop ...
- **Generic preconditions**
- **Unsatisfied sub-goals** thrown as **alerts**



TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

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- Have dinner and drinks at a good local restaurant. I want to spend a maximum time of 3 hours here. #dinner

manhattan_gettingto

TO DO T

s:

manhattan_gettingto

Getting to manhattan

museum

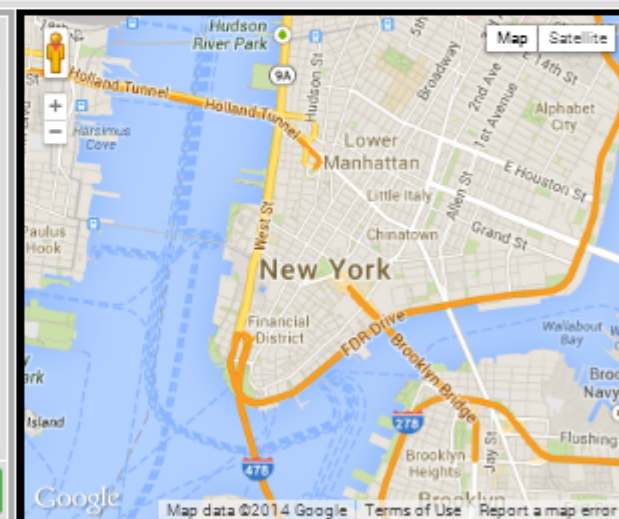
lunch

Add new activity »

Critique existing activity »

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours)
#shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk





ACTIVITY CRITIQUES

- **Automated Critiques**

- Constraint checking on quantitative values (cost, duration) input by crowd workers
- If violated, added to list of outstanding alerts

- **Human Critiques**

- Crowd workers can critique existing activities
- Each critique gets a new tag, with a pointer to the parent tag / activity

- Both kinds of critiques **resolved by future crowd workers** in further iterations
- AI-MIX **continues until no unresolved** alerts

TOUR REQUEST

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TO DO Tags:

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Add new activity »

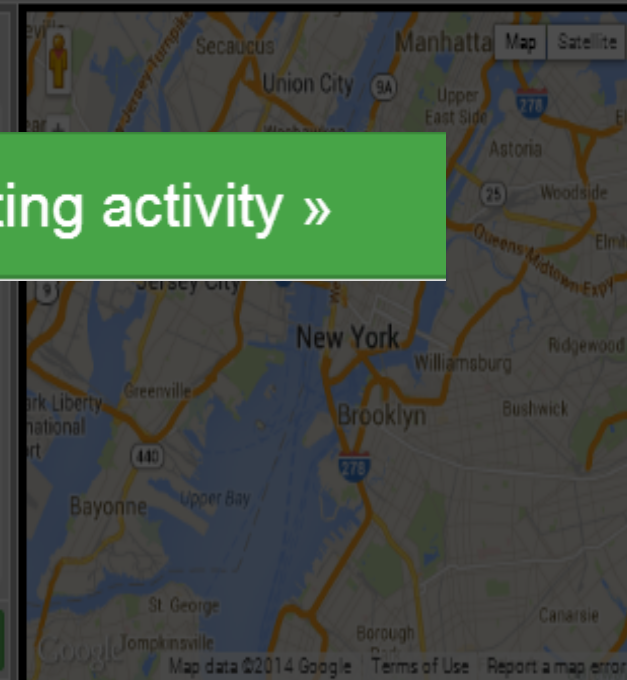
Existing Activities:

Macys: Awesome clothes
#shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Critique existing activity »

Critique existing activity »





ADDING A CRITIQUE

TourPlanner Instructions ▾

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

- Have a breakfast at a good local restaurant. #breakfast

Existing Activities

Select to provide orderings among activities

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours) #shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Your Critiques

*Select your options from the column on the left.

*All times must be in 24-hr format.



Click on the existing activities to enter your critique. All fields are required. Hit Submit when you are finished.

Submit

Go Back

Submit your hit



ADDING A CRITIQUE

TourPlanner Instructions ▾

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

- Have a breakfast at a good local restaurant. #breakfast

Existing Activities

Select to provide orderings
among activities

Macys: Awesome clothes and
the head quarters (10:00 hrs) (1
hours) #shop

Manhattan: Walk near the NY
public library and the charging
bull (14:00 hrs) #walk

Your Critiques

Tag: #shop

Location: Macys

Description: Awesome clothes and the head quarte

Time:

10:00

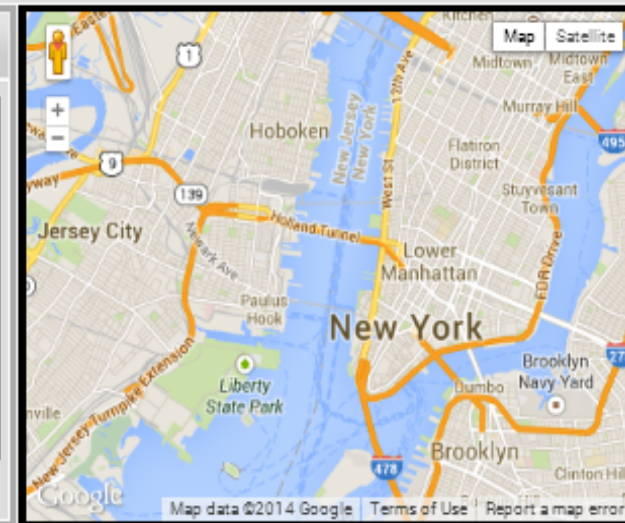
Duration: 1

Cost:

-remove-

*Select your options from the column on the left.

*All times must be in 24-hr format.



Click on the existing activities to enter your critiques. All form fields are required. Hit Submit when you are finished.

Submit

Go Back



ADDING AN ORDERING CONSTRAINT

TourPlanner Instructions

TOUR REQUEST

Going to New York City for only a day in about a month. Where is a must to eat at that I can make reservations at? With so little time, I don't exactly want to spend it waiting for hours to get seated/get food. Also, what are the must things I should do and see in NYC? Off the beaten path things are preferred! :) I've been to NYC before, so perhaps new speakasies, restaurants and night life recommendations would be awesome.

- Have a breakfast at a good local restaurant. #breakfast

Existing Activities

Select to provide orderings among activities

Macys: Awesome clothes and the head quarters (10:00 hrs) (1 hours) #shop

Manhattan: Walk near the NY public library and the charging bull (14:00 hrs) #walk

Your Critiques

lunch

before

after

touristy

-remove-

*Select your option from the column on the left.

*All times must be in 24-hr format.



Click on the existing activities to enter your critiques. All form fields are required. Hit Submit when you are finished.

Submit

Go Back



PLAN GENERATION: MAKING A SCHEDULE

- **Answer Set Programming (ASP)** used to put suggested activities together into a schedule / actionable plan
 - Knowledge base that models **common sense information**
 - Object Declarations
 - State Declarations
 - Domain Independent Axioms
- For Travel Planning domain:
 - **Temporal Constraints**
 - Typical time ranges of activity types like breakfast, lunch, dinner
 - **Existential Constraints**
 - *At least* one instance of each requested activity type
 - **Contiguity Constraints**
 - Same activity occurring at two different time points implies it also occurs in between
 - **Uniqueness**
 - Same activity over multiple time points is at the same location



PRELIMINARY EXPERIMENTS

- Evaluated on **Amazon's mTurk** platform
- **Human Intelligence Tasks (HITs)** were available only to crowd workers:
 - From the United States
 - HIT approval rate > 50%
 - Paid 20c. per HIT
- Travel Planning scenarios for **six US cities**
 - Washington D.C., Chicago, New York, San Francisco, Los Angeles, Las Vegas
- **150 turkers** (crowd workers)



EXPERIMENTAL CONDITIONS

- **NO-AUTO**

- No automated critiques
- All suggestions in free, unstructured text format

- **AUTO-SCHED**

- Constraint violations checked for cost and duration

- **AUTO-SCHED + SUB-GOAL**

- Constraint violations checked for cost and duration
- System processes unstructured text
- Generates alerts for missing preconditions (unsatisfied sub-goals)



RESULTS: TOUR-PLAN QUALITY

AUTO-SCHED

AUTO-SCHED + SUB-GOAL

Show: Go to TKTS half ticket discount booth. You have to stand in line early but it's an authentic nyc experience #show(3 hours)(200.0 \$)

Show: Go to show #show(3 hours)(200.0 \$)

Show: ABSOLUTELY CANNOT go wrong with Phantom of the Opera #show(3 hours)(200.0 \$)

Lunch: Alice's Tea Cup #lunch(20.0 \$)

Design: Walk around the Garment District (go into shops) just south of Times Square. They often print their own fabrics. #design(2 hours)(0.0 \$)

Dessert: Serendipity #dessert(1 hours)(10.0 \$)

piccolo angelo: Italian in the Village - real deal #italiandinner(2 hours)(60.0 \$)

Lombardi's Pizza: #italian_dinner #italiandinner_todo1

Ice Cream: <http://www.chinatownicecreamfactory.com/> #italiandinner_todo0

#lunch: Mangia Organics #lunch_todo0

watch Wicked (musical): Do watch Wicked the musical. It's a fantastic show and one of the most popular on Broadway right now! #broadwayshow(3 hours)(150.0 \$)

watch How to Succeed in Business: Also a great show, a little less grand than Wicked. #broadwayshow(3 hours)(150.0 \$)

Activity Steamer: #lunch #lunch_todo1

Paradis To-Go: Turkey & Gruyere is pretty delicious. The menu is simple, affordable, but certainly worth the time #lunch(1 hours)(10.0 \$)

cupcakes!: Magnolia Bakery on Bleecker in the Village #dessert(1 hours)(10.0 \$)



RESULTS: ROLE OF PLANNER MODULE

VOTED ICAPS 2014 BEST DEMO BY ... THE CROWD!

ICAPS
2014

International Conference on Automated Planning and Scheduling

2014 ICAPS System Demonstration

People's Choice Award

Presented to

L. Manikonda, T. Chakraborti, S. De, K. Talamadupula, S.

For the ICAPS 2014 System Demonstration

AI-Mix: How a Planner can Help Guide Hur
Towards a Better Crowdsourced Plan

June 24, 2014, Portsmouth, New Hampshire, US



GOAL



AI-MIX: A SUMMARY

- Automated Planning for Crowdsourced Planning
 - Interaction between Requester, Crowd, Planner
- Interpretation & Steering
 - Unstructured text
 - Impedance mismatch
 - Incomplete and unstructured domain
- Effective plan generation
 - Sub-goal generation
 - Constraint verification
 - Constructive critiquing
- Preliminary results from TourPlanning domain
 - Beneficial to include planner
 - Number of turker responses (engagement)
 - Critiques addressed (usefulness)
 - More detailed suggestions (steering)

POSTER (Near EAAI posters)
Room: 200B/C
Time: 5:30pm – 7:00pm
TODAY!

TODAY!