

# Requirements Engineering for Urban Applications

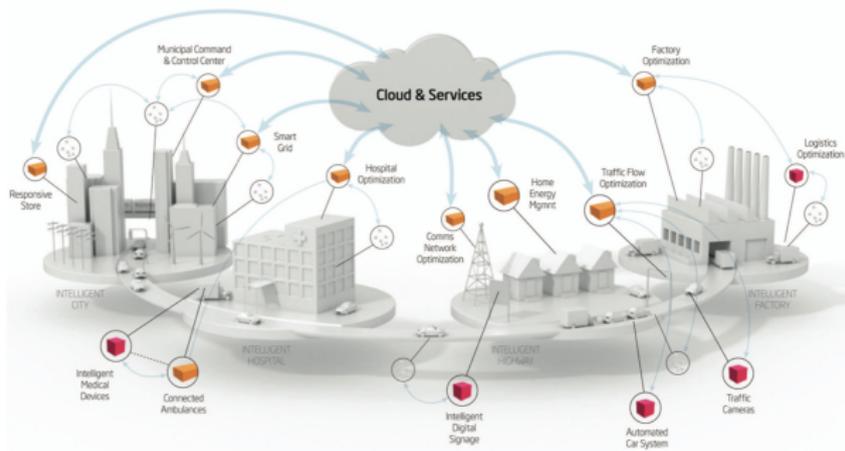
## Crowdsourcing and Crowdsensing Requirements

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# Requirements Engineering for Urban Applications

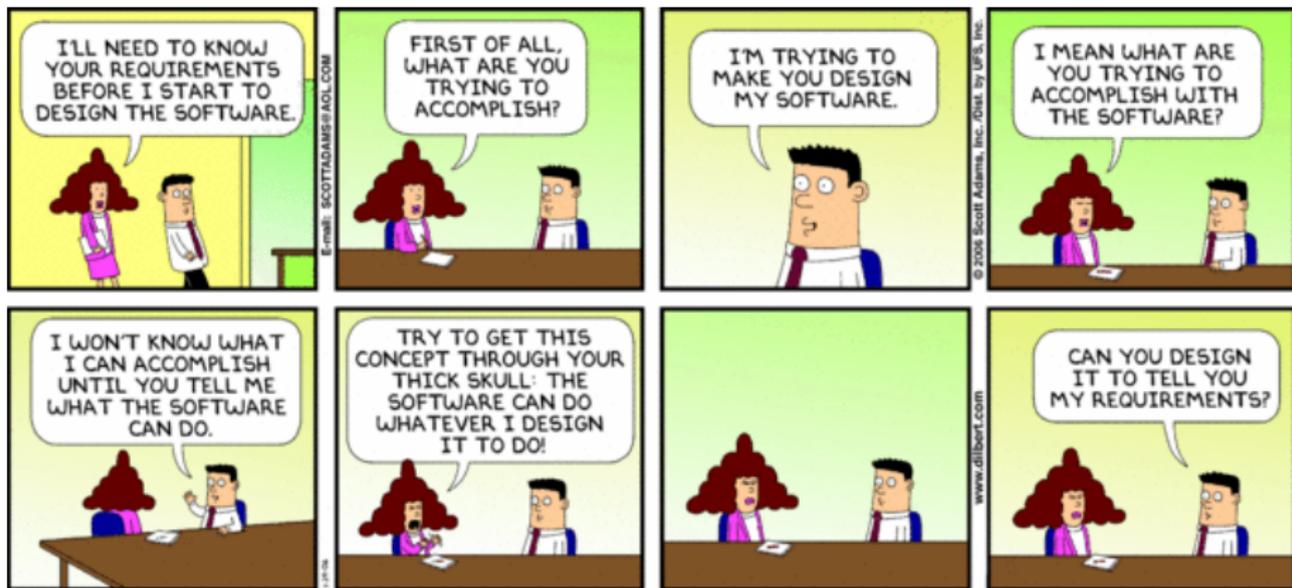
- ▶ We have been building increasingly sophisticated urban sensing, communication, and computing, and data infrastructures



Source: <http://www.cnet.se/wp-content/uploads/2015/11/smartcities.png>

But, how are we doing in understanding what the **stakeholders** of urban applications want?

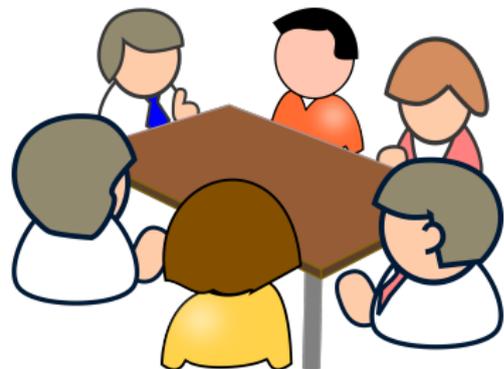
# So, What do the Stakeholders Want?



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# Requirements Elicitation

How do we acquire requirements for an application to be developed?



Interview a **few** stakeholders  
and develop *user stories*  
(as a *role*, I want *feature*, so that *benefit*)

Is this model of acquiring requirements effective for urban applications?

- ▶ Large variety of stakeholders
- ▶ Many usage contexts
- ▶ Continuously evolving requirements

# Outline

## Crowdsourcing Requirements

### Requirements from Social Media

### Crowdsensing Requirements

# Crowdsourcing Requirements

## Crowd RE: Requirements for the masses; from the masses

- ▶ Solicit ideas from the general public or the so called *crowd*
- ▶ Represent ideas as requirements

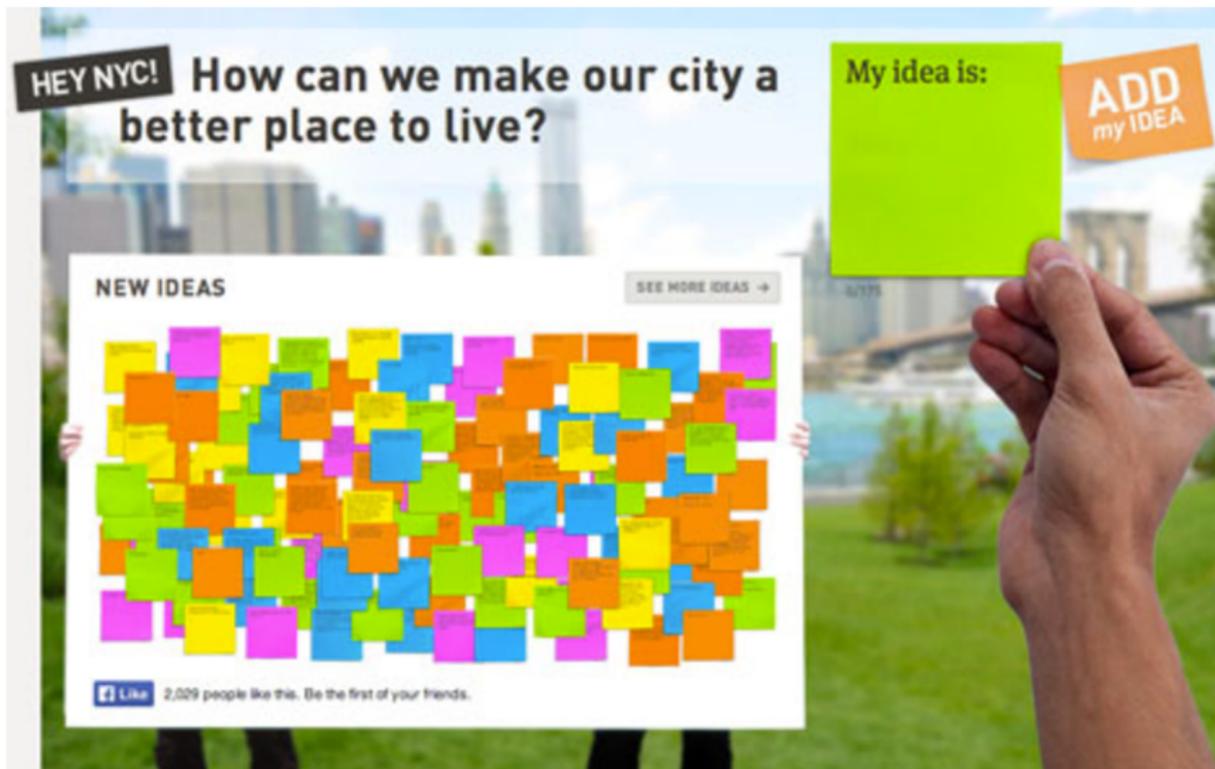


The logo for Innocentive, consisting of the word "INNOCENTIVE" in white, uppercase, sans-serif font, centered within a solid blue rounded rectangular background.



- ▶ A large number of workers from diverse backgrounds
- ▶ Crowd campaigns are relatively inexpensive

# Change By Us: Crowdsourcing NYC



Screenshot: <http://weburbanist.com/2014/03/05/crowdsourced-city-14-citizen-directed-urban-projects/>

# Pedestrians & Cyclists Crowdmap City Problem Areas [My Ideal City]



Screenshot: <https://www.psfk.com/2013/04/china-crowdmaps-pedestrian-and-cyclist-problem-areas-my-ideal-city.html>

Place Pulse | Mapping Urban x Pradeep Kumar

pulse.media.mit.edu

**PLACE PULSE** 1,468,714 clicks

Vision Rankings Maps Data Papers About

Which place looks safer ?

For this question: 473,381 clicks collected Goal: 500,000 clicks

[SEE REAL-TIME RANKINGS](#)

RANK	CITY	CLICKS	TREND	RANK	CITY	CLICKS	TREND
1	Washington DC	8234		54	Gaborone	6058	
2	Toronto	28357		55	Rio De Janeiro	32150	
3	Minneapolis	7111		56	Belo Horizonte	16923	

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Screenshot: <http://pulse.media.mit.edu/>

## Facilitating Creativity in Crowd RE

- ▶ Typical crowdsourced tasks require basic human abilities, e.g, language understanding and visual recognition, but not creativity
- ▶ RE is a creative problem solving process
  - Goal modeling: Objective finding, problem finding
  - Requirements acquisition: Idea generation
  - Architecture modeling: Solution finding



How can we facilitate crowdsourcing of requirements acquisition (idea generation), a task that requires participants to exercise creativity?

[Murukannaiah, Ajmeri, and Singh. “Acquiring creative requirements from the crowd...” In *Proc. RE*, 2016, pp. 176–185.]

# Creative Idea Generation

- ▶ Idea generation is often understood as a social process

**Pros:** Cognitive stimulation promotes creativity

**Cons:** Evaluation apprehension, social loafing



- ▶ Facilitating group work for crowdsourced tasks is nontrivial

- ▶ Workers are from different locations,  
and their work styles and motivations differ



How can we promote creativity in crowdsourced tasks, where group work is not viable?

# Crowdsourcing Creative Idea Generation

- ▶ Cognitive stimulation produced by exposure to others' ideas is key to an individual's creativity in a group
- ▶ A **sequential task design** can yield the desired cognitive stimulation

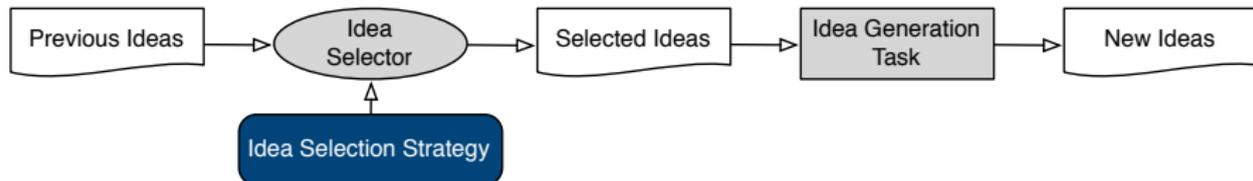


- ▶ The sequential task design may lead to **information overload**

# Reducing Information Overload



Select a few ideas from a pool of previously acquired ideas to cognitively stimulate a new worker



## Selection of Stimulating Ideas

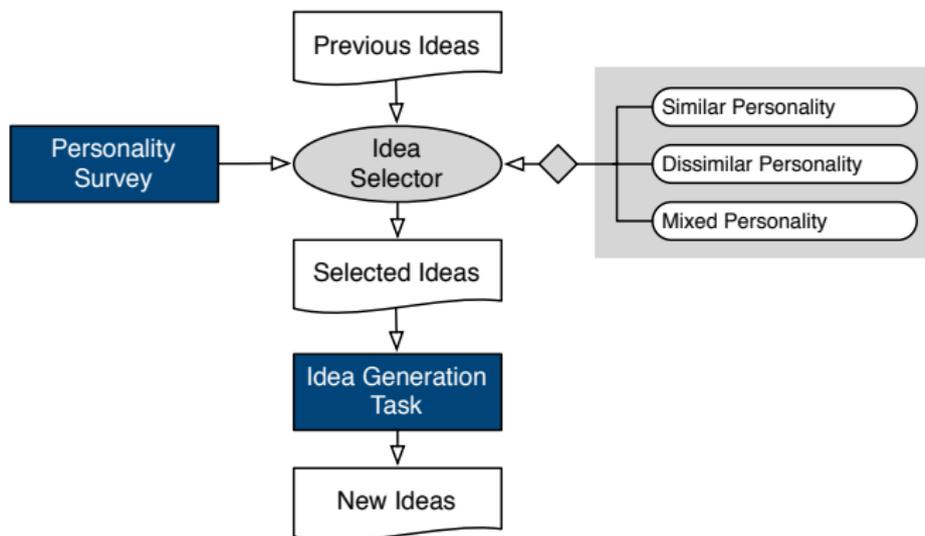
A group's **personality** composition influences its **creative** performance

### The Big Five Personality Traits

Trait	Description
<b>O</b> penness	Curious, original, intellectual, creative, and open to new ideas.
<b>C</b> onscientiousness	Organized, systematic, punctual, achievement oriented, and dependable.
<b>E</b> xtraversion	Outgoing, talkative, sociable, and enjoys being in social situations.
<b>A</b> greeableness	Affable, tolerant, sensitive, trusting, kind, and warm.
<b>N</b> euroticism	Anxious, irritable, temperamental, and moody.

Source: <https://open.lib.umn.edu/principlesmanagement/chapter/2-3-personality-and-values-3/>

# Personality-based Ideal Selection

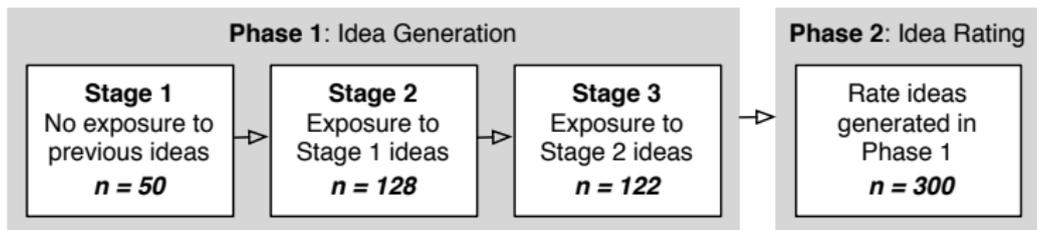


$$\text{Personality distance: } \sum_{\text{trait} \in \{O,C,E,A,N\}} (\text{trait}_i - \text{trait}_j)^2$$

# Empirical Study: Requirements for a Smart Home



- ▶ The emerging domain provides a large space for exercising **creativity**
- ▶ The concept is not new, which makes it a **viable topic**
- ▶ The crowd may find generating ideas for smart homes **fun & worthwhile**



# Empirical Study Phase 1: Idea Generation Task

## Sample Smart Home Requirements

---

1. **As a** pet owner,  
**I want** my smart home to let me know when the dog uses the doggy door,  
**so that** I can keep track of the pets whereabouts.

**Application Category:** *Safety*

**Tags:** **pets** **location**

2... ..

## New Smart Home Requirement

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**As a**

**I want**

**so that**

**Application Category**

**Tags**

**Add Requirement**

# Empirical Study Phase 2: Measuring Creativity of the Ideas

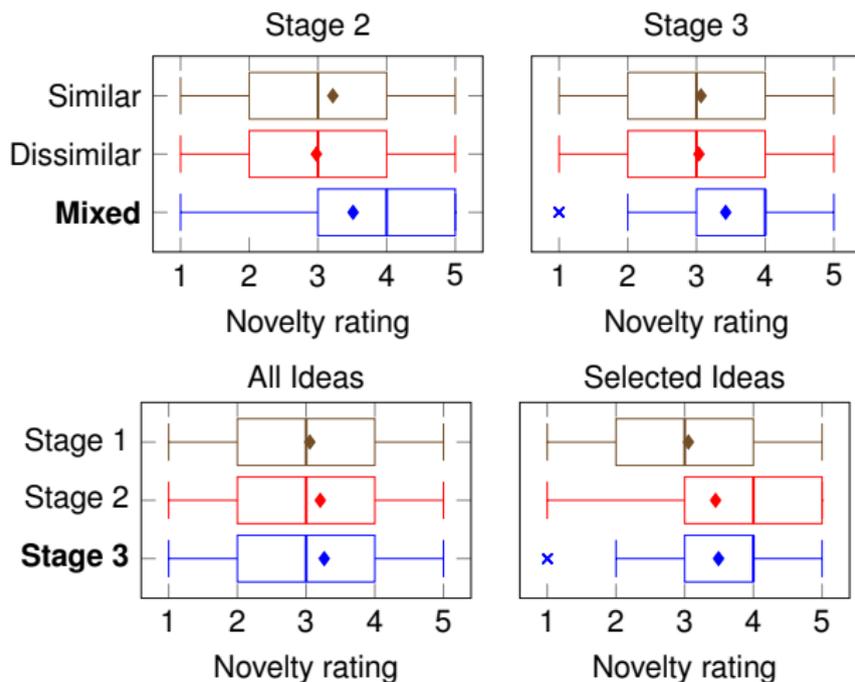
Creativity entails **novelty** (originality) and **usefulness** (value adding)

**Rate Smart Home Requirements** Scale: 1: Very Low 2: Low 3: Medium 4: High 5: Very High

- |      |   | 1                  | 2                     | 3                     | 4                     | 5                     |                       |
|------|---|--------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1.   | <p><b>As a home owner,</b><br/> <b>I want</b> my smart home to turn on yard lights when motion is detected<br/> <b>so that</b> break-ins can be avoided<br/> <b>Application Category:</b> <i>Safety</i><br/> <b>Tags:</b> <span>breakin</span></p>  | <b>Clarity:</b>    | <input type="radio"/> |
|      |   | <b>Novelty:</b>    | <input type="radio"/> |
|      |   | <b>Usefulness:</b> | <input type="radio"/> |
| 2.   | <p><b>As a home occupant,</b><br/> <b>I want my</b> my smart home to learn my lighting habits and continue to use them when I am away<br/> <b>so that</b> intruders are deterred.<br/> <b>Application Category:</b> <i>Safety</i><br/> <b>Tags:</b> <span>Vacation</span> <span>lighting</span></p> | <b>Clarity:</b>    | <input type="radio"/> |
|      |   | <b>Novelty:</b>    | <input type="radio"/> |
|      |   | <b>Usefulness:</b> | <input type="radio"/> |
| 3... | ...   |                    |                       |                       |                       |                       |                       |

**Rate Requirements**

# Results: Personality-Based Idea Selection Strategies



# Outline

Crowdsourcing Requirements

**Requirements from Social Media**

Crowdsensing Requirements

# User Discussions

[-] [Vitztlampahecatl](#) 222 points 11 months ago

| **OK Google, find directions to the nearest gas station.**

Done

[permalink](#) [embed](#) [save](#) [give gold](#)

[-] [darknecross](#) 122 points 11 months ago

Last time I did this it directed me to the station from the exit I had just passed, so it wanted me to get off at the next exit and head back up the interstate the other direction...

On-route search is much better.

[permalink](#) [embed](#) [save](#) [parent](#) [give gold](#)

[-] [xenomorph](#) 31 points 11 months ago

That probably just means that gas station is closer even if you have to go back than forward. Sometimes the one ahead of you will be too far away. Otherwise if you're not in a hurry you can probably just get off at the next gas sign.

[permalink](#) [embed](#) [save](#) [parent](#) [give gold](#)

[-] [darknecross](#) 11 points 11 months ago

There was gas at the exit they wanted me to turn around at...

[permalink](#) [embed](#) [save](#) [parent](#) [give gold](#)

[-] [IANALbutIAMAcat](#) -1 points 11 months ago

Going to a gas station that is en route for you is going to be less added distance than if you have to back track.

[permalink](#) [save](#) [parent](#) [give gold](#)

[-] [AngryItalian](#) 1 point 11 months ago

Yes but if you don't have enough gas to make that distance adding that distance is kind of necessary.

[permalink](#) [save](#) [parent](#) [give gold](#)

# User Discussions

Let's help reform our city! Can you help me find vacant lots [former gas stations] in Oakland? (self.oakland)  
submitted 2 years ago \* by rshultz

Hey Reddit,

I am compiling a list of all the vacant lots in Oakland that were former gas stations. These lots have usually been unoccupied for years so I am mainly directing this request to folks who grew up in the town or have been living here for several years.

I want to develop this comprehensive list in order to lobby the city council to acquire the necessary city funds to re-purpose the land for general redevelopment. Currently, it is illegal to build on these plots of land as there are [environmental](#) restrictions for building on top of underground gasoline storage tanks.

This is all I have so far:

\* [Example One](#) --> [Rockridge: Claremont at College](#)

\* [Example Two](#) --> [The Laurel: High at MacArthur](#)

↑ [-] [zwenhor](#) 5 points 2 years ago

↓ the lot on the ne corner of 14th and Union St in west oakland looks like an abandoned gas station

[permalink](#) [embed](#)

↑ [-] [eugenbluegenes](#) 3 points 2 years ago\*

↓ Yup, that's a closed gas station. Interestingly enough, I recently reviewed that case and it's actually getting close to meeting closure criteria. Don't know much about post-remedial plans for the property, but I do know there was significant legal wrangling with lawsuits trying to work out the responsible party. Unfortunately, this implies there may be additional complications. That's kinda conjecture on my part though.

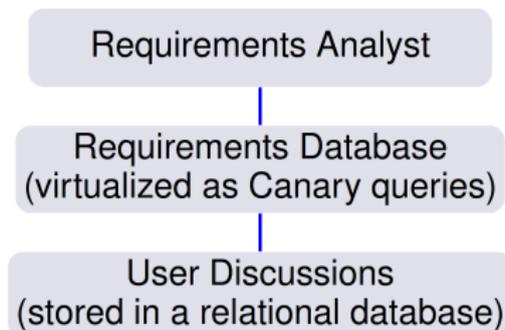
[permalink](#) [embed](#) [parent](#)

↑ [-] [\[deleted\]](#) 3 points 2 years ago

↓ I know next to nothing about this, but is it not very risky to build on abandoned gas stations with the gas lines and what not? My apologies if I'm mistaken, but I'm just thinking of the site that got quarantined for development in my hometown for some reason along those lines.



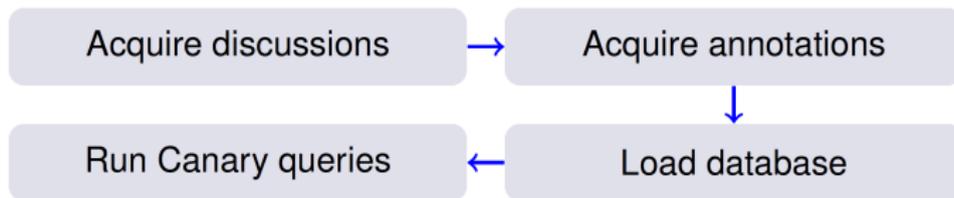
# Canary: A Requirements View of User Discussions



Canary realizes a requirements-oriented store over user discussions stored in traditional information stores. The view is realized via a mapping from Canary queries to SQL queries

[Kanchev, Murukannaiah, Chopra, and Sawyer. "Canary: Extracting Requirements-Related Information from Online Discussions."  
In *Proc. RE*, 2017, pp. 1–10.]

# Canary: Annotations and Query Language




---

<query> : <expr> | <arg\_expr>  
 <expr> : <req\_expr> | <sol\_expr>  
 <req\_expr> : requirement | requirement where <condition> |  
                   <aggregator> ( <req\_expr> )  
 <sol\_expr> : solution ( <req\_expr> ) | solution ( <req\_expr> ) where  
                   <condition> | <aggregator> ( <sol\_expr> )  
 <arg\_expr> : <arg\_entity> ( <expr> ) | <arg\_entity> ( <expr> ) where  
                   <condition>  
 <arg\_entity> : support | rebuttal  
 <aggregator> : popular | unpopular | controversial | discussed

---

# High-Level Queries about Requirements

## requirement

text	annotation	user	UR	score	depth
save address	requirement	John	9101	912	1
coordinates	requirement	Stuart	34856	105	2

```
solution (
  requirement where text regexp 'save address'
)
```

text	annotation	user	UR	score	depth
long press and send to Keep	solution	Henry	82,104	-18	2
custom overlay engine	solution	Patrick	921	149	2

```
popular ( solution ( requirement where regexp
  'save address' ) )
```

text	annotation	user	UR	score	pop score
custom overlay engine	solution	Patrick	921	149	298

# Outline

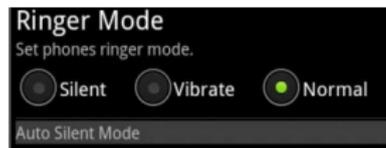
Crowdsourcing Requirements

Requirements from Social Media

Crowdsensing Requirements

# Crowdsensing Requirements: RE at Runtime

## Ringer Manager Application



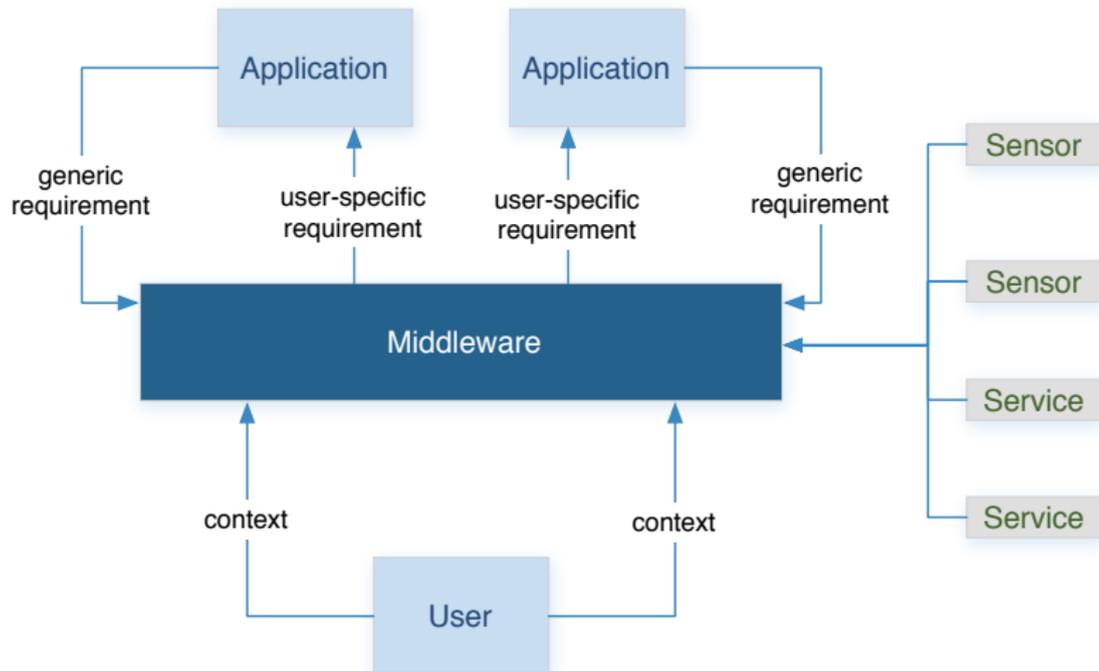
## Specify generic requirements at design time

- ▶ Keep the phone silent when the user is busy

## Sense user-specific requirements at run time

- ▶ Keep the phone silent when I am in a meeting, except when boss calls
- ▶ Keep the phone silent when I am working, except for calls from family

# RE at Runtime: Requirements Reflection



# RE at Runtime: Methodology and Middleware

## Methodology: To support developers

- ▶ How can we facilitate developers to systematically reason about the requirements of an intelligent application and derive its specification?

Murukannaiah and Singh. “Xipho: Extending Tropos to engineer context-aware personal agents.” In *Proc. AAMAS*, 2014, pp. 309-316.

## Middleware: To support developers and end users

- ▶ How can we engage end users in tailoring developer-specified requirements to meet their individual needs?

Murukannaiah and Singh. “Platys: An active learning framework for place-aware application development and its evaluation.” *TOSEM*, 2015, 24(3):1–33.

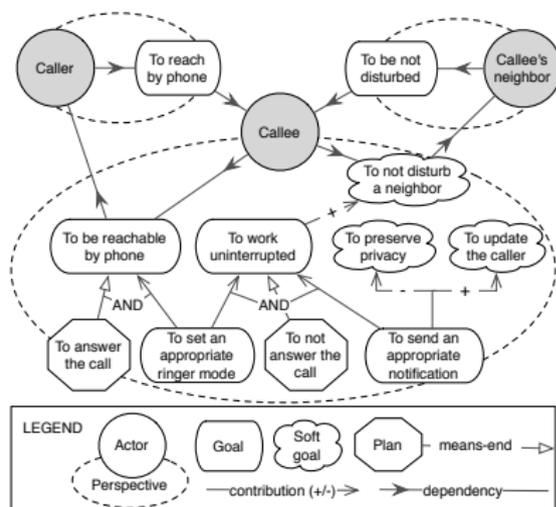
# Modeling Requirements

Think not just What and How, but more importantly, **Why!**

## Agent-oriented modeling

- ▶ **Actor:** A social, physical, or software agent
- ▶ **Goal:** A strategic interest of an actor
- ▶ **Plan:** An abstraction of action
- ▶ **Belief:** An actor's representation of the world
- ▶ **Dependency:** A relationship between actors

## An actor model of Intelligent Ringer



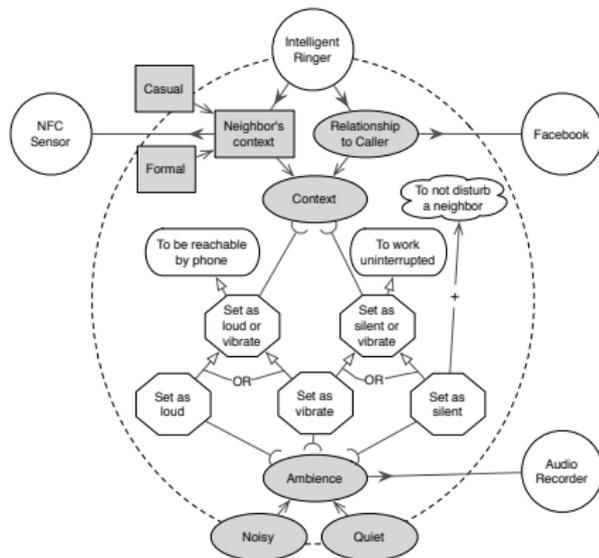
# Bridging Requirements and Data

## Xipho Methodology

- ▶ Provides systematic steps to map *agent capabilities* to *data abstractions*
- ▶ Yields a specification grounded in data, e.g.,  
 $Relationship = ?R_1 \wedge$   
 $Neighbor's\ context =$   
 $Casual \wedge Ambience =$   
 $Noisy \rightarrow Set\ as\ loud$

Connects intents and data

## A conceptual model of Intelligent Ringer



# Machine Learning Context

## Practical considerations

- ▶ **Multimodal** and **sporadic**: Originating from multiple sensors
- ▶ **Sparse**: Sensing consumes energy

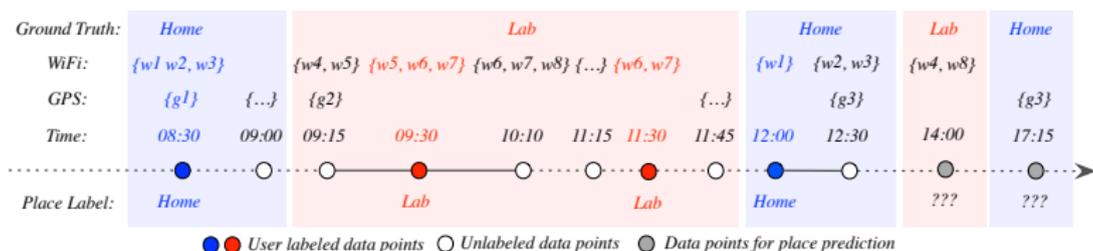


Figure: Stream of intermittent sensor data and place labels

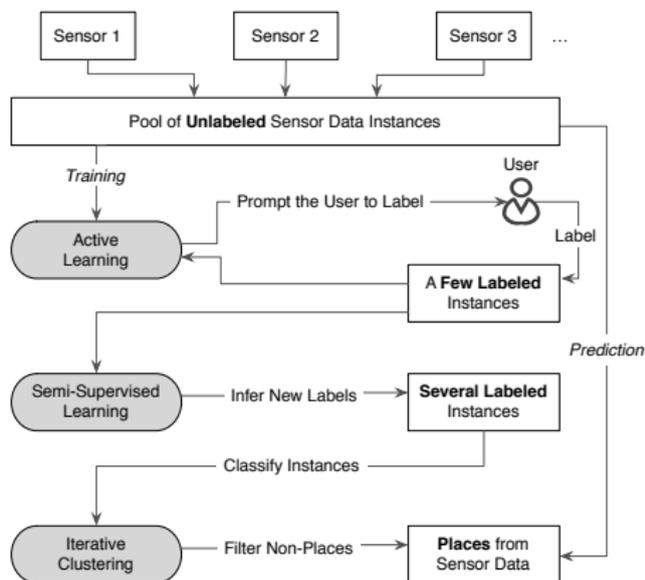
## Traditional approaches

- ▶ **Unsupervised**: Require frequent sensing
- ▶ **Supervised**: Require several labeled instances to perform well

# Platys Reasoner: A Context Learning Pipeline

## Platys Reasoner: A middle ground solution

- ▶ Active learning seeks to reduce labeling effort
- ▶ Semi-supervised learning deals with infrequent sensor data

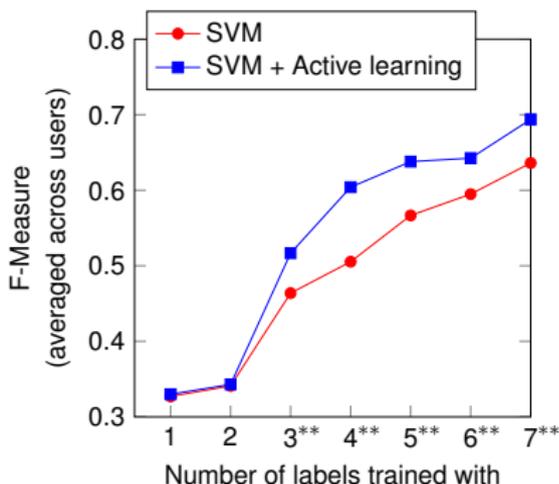
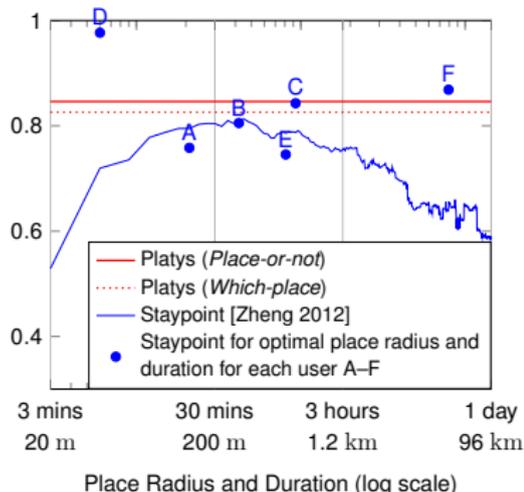




# Platys Reasoner User Study

What benefits does Platys Reasoner offer compared to traditional unsupervised and supervised approaches?

- ▶ No set of parameter values is optimal for every user
- ▶ Platys achieves better F-measure than two traditional classifiers



# Summary and Directions

## Requirements Elicitation

- ▶ A framework for creative idea generation (RE 2016)
- ▶ A language for querying requirements from social media (RE 2017)
- ▶ A middleware for facilitating RE at runtime (AAMAS 2014, TOSEM 2015)

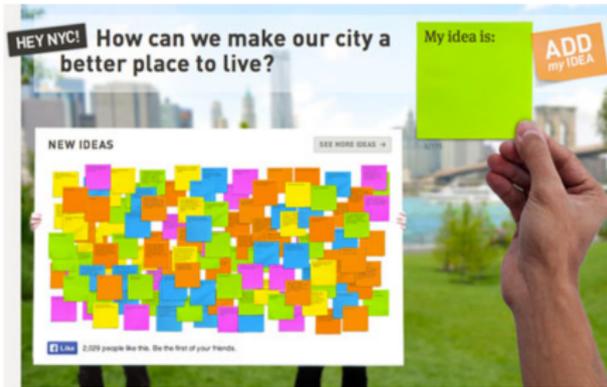
## Data-Driven Challenges

- ▶ Crowd-acquired data: Summarizing and prioritizing requirements
- ▶ Social media data: Mining arguments
- ▶ Data from mobile and social sensors: Context learning

## Explainable Artificial Intelligence (XAI)

- ▶ Bridging users' intents and the insights their data provide

## Change By Us: Crowdsourcing NYC



## MyIdealCity: Crowdsourced Plan to Redesign a City in South America

**mic BOGOTÁ**  
MY IDEAL CITY

Participate in building the future of Bogotá

Home Maximized Spaces Sensible City **Citizen Sourced** Urban Canvas Green Scaping

# Citizen Sourced

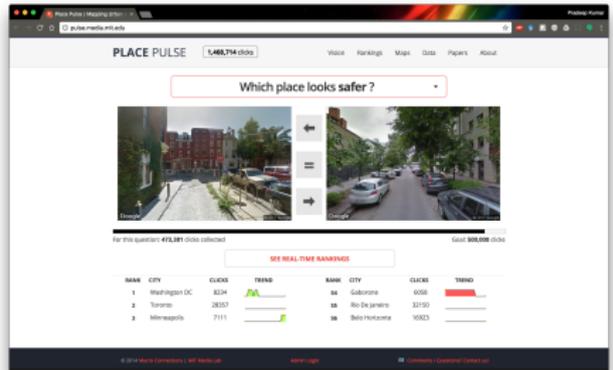
Harnessing the power of citizens to raise the collective resources and benefits available across communities, neighborhoods and entire cities.

Questions. Suggest your idea



# M

@micboc Bogota 22 hours



## Pedestrians & Cyclists Crowmap City Problem Areas [My Ideal City]



Thank You