



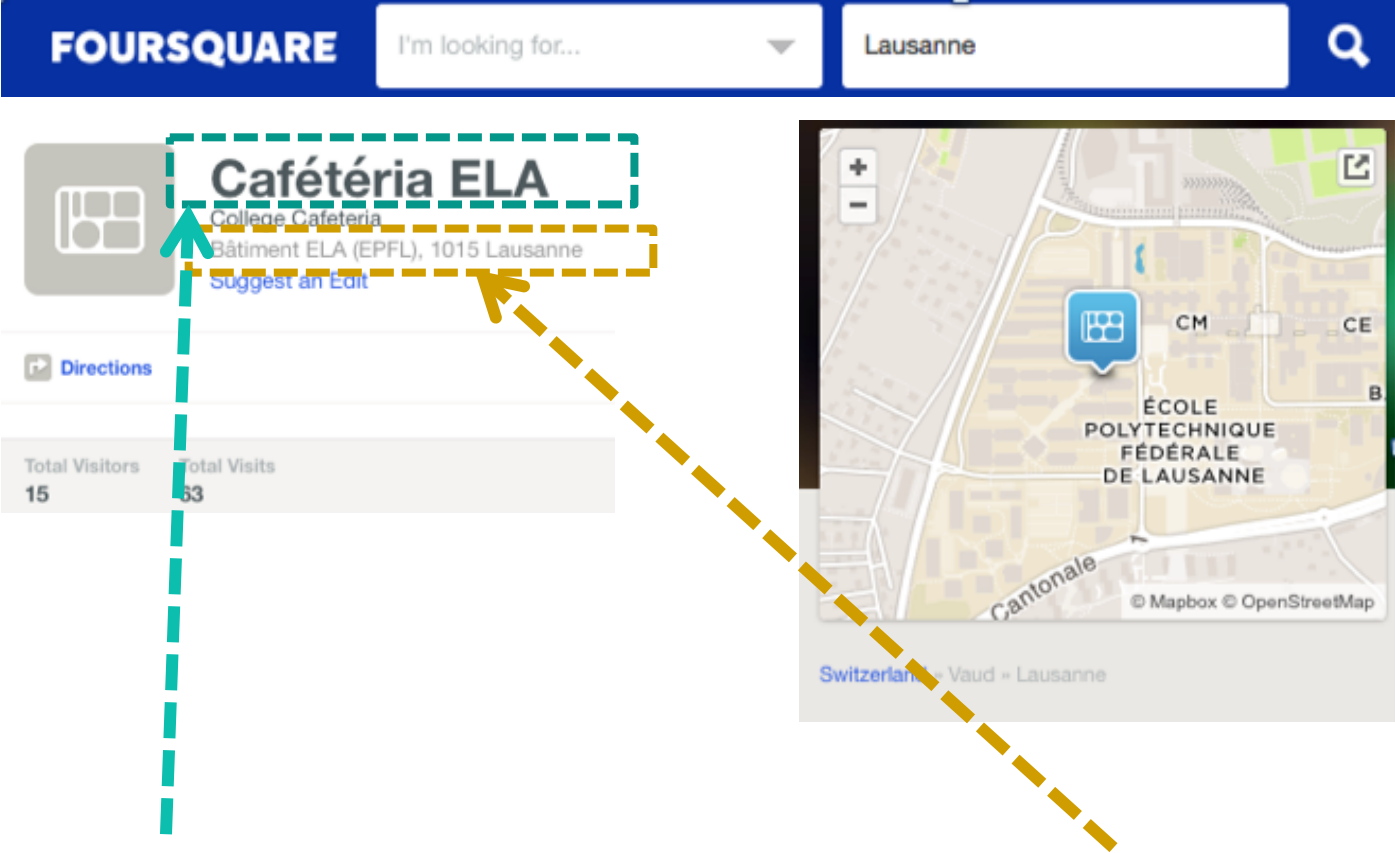
# Predicting Users' Motivations Behind Location Check-Ins and Utility Implications of Privacy Protection Mechanisms

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# Location Check-in



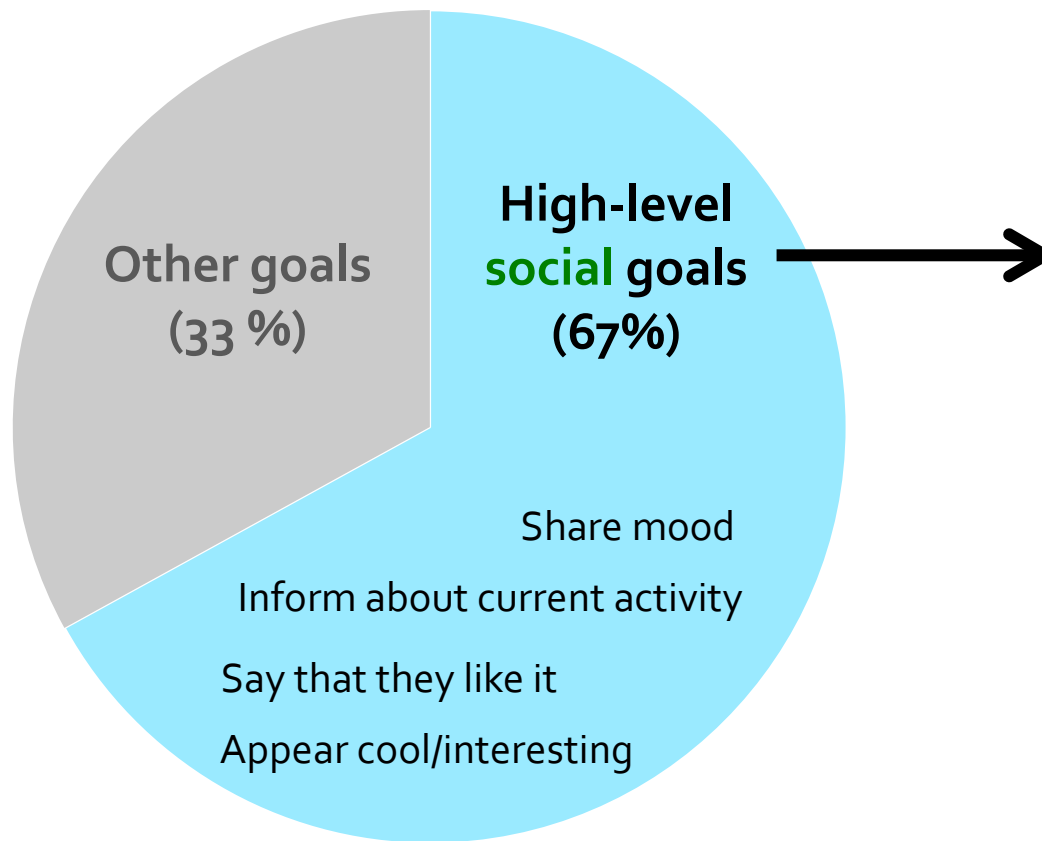
Actual venue and type

+

Accurate geographic location

# Location Check-in

- Why do people check in to places?



- How useful is **detailed geographic + semantic** information of a check-in?
- Can we **predict usefulness** of a check-in after removing some semantic + geographic information?

n = 3532 check-ins, Jan. 2014

# Contributions

- **Study purpose** of individual location check-ins
- **Design inference system** to predict purpose of location check-ins
- **Evaluate perceived loss of utility** due to location obfuscation
  - Based on users' perception

# Outline

- 1. Related Work**
- 2. Methodology and Data Collection**
- 3. Results**
  1. Check-in Purpose and Inference
  2. Utility of Check-ins
- 4. Summary and Future Work**

# 1. Related Work

## Motivation for check-ins

- Desire to connect with other and project interesting image of oneself [27,28]
- Impression management [12,21]

## Utility of check-ins

- Importance of audience of check-ins [5]
- Perception of check-ins by social circle

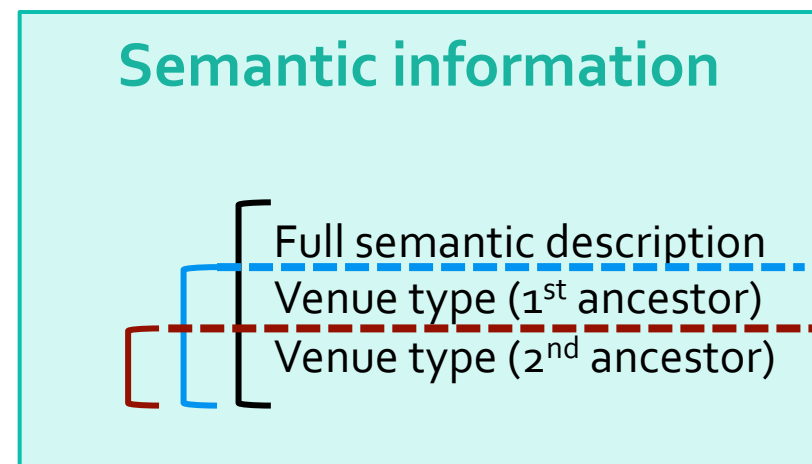
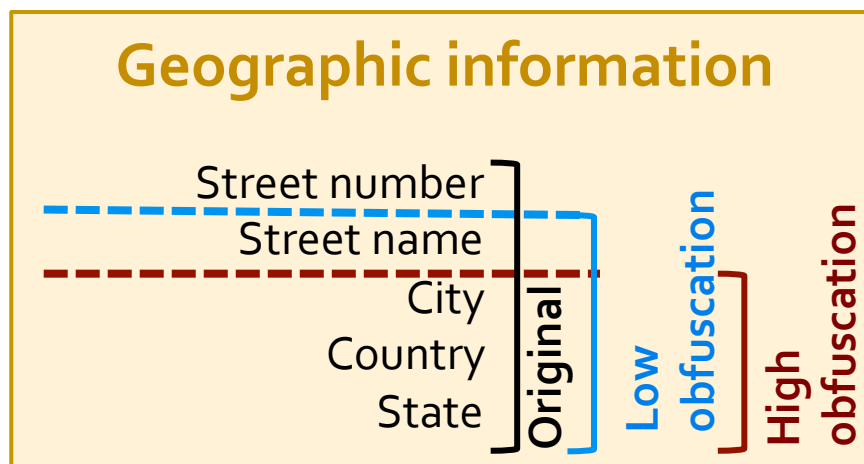
## Location obfuscation

- Well-studied topic in mobile networks
- Users lack awareness of long-term threats [3]
- Limited effect on application functionality [23]

- **Lack of user-centric utility functions for location check-ins**
  - Most prior works focus on the application dimension [15,23]
    - (e.g., fraction of restaurants that are missed, error of traffic information, etc.)
  - We focus on the user, by predicting utility loss based on users' perception


## 2. Methodology and Data Collection

- **Personalized survey about Foursquare check-ins**
  - Deployed over Mechanical Turk & ad-hoc Foursquare app
  - Provides ground-truth about
    - Purpose of actual check-ins
    - Utility of check-ins if “some” location information is obfuscated
- **Location obfuscation through generalization**



Original check-in

• **Check-in #1**  
 On Saturday 20th Oct 2012 at 6:40PM, you made the following check-in:



**Unknown User**  
 "Damn you phone problems"  
 October 20, Saturday, 06:40PM




What was the **primary** purpose behind the check-in above?

Purpose of check-in

- Say that I like it
- Appear cool/interesting
- Share mood
- Keep track of the places I visit
- Wish people to join me
- Inform about people around me
- Inform about activity
- Inform about location
- Inform about venue
- Inform about location + venue
- Recommend it
- Participate in a game/competition
- Get a reward
- Other (write the purpose in the comment box)

Please enter your comment here:

Utility of check-in

• On a scale from 1 to 5, where 1 is "not at all" and 5 is "perfectly", to what extent would your purposes be met if the precise venue information  was replaced by the following:

	Not at all 1	2	3	4	Perfectly 5
At an electronics store, at E Dixon Blvd (Shelby 28152, NC, US)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
At a shop and service, at E Dixon Blvd (Shelby 28152, NC, US)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
At an electronics store, in Shelby (NC, US)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
At a shop and service, in Shelby (NC, US)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

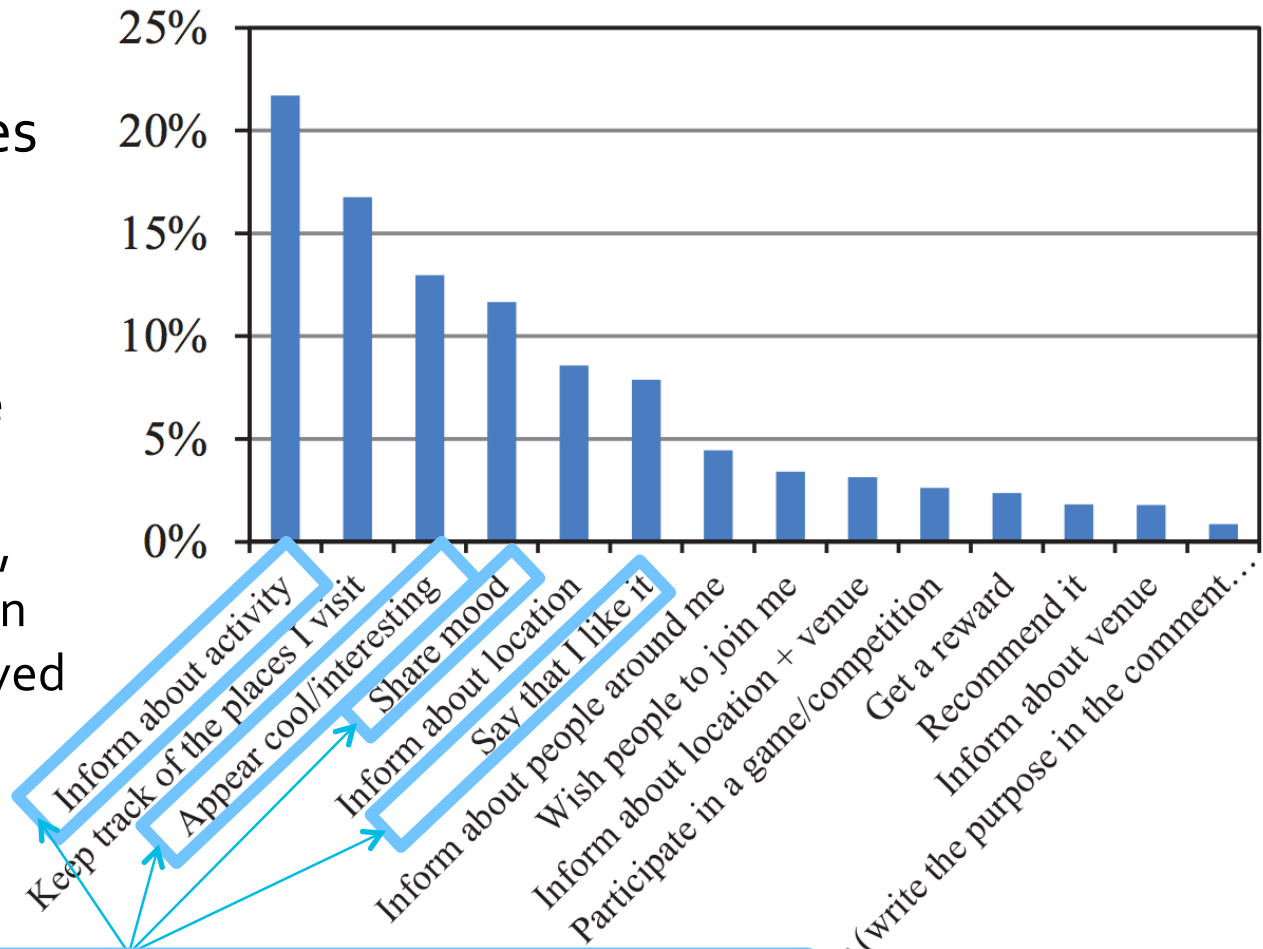


# 3. Results

## ■ Participants

- 77 valid questionnaires
  - 43% male, avg. age 29 ( $\pm 6$  y.), 96% from the US
  - 14% students, 12% education 7% unemployed

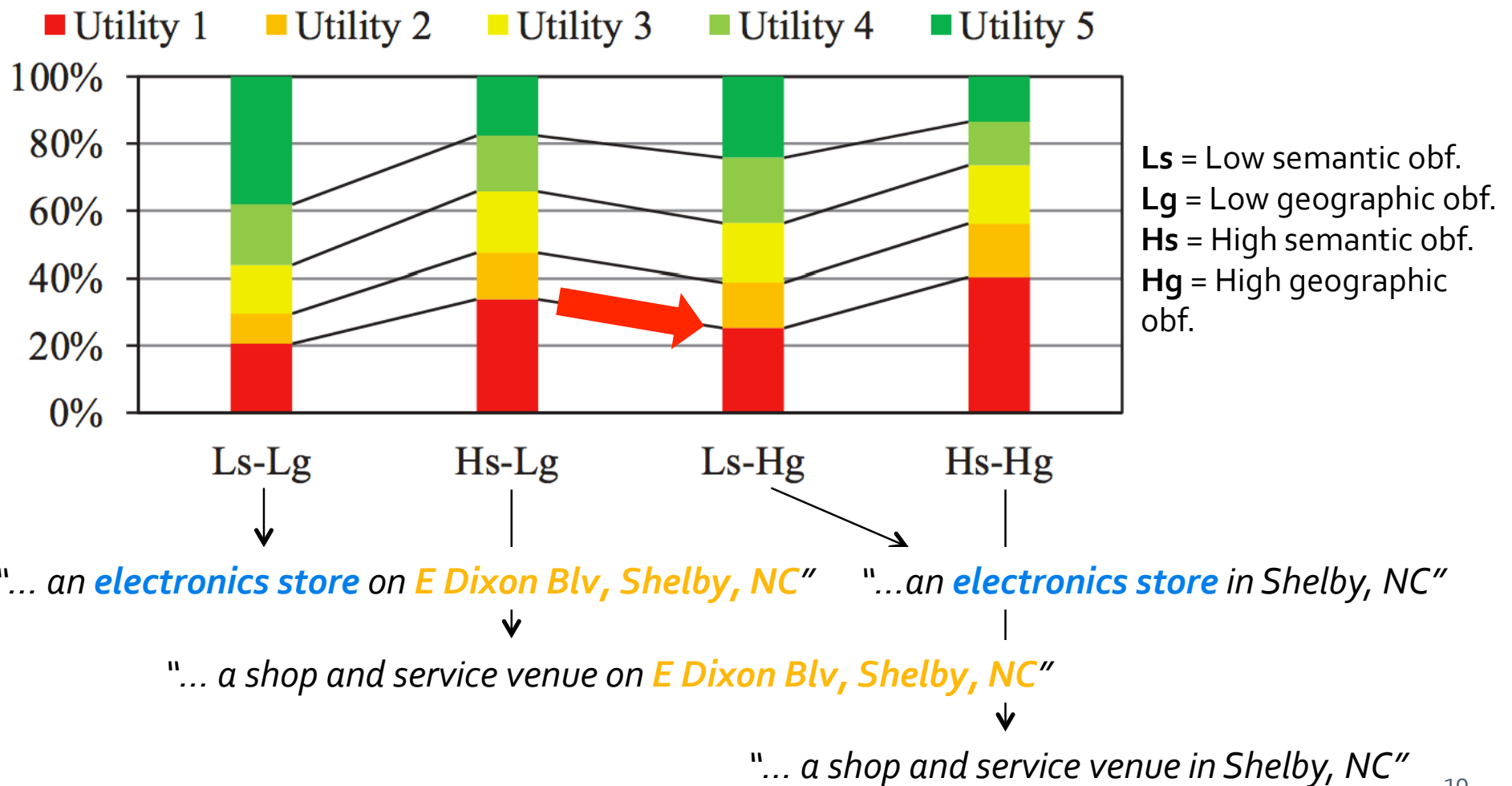
## ■ Purposes of Check-ins



67% of all check-ins' purposes related to a high-level social goal

# Utility vs. Obfuscation Levels

- “On a scale from 1 to 5 (...), to what extent would your purpose be met, if the precise venue information (...) was replaced by (...)”

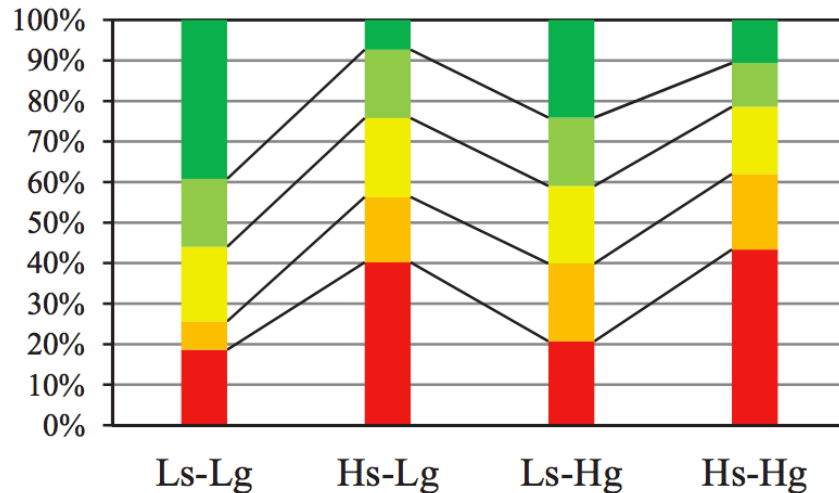


# Utility vs. Obfuscation Levels

- Utility changes depending on the actual purpose of check-ins

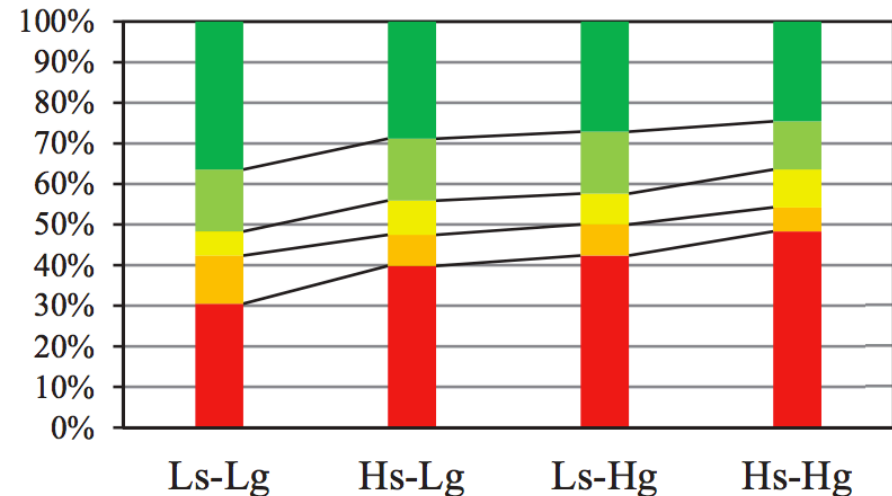
**Purpose: Inform about activity**

■ Utility 1 ■ Utility 2 ■ Utility 3 ■ Utility 4 ■ Utility 5



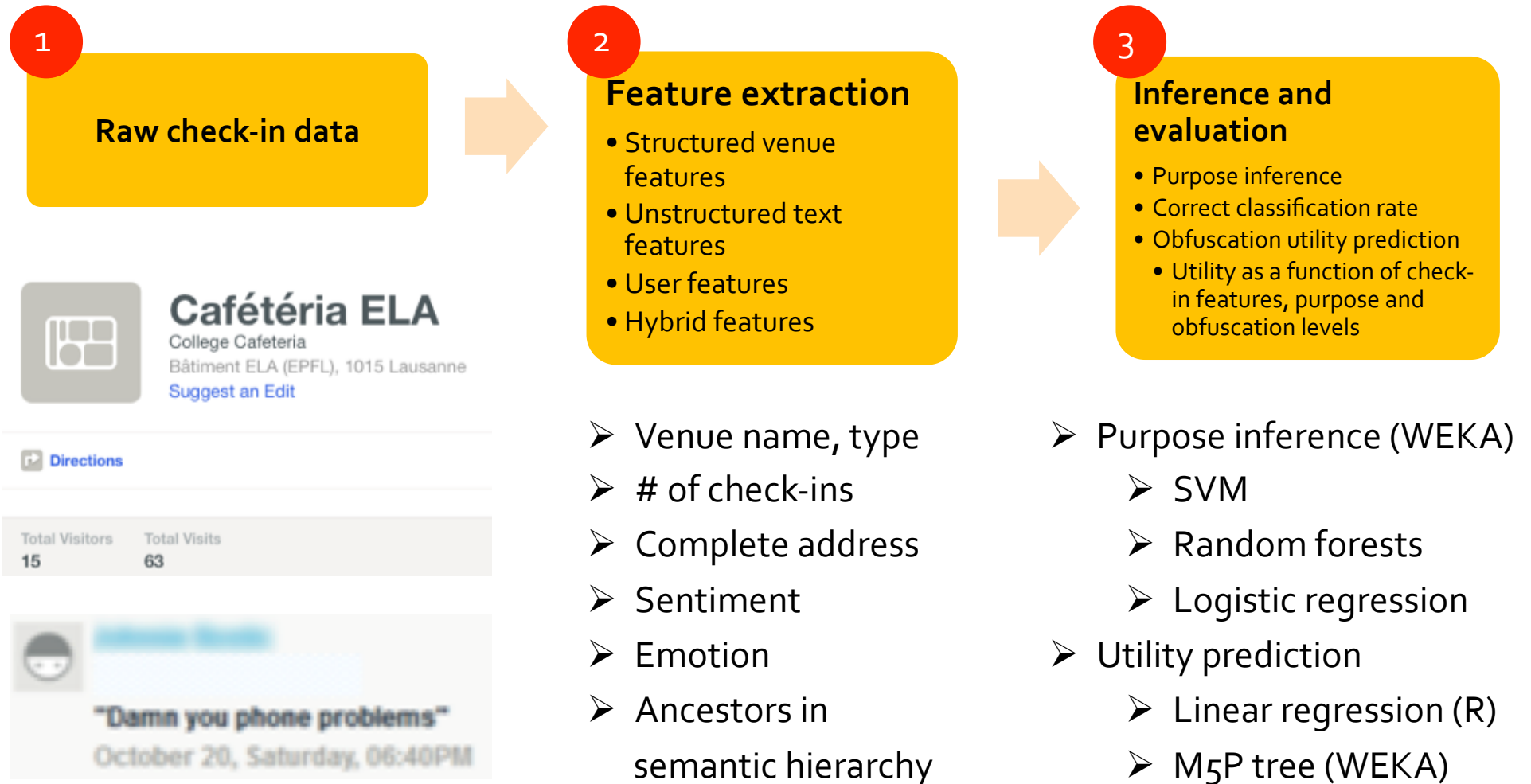
**Purpose: Wish people to join me**

■ Utility 1 ■ Utility 2 ■ Utility 3 ■ Utility 4 ■ Utility 5



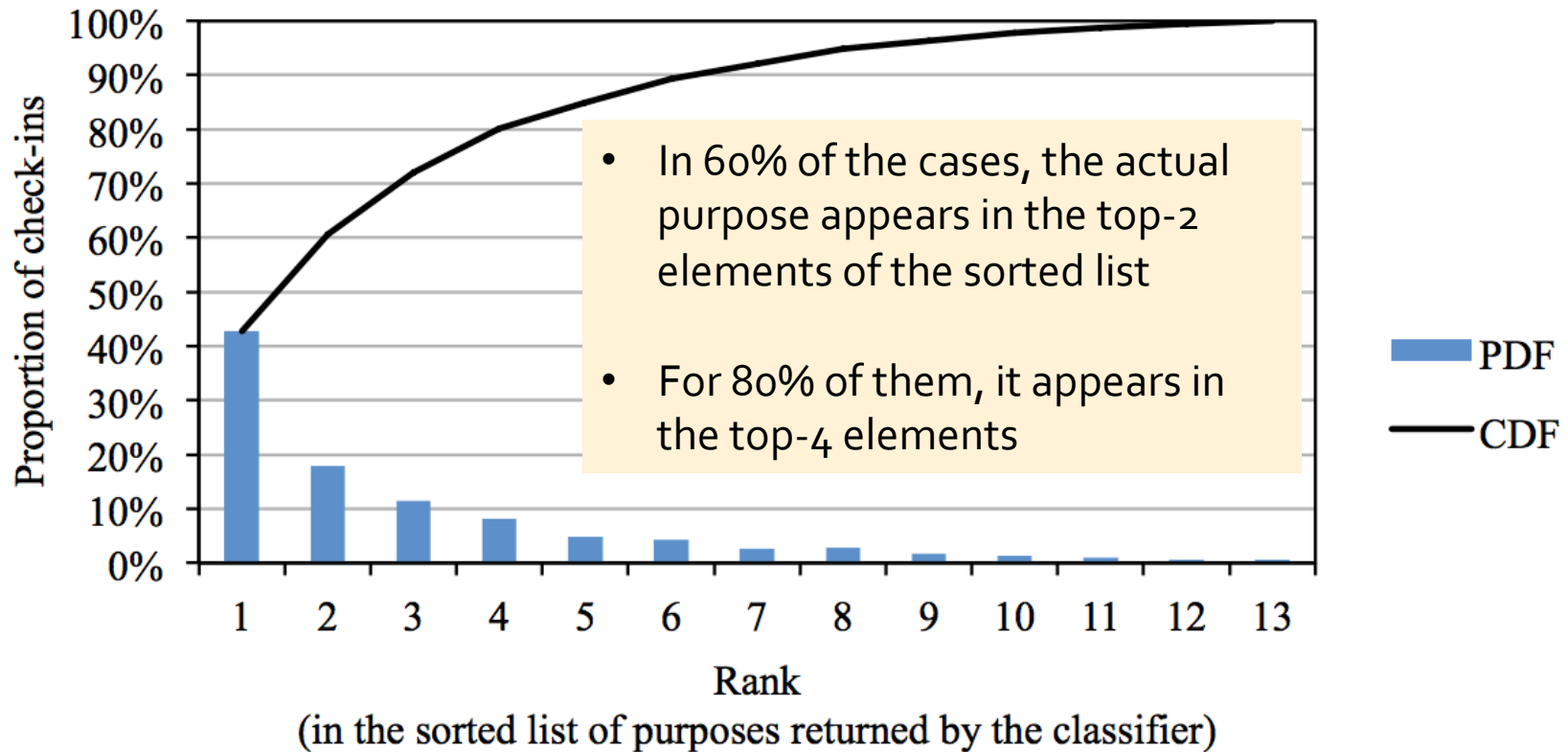
- For **socially-oriented** goals, semantic obfuscation is worse than geographic obfuscation (across different purposes)

# Inference of a Check-in's Purpose



# Purpose Inference

- **13-class purpose classifier**
  - Random Forest, 10-fold cross-validation



# Modeling Utility vs. Obfuscation

- We can infer the purpose of a check-in
- How accurately can we estimate the utility of a check-in, after obfuscating it?
  - By taking into account the inferred purpose of the check-in and other information publicly accessible to the user
- Results
  - Linear model:  $R^2 = 0.21$ , mean error 1.18 over range [1,5] ( $p < .01$ )
    - Semantic obfuscation coefficient (-0.73) has a 82% more negative effect on utility as compared to geographic obfuscation (-0.4)
  - Non-linear model (M5P model tree technique): mean error 0.66 (-56% as compared to the linear model), corr. coeff. 0.8
    - 2x better than linear model

# Summary and Future Work

- **We propose an automated check-in purpose inference model, and evaluate loss of utility due to data obfuscation**
- **Purposes of check-ins mediate the perceived loss of utility due to obfuscation**
  - Obfuscating check-ins' data produces only limited effects on their perceived utility
    - For 60% of check-ins, some obfuscation causes no loss of utility
    - Semantic obfuscation is 2x worse than geographic obfuscation, in terms of utility for the users
- **Possible to implement privacy-preserving features for location-sharing services, with minimal effect on usability**
  - Propose by default optimal obfuscation level for given check-in
  - New purpose-specific features: "directions to venue" vs. "share picture"
  - More appropriate way of presenting location histories to the users
- **Future work**
  - Explore differences across Location-Based Social Networks
  - Run a trial with a mobile application