



# Exploring Social-Historical Ties on Location-Based Social Networks

Huiji Gao, Jiliang Tang, Huan Liu

Computer Science and Engineering, Arizona State University, USA  
 {Huiji.Gao@asu.edu, Jiliang.Tang@asu.edu, Huan.Liu@asu.edu}

## Location-Based Social Networks

- Foursquare, Facebook Places, Gowalla  
- Essential Contents Provided by LBSNs
  - Check-in history with time stamps
  - Social Networks derived from check-in locations
  - Interdependency of social networks and locations
- Significance of "Check-in" behavior
  - Reflect the interactions between users and real world
  - Bridge the gap between the real world and online social networks

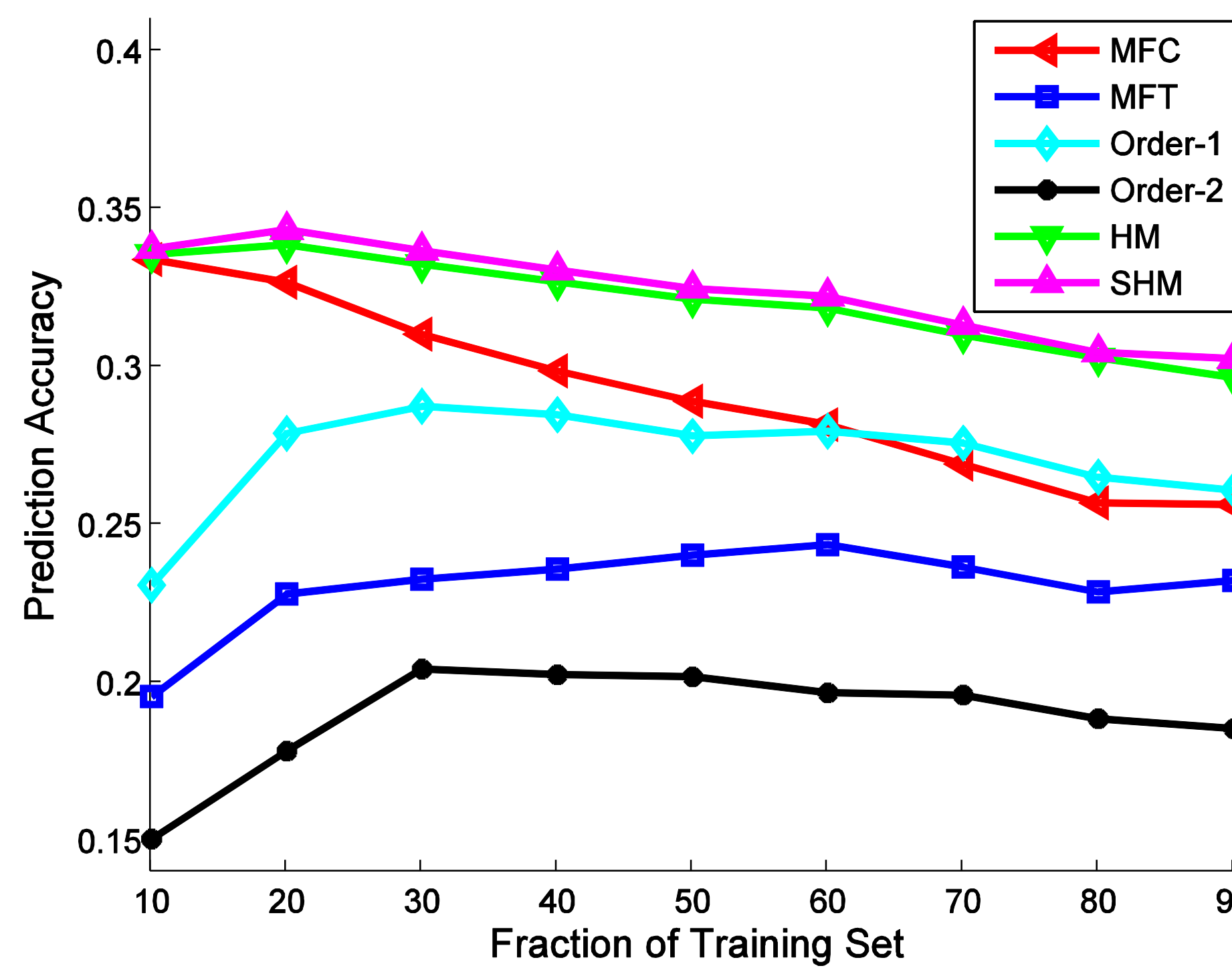
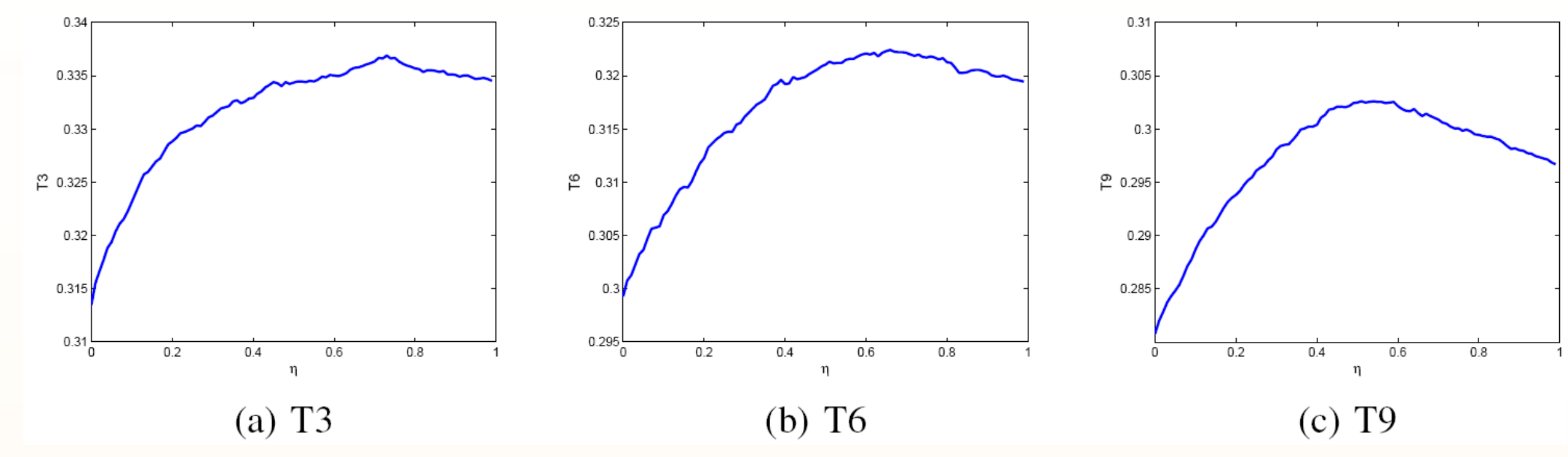
## Analyzing Social-Historical Ties

- Dataset
 

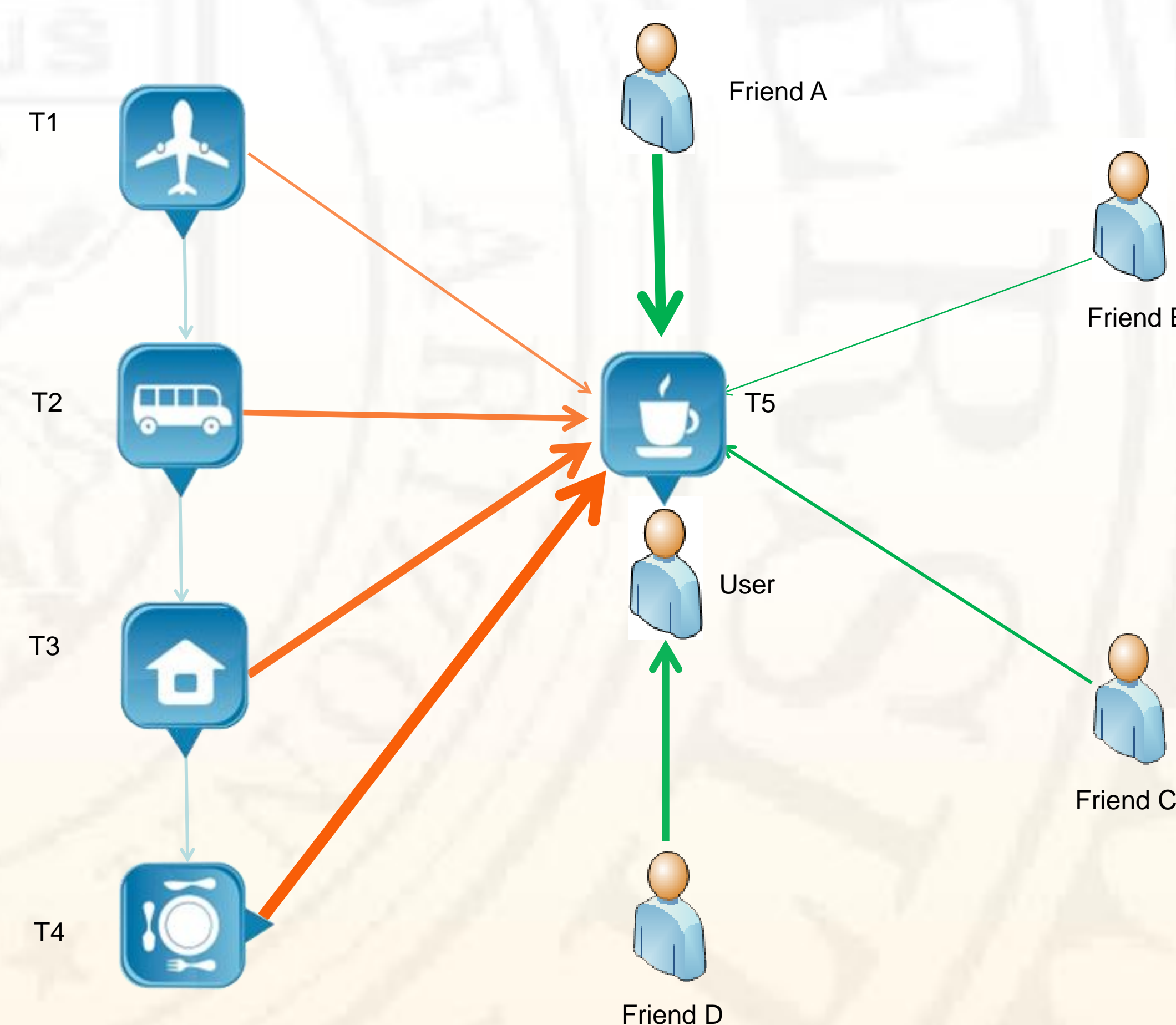
number of users	18,107
number of check-ins	2,073,740
number of links	123,325
average check-ins per user	101
clustering coefficient	0.1841
average degree	10.58
- Historical Ties
  - Power-law Distribution
    - (a) Power-law distribution of check-ins in whole dataset
    - (b) Power-law distribution of individual check-ins
  - Short-term Effect
    - The historical tie strengths of the previous check-ins decrease over time.
- Social Ties
  - Common Check-ins
 

between friends	11.8306
between strangers	4.3226
  - Check-in Similarities
    - Users with friendship have higher check-in similarity than those without.
    - Null hypothesis  $H_0: S_F \leq S_R$ , rejected at significant level  $\alpha = 0.001$  with p-value of  $2.6e-6$ .

## Evaluation Results

- Performance Comparison of Prediction Models
 
- Performance of Social-Historical Model w.r.t.  $\eta$ 


## Social-Historical Ties of Check-ins



- Historical Check-ins provide rich information about a user's interests.
- Social theory suggests human movement is usually affected by their social ties.

## Modeling Social-Historical Ties

- Correspondences between language and LBSN Modeling
 

Language Modeling	LBSN Modeling
Corpus	Check-in collection
Document	Individual check-ins
Document Structure	Paragraph
Document Structure	Phrase
Document Structure	Word
	Check-in Structure
	Monthly check-in sequence
	Weekly check-in sequence
	Daily check-in sequence
	Check-in location
- Hierarchical Pitman-Yor Language Model (HPY)
  - HPY LBSN Model
    - Historical Model
 
$$P_H^i(c_{n+1} = l) = P_{HPY}^{i,i}(c_{n+1} = l)$$
    - Social Model
 
$$P_S^i(c_{n+1} = l) = \sum_{u_j \in N(u_i)} sim(u_i, u_j) P_{HPY}^{i,j}(c_{n+1} = l)$$
    - Social-Historical Model
 
$$P_{SH}^i(c_{n+1} = l) = \eta P_H^i(c_{n+1} = l) + (1 - \eta) P_S^i(c_{n+1} = l)$$

## Conclusions and Future work

- The social-historical model performs comparably with the historical model. Further work is to explore the social networks information to improve location-based services.
- We can also include social tie strengths in sequence constrains, and take advantage of periodic information for modeling check-ins.

This work is, in part, supported by ONR (Office of Naval Research)