# Persistent Roles in Online Social Networks

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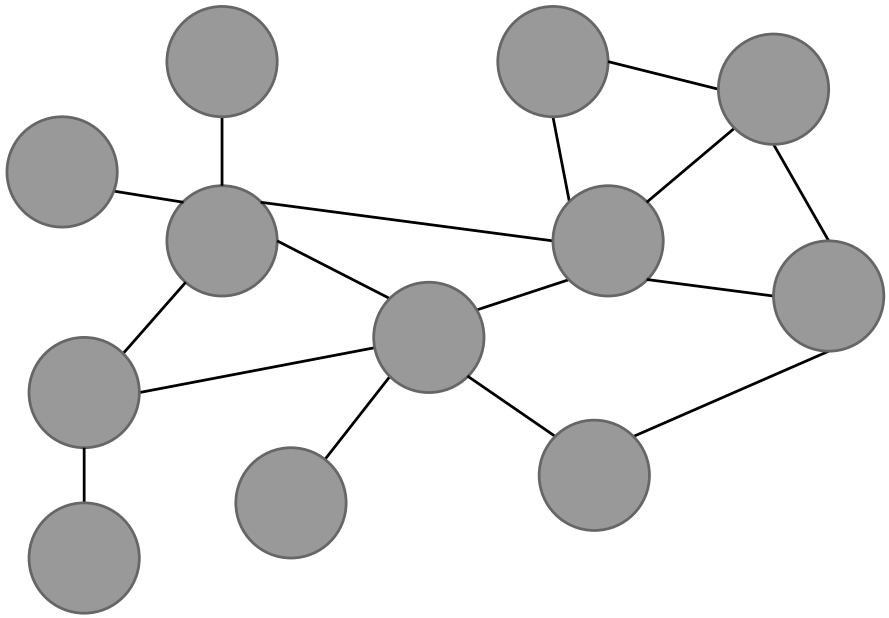
# Introduction

# Social Networks

# Social Network Analysis

The study of relationship between actors.

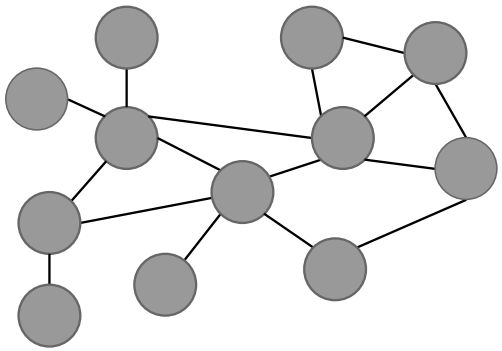


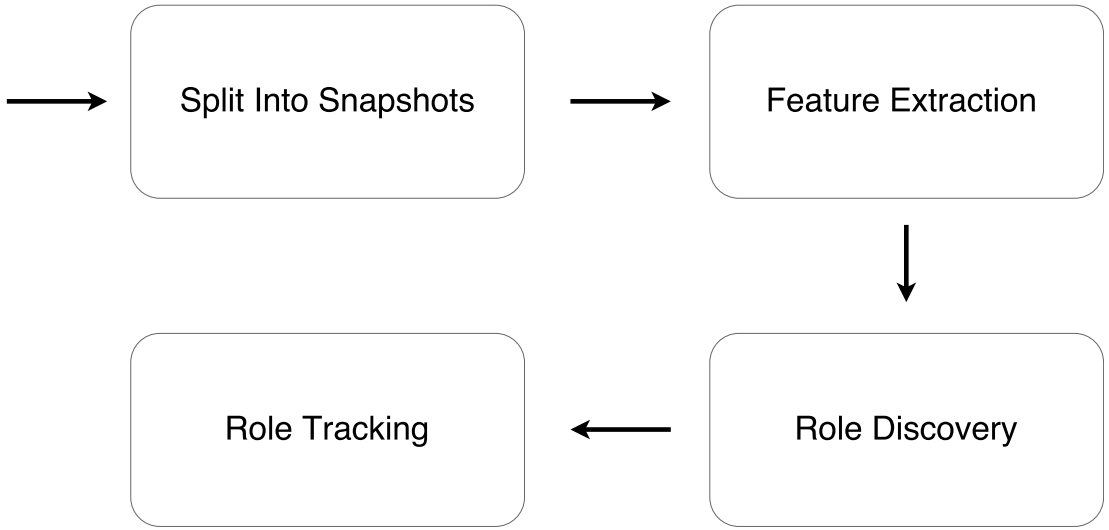
# The Goal of the Article

Persistent roles should occur in any social network
Based on the structure of the network

# Methodology

# The Approach

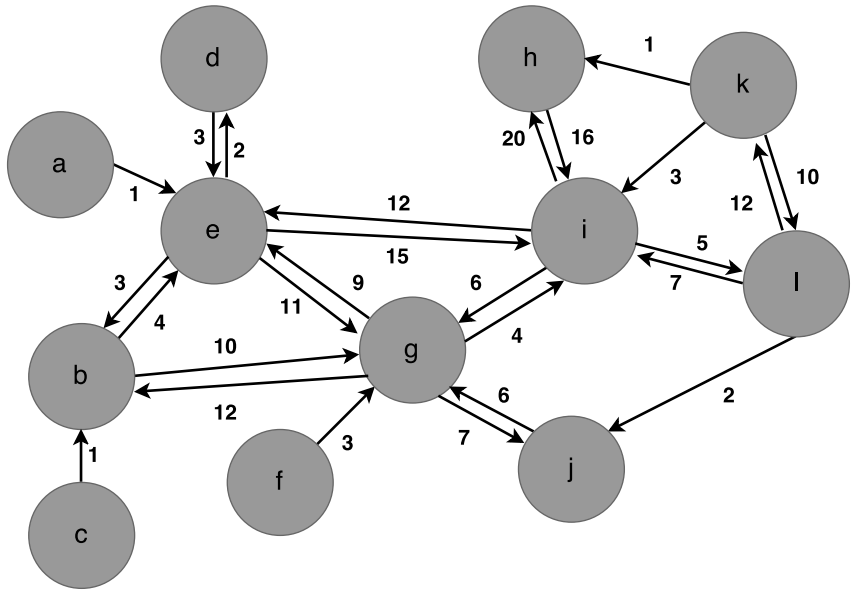




# The Data

Datasets:

- Facebook - Wall posts from one user to another
- Scratch - Comments on uploaded programming projects



# Snapshots

The datasets are split into a total of 26 snapshots:

- 7 from Facebook
- 19 from Scratch

**Social Network Graph**

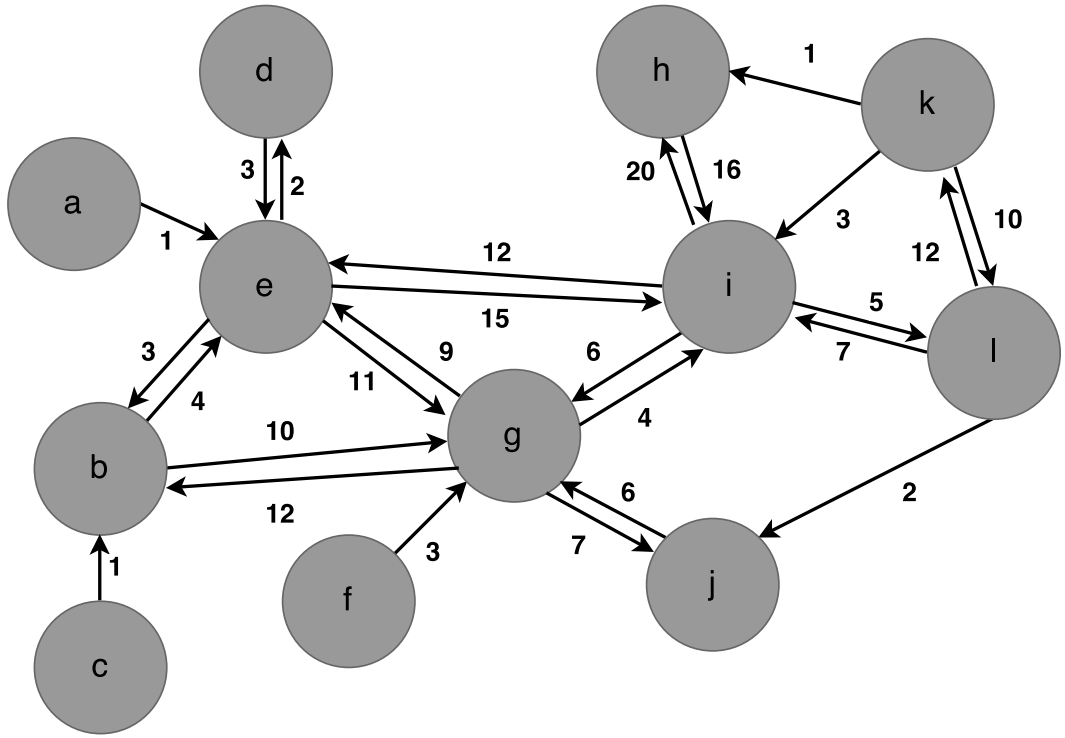
$D = (N, E)$

**Snapshot**

$S_t = (N_t, E_t)$

# Feature Selection

- In-degree
- Out-degree
- Weighted in-degree
- Weighted out-degree

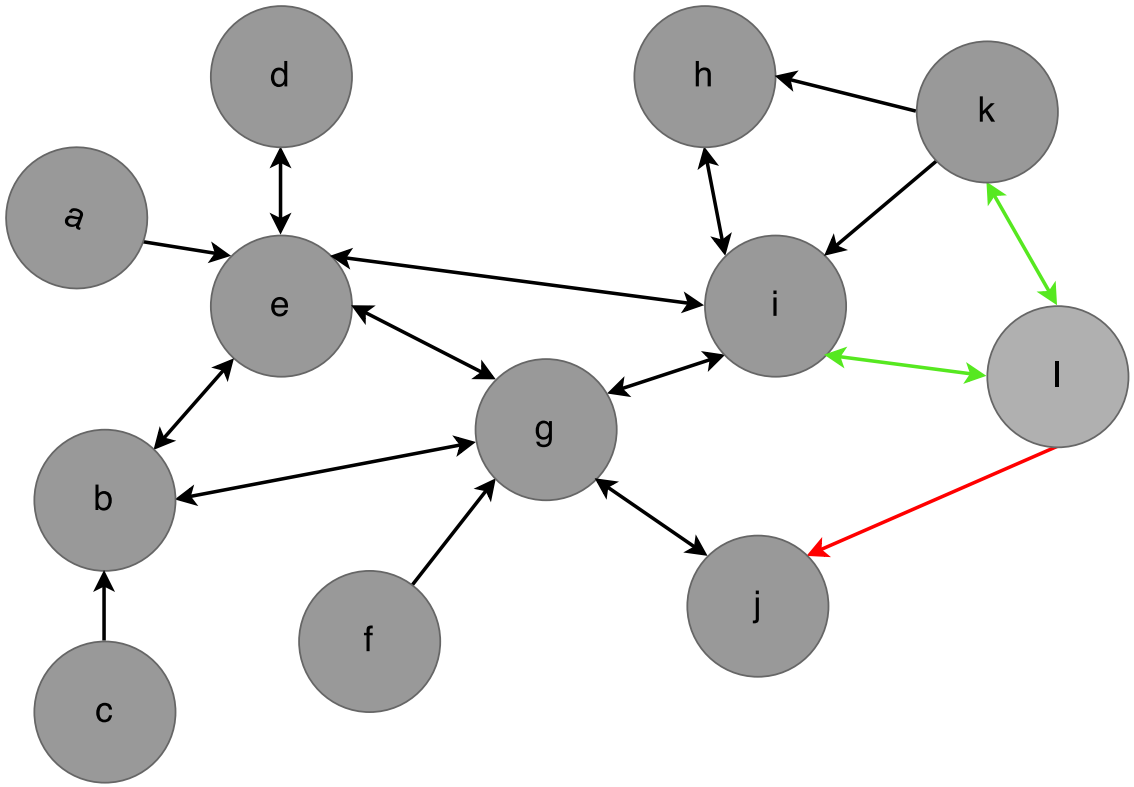


# Feature Selection

*Reciprocity* is the rate a user is replayed. The value of this feature is between 1 and 0.

**Reciprocity**

$$r = \frac{\text{Out-degree}^{<->}}{\text{Out-degree}}$$



# Feature Selection

The *new activity count* feature is the number of new outgoing edges based on the difference of snapshot $S_t$ and $S_{t-1}$

**New Activity Count**

$$c = \text{Out-degree}_t - \text{Out-degree}_{t-1}$$

The feature *social strategy* is the ratio of new outgoing edges over all outgoing edges

**Social Strategy**

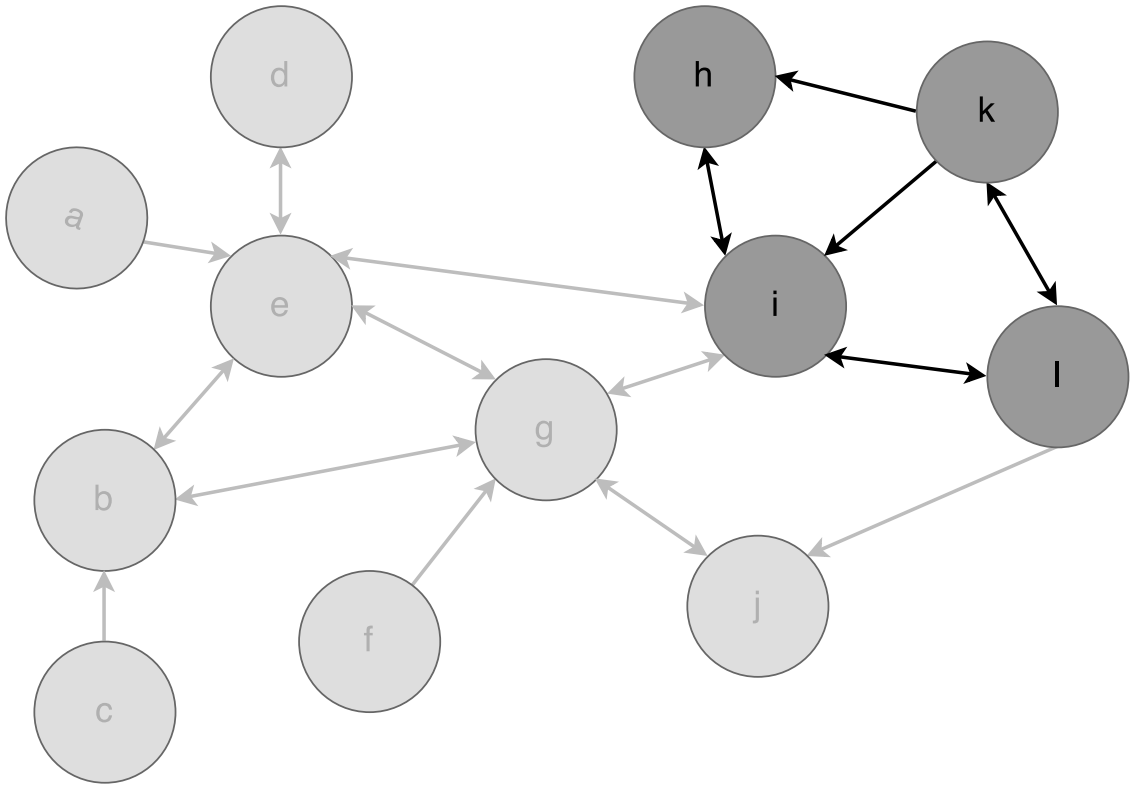
$$s = \frac{\text{New Activity Count}}{\text{Out-degree}}$$

# Feature Selection

The value of the feature *betweenness centrality* is the product of the number of shortest paths passing through a vertex

**Betweenness Centrality**

$$b(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

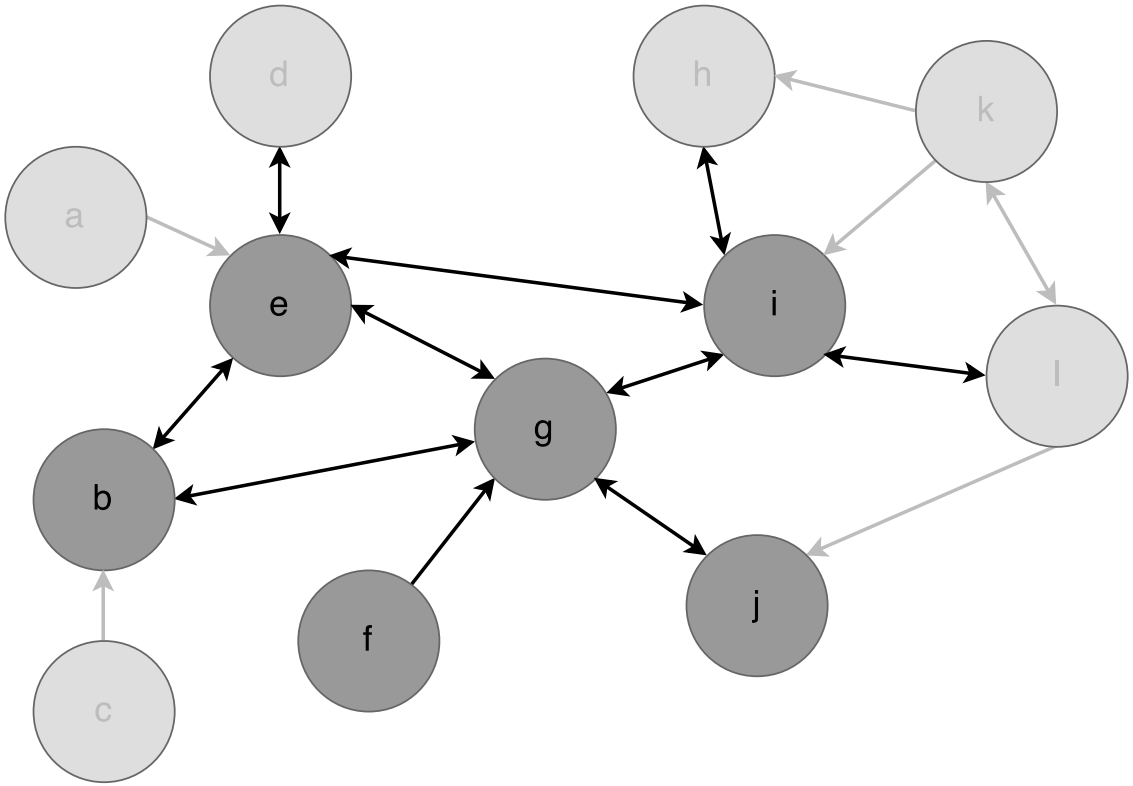


# Feature Selection

The feature *PageRank* measures centrality based on ingoing edges

**PageRank**

$$pr(g) = 1 - d + d\left(\frac{pr(b)}{2} + \frac{pr(e)}{4} + \frac{pr(f)}{1} + \frac{pr(i)}{4} + \frac{pr(j)}{1}\right)$$

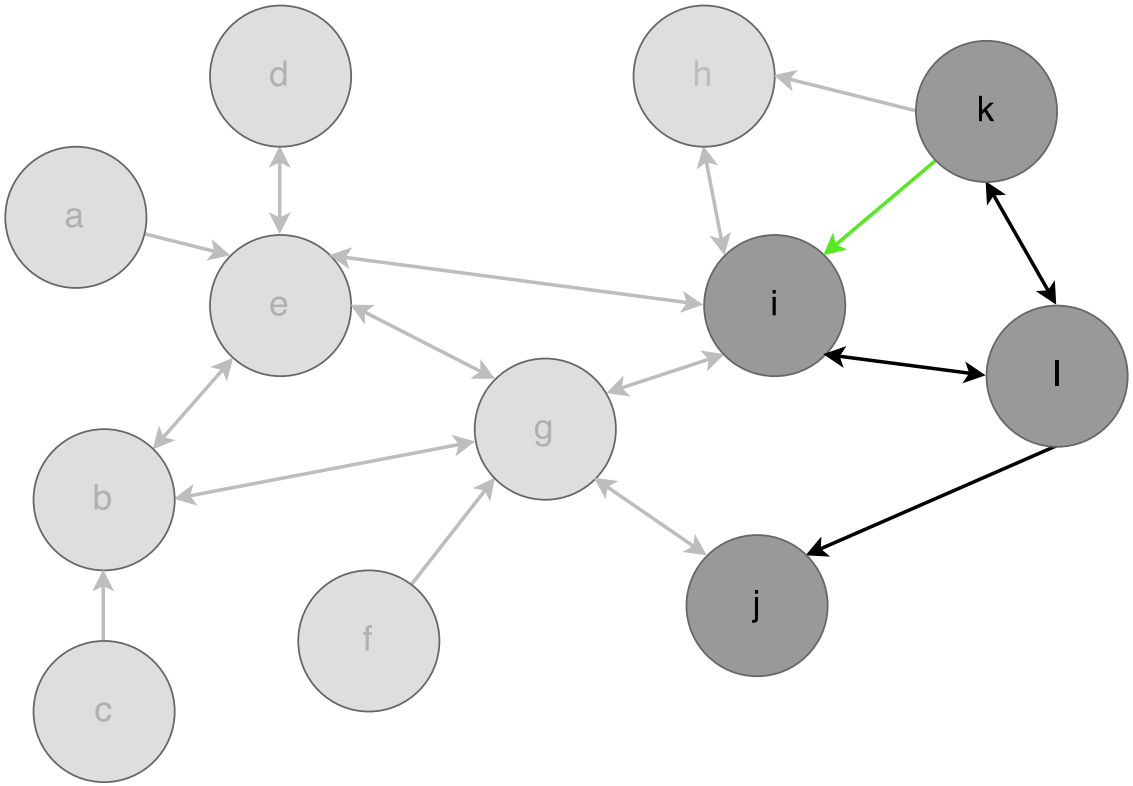


# Feature Selection

*Transitivity* measures is the local clustering coefficient which gives the probability of a vertexes neighbours being connected

## Transitivity

$$C(v_i) = \frac{|\{e_{jk} : v_j, v_k \in N_i, e_{jk} \in E\}|}{k_i(k_i - 1)}$$



# Selected Features

Summary of the features

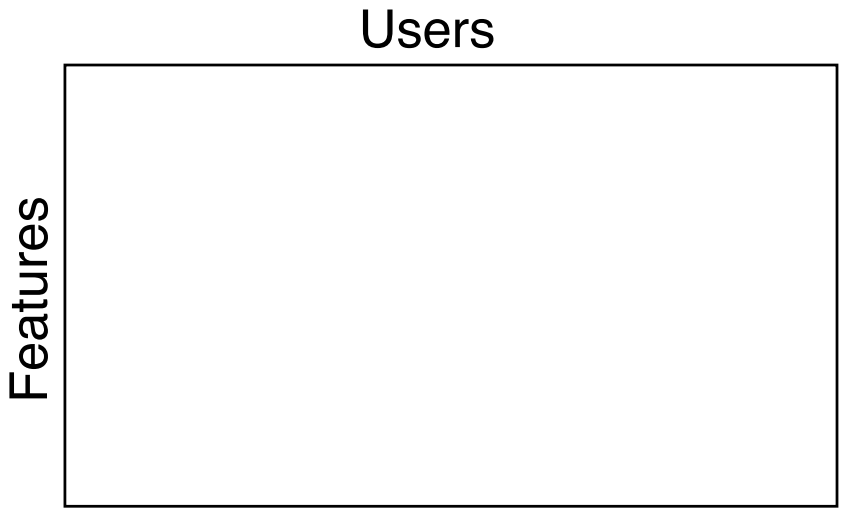
- In-degree
- Out-degree
- Weighted in-degree
- Weighted out-degree
- Reciprocity
- New activity count
- Social strategy
- Betweenness centrality
- PageRang
- Transitivity

Features omitted from the walk-though

- Weighted PageRank
- Weighted transitivity

# Feature Extraction

The result of feature extraction is a features × users feature matrix

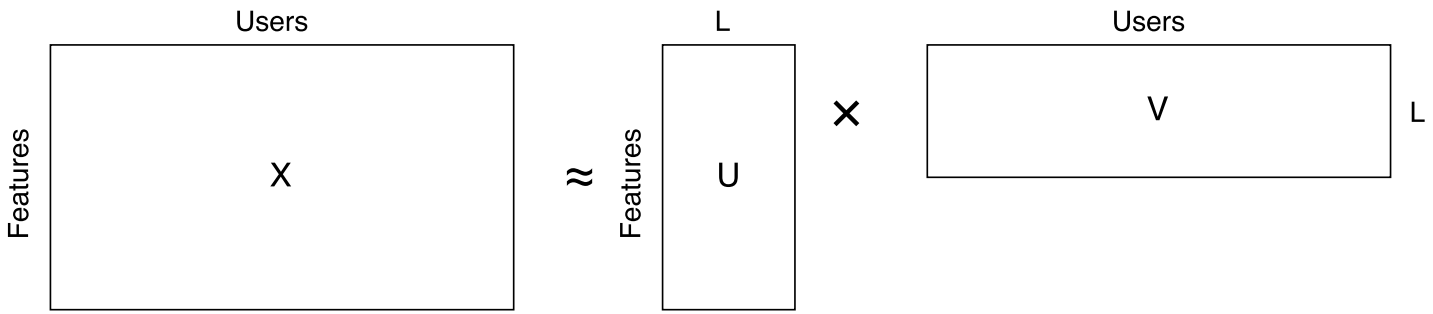



The features in the matrix is normalized by the use of feature scaling so that all values is within the interval of 1 and 0

# Role Discovery

**Non-negative Matrix Factorization**

$$X \approx UV$$




- Matrix U is role features
- Matrix V is membership weights for the roles for each user

# Selection of L

**Root Mean Squired Error**

$$RMSE = \sqrt{\frac{1}{|X|} \sum_{(u,f) \in X} (X_{u,f} - X'_{u,f})^2}$$

Figure: Facebook

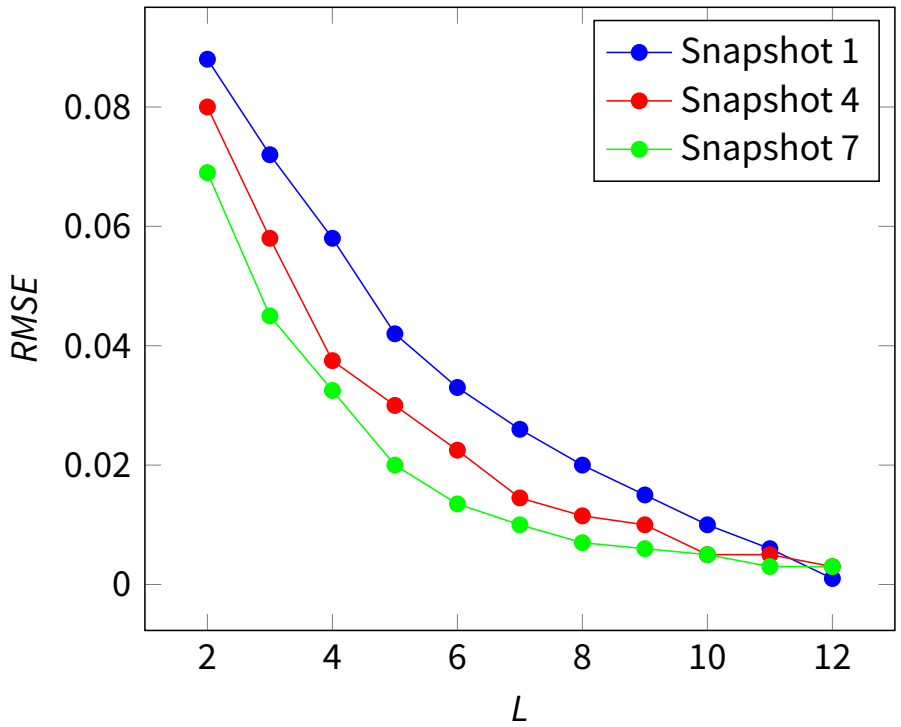
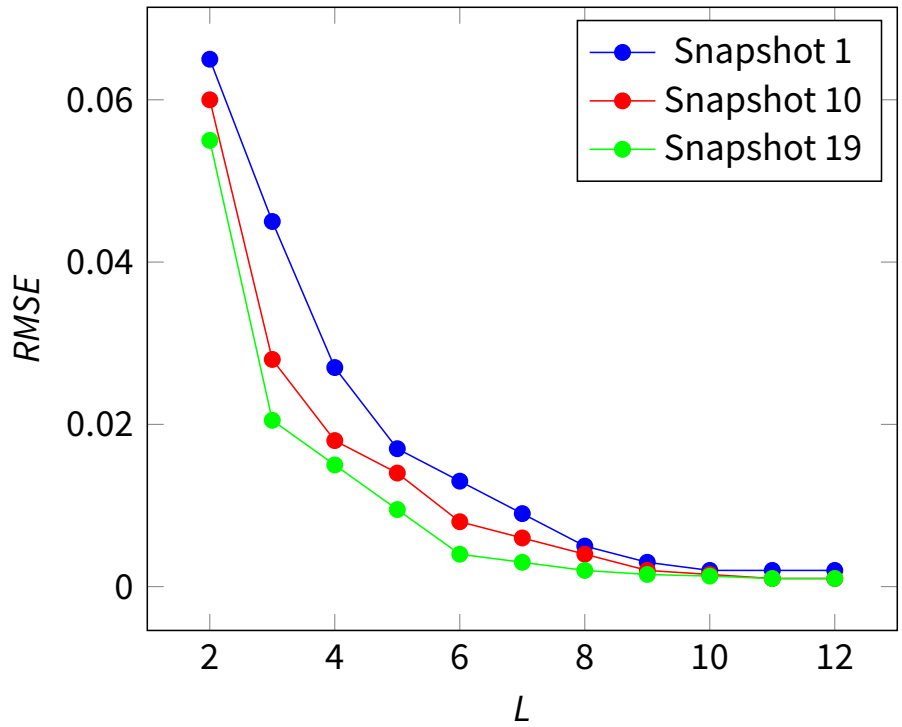



Figure: Scratch



# Tracing Roles

## Cosine Similarity

$$sim(A_i, B_i) = \frac{\sum_{i=1}^{n} A_i B_i}{\sqrt{\sum_{i=1}^{n} A_i^2}\sqrt{\sum_{i=1}^{n} B_i^2}}$$

Cosine similarity returns a value between -1 and 1

- -1 means that the vectors are opposites
- 1 means they are exactly the same

The article sets a threshold on 0.75 that roles from $S_t$ and $S_{t+1}$ must have similarity measure above

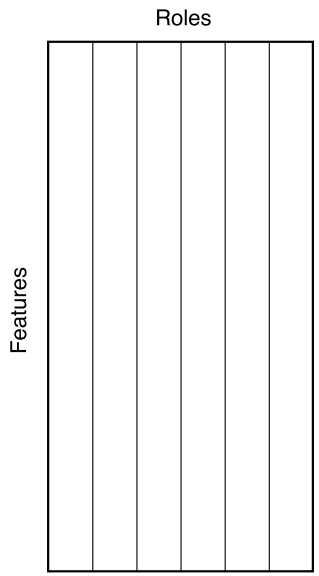



Figure: $U_t$

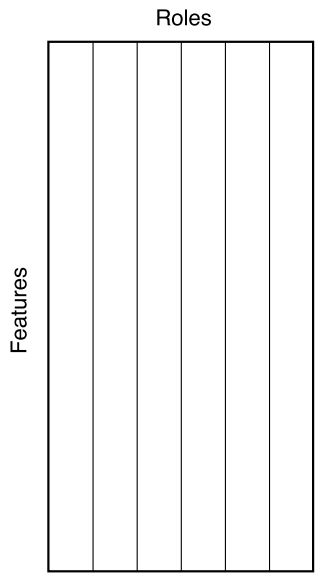


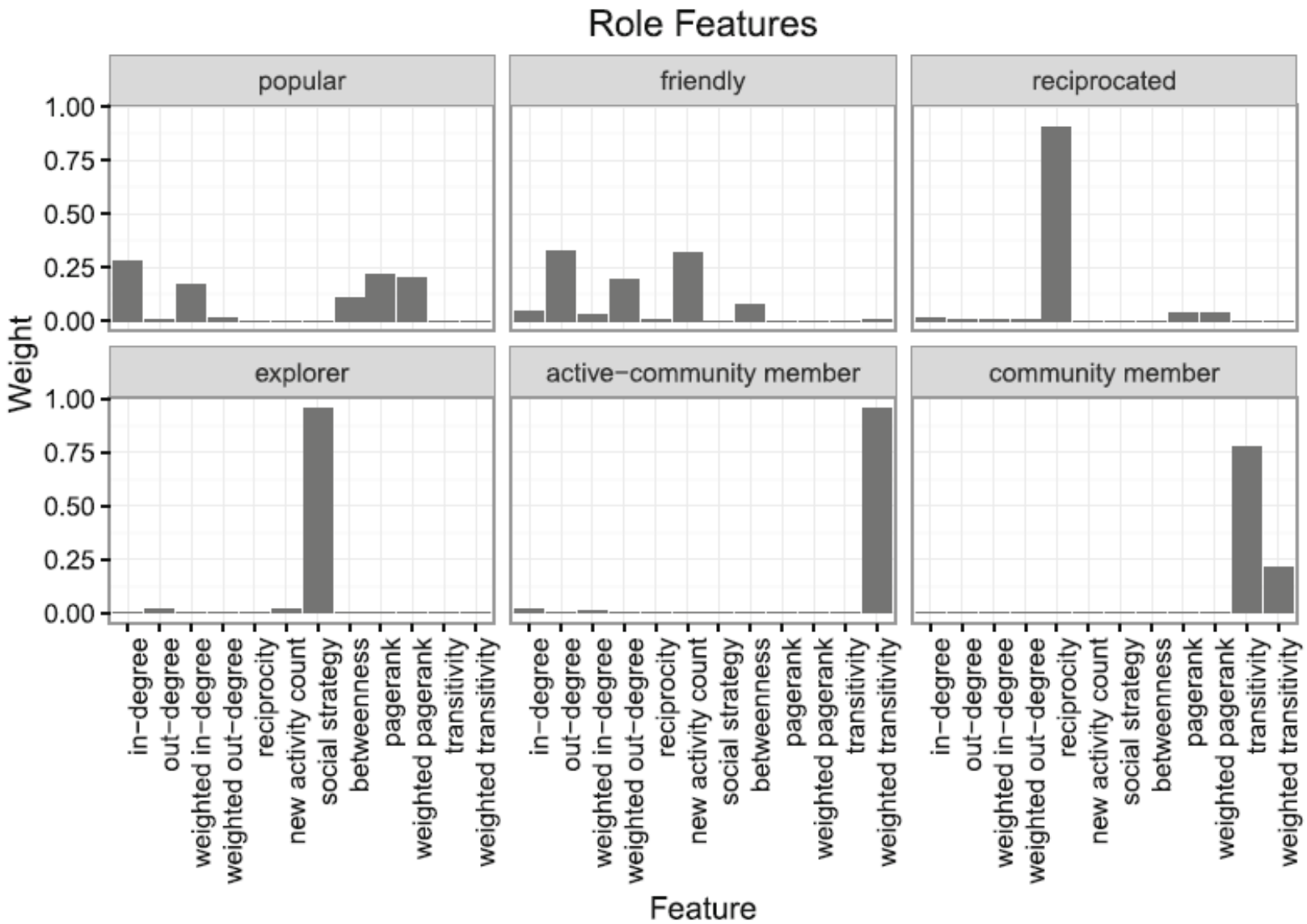

Figure: $U_{t+1}$

# Results

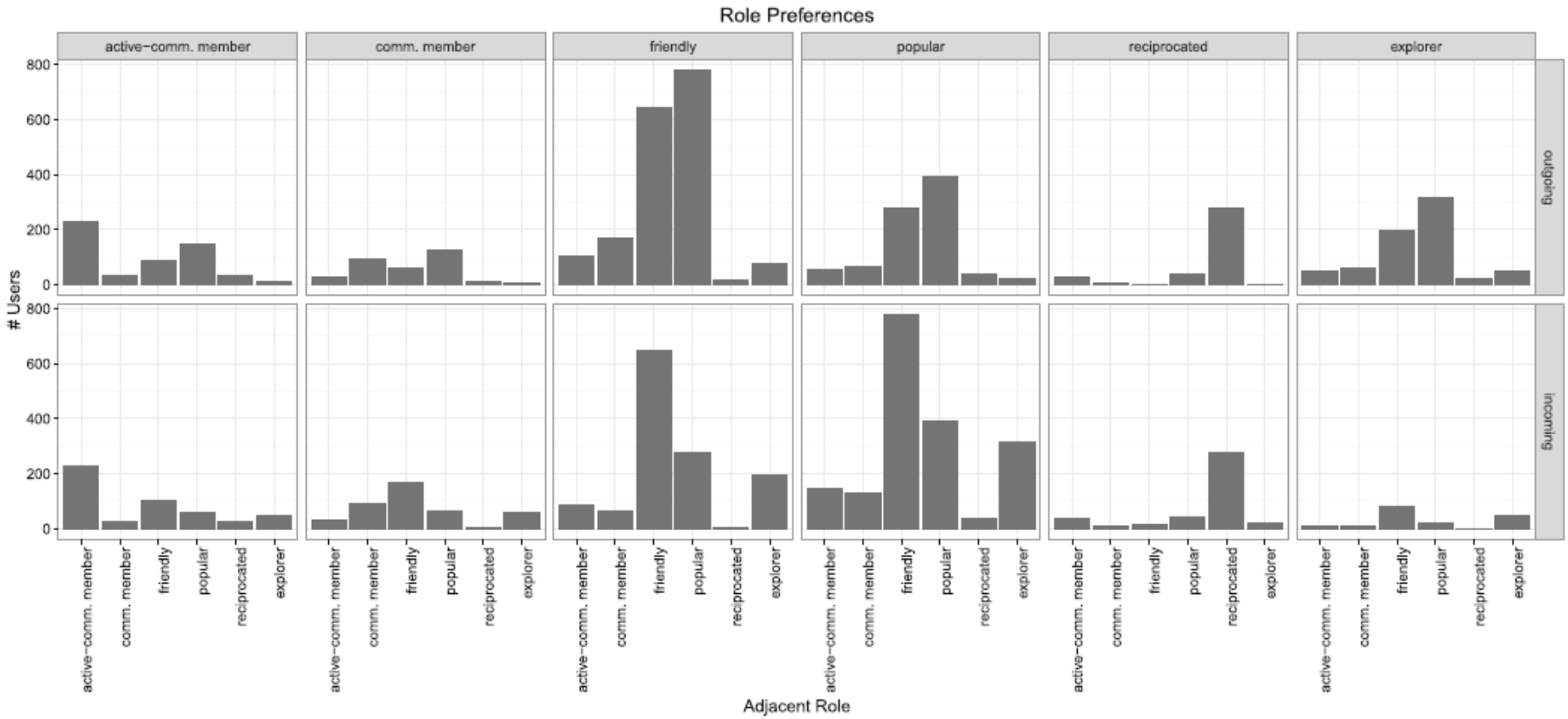
# The Roles

| Role | Feature Characteristics |
|---|---|
| Popular | In-degree, Betweenness, PageRank |
| Friendly | Out-degree |
| Reciprocated | Reciprocity |
| Explorer | Social Strategy |
| Community Member | Transitivity |
| Active Community Member | Weighted transitivity |

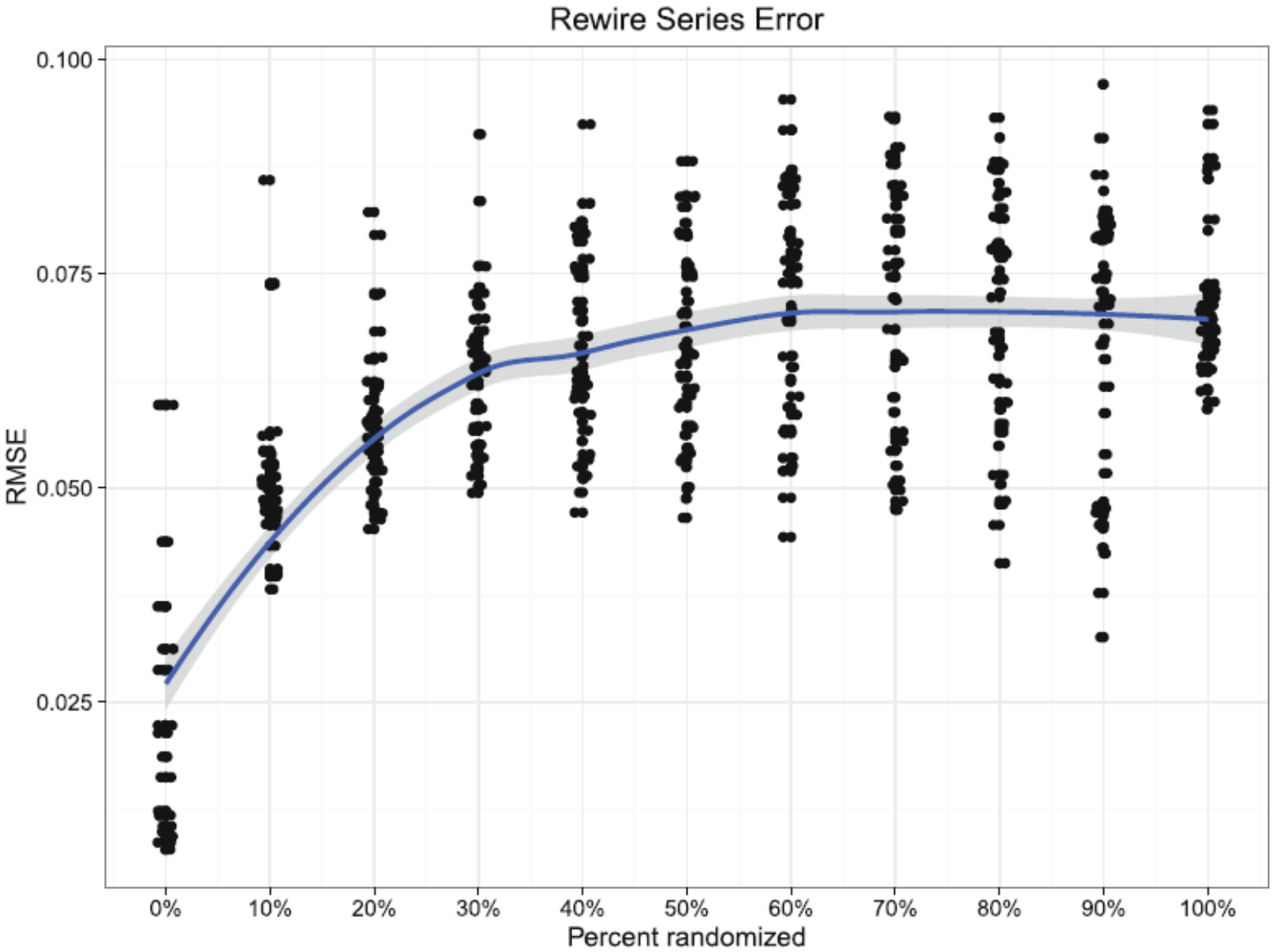
# Feature Representation of the Roles



# Interaction Preferences



# Evidence of Roles Dependence on Network Structure



# Conclusion

# Conclusion

This article presents a methodology which identify six different roles that are:

- Persistent throughout the timespan of the datasets
- Independently derived from different datasets

# Shortcomings

- They does not argue for their selection of features or give a reference to an article that does.
- I would have appreciated some more examples or are more detailed description of some of their approaches.
- The distribution of snapshots are not consistent.