# LECTURE 16 :LEVERAGING SOCIAL NETWORK TO FIGHT SPAM

COMP4941: Social Information Network Analysis and Engineering

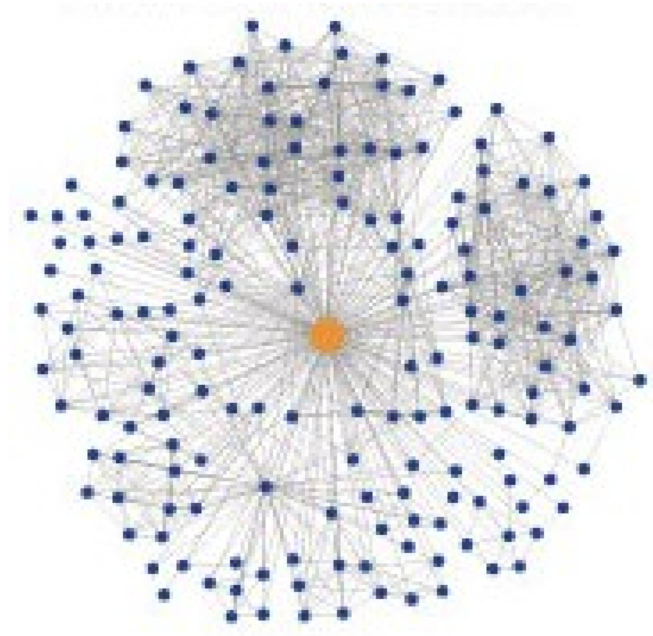
Wednesday April 22th 2015

# DISCOVERING SOCIAL CIRCLES

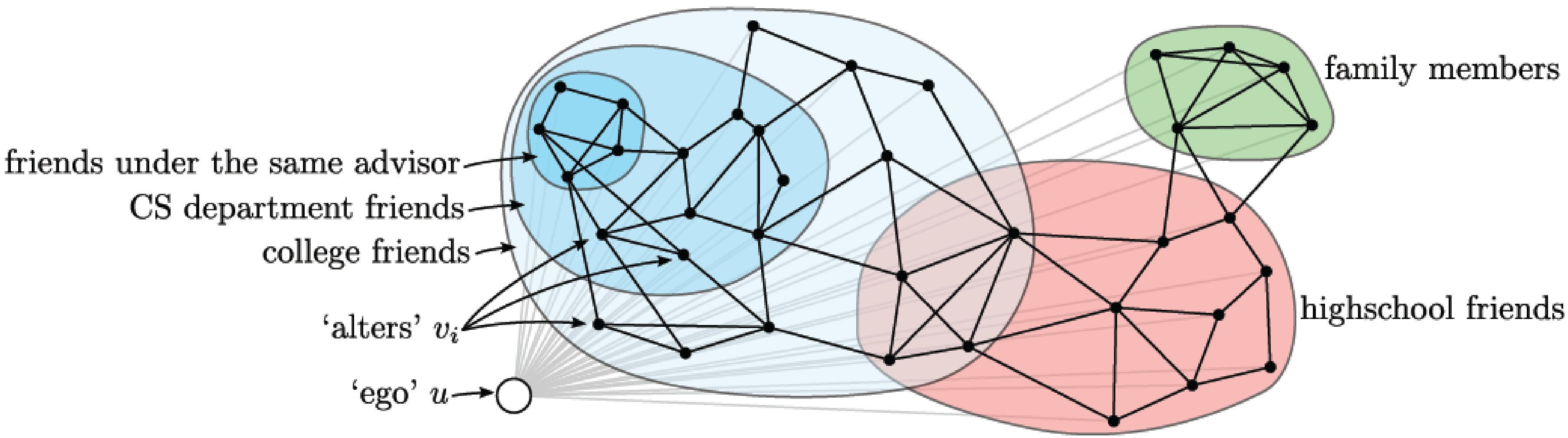
# Social Circles



- **Take a user (yellow circle) and discover her social circles:**
- **Why is it useful?**
  - To organize friend lists
  - Control privacy and access settings
  - Filter content
- **Facebook, Twitter, Google+:**
  - Groups, lists, circles



# Social Circles




- Given **ego** node $u$ and a network of her friends
- **Find circles!**
  - Use network as well as user profile information
  - For each circle we want to know why it is there!

# The Model of Circles



- **Suppose we know all the circles in the ego-network**
- **We model the prob. of edge**

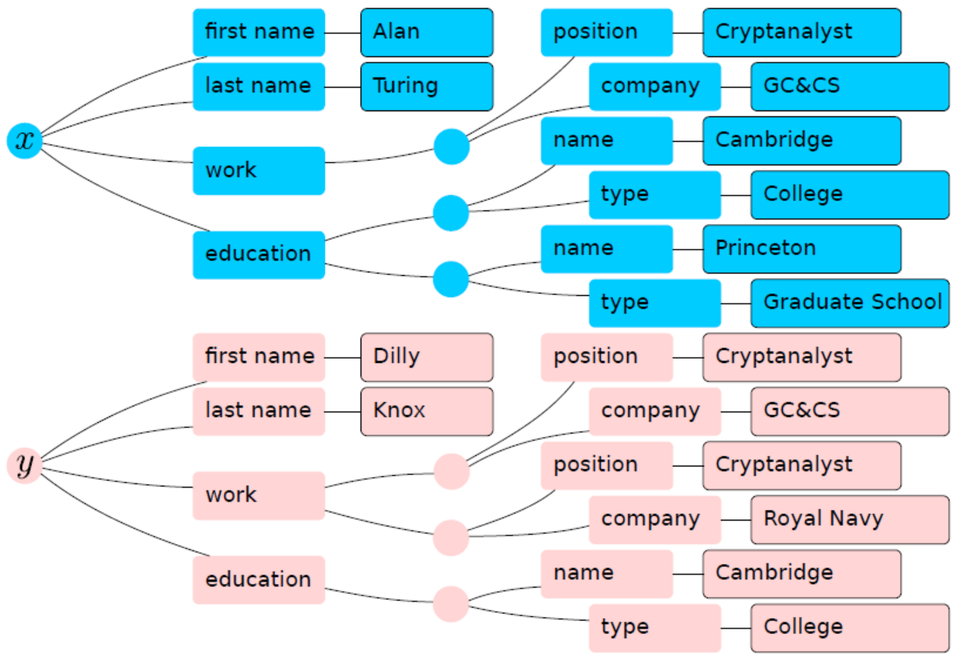
$$p((x,y) \in E) \propto \exp\Bigg\{ \underbrace{\sum_{C_k \supseteq \{x,y\}} \langle \phi(x,y), \theta_k \rangle}_{\text{circles containing both nodes}} - \underbrace{\sum_{C_k \not\supseteq \{x,y\}} \langle \phi(x,y), \theta_k \rangle}_{\text{all other circles}} \Bigg\}$$

  - where:
    - $\phi(x,y)$is a feature vector describing $(x,y)$
      - Are $x$ and $y$ from same school, same town, same age, ...
    - $\theta_k$ is parameter vector that we aim to estimate
      - High $\theta_k[i]$ means being similar in feature $i$ is important for circle $k$

# Creating the Features $\phi(x, y)$



- **Two ways to create feature vectors $\phi(x, y)$**




$$\phi(x,y) = \begin{bmatrix}0\\0\\0\\0\\1\\1\\0\\1\\1\\0\\0\end{bmatrix}\begin{array}{l}\textit{first name} : \textit{Dilly}\\ \textit{last name} : \textit{Knox}\\ \textit{first name} : \textit{Alan}\\ \textit{last name} : \textit{Turing}\\ \textit{work} : \textit{position} : \textit{Cryptanalyst}\\ \textit{work} : \textit{location} : \textit{GC\&CS}\\ \textit{work} : \textit{location} : \textit{Royal Navy}\\ \textit{education} : \textit{name} : \textit{Cambridge}\\ \textit{education} : \textit{type} : \textit{College}\\ \textit{education} : \textit{name} : \textit{Princeton}\\ \textit{education} : \textit{type} : \textit{Graduate School}\end{array}$$

$$\phi(x,y) = \begin{bmatrix}0\\0\\1\\1\\1\\1\end{bmatrix}\begin{array}{l}\textit{first name}\\ \textit{last name}\\ \textit{work} : \textit{position}\\ \textit{work} : \textit{location}\\ \textit{education} : \textit{name}\\ \textit{education} : \textit{type}\end{array}$$

# Circle Discovery



- **Given an ego-graph G**
- **And edges features $\phi(x, y)$**
- **Want to discover:**
  - Circle node memberships $C$ and
  - Circle parameters $\theta_k$

such that we maximize the likelihood:

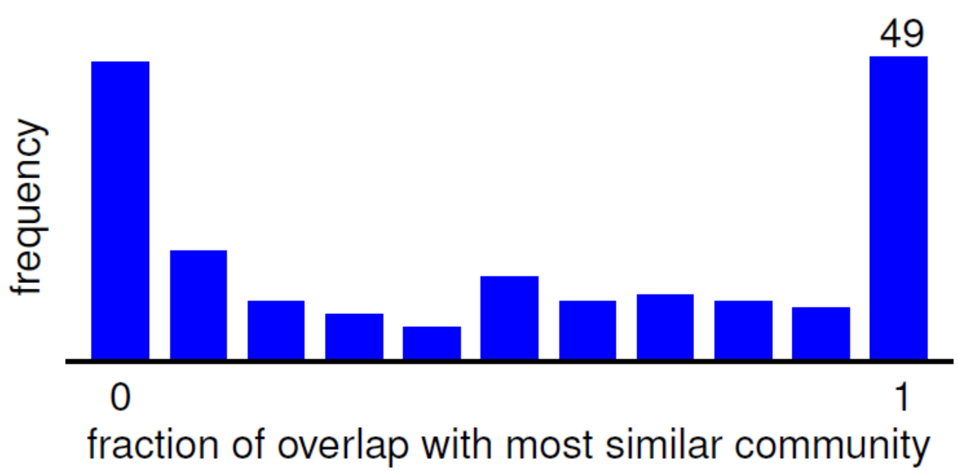
$$P_{\Theta}(G; \mathcal{C}) = \prod_{e \in E} p(e \in E) \times \prod_{e \notin E} p(e \notin E)$$

To see the details of this is accomplished see: *Discovering Social Circles in Ego Networks* by J. McAuley, J.L. http://arxiv.org/abs/1210.8182

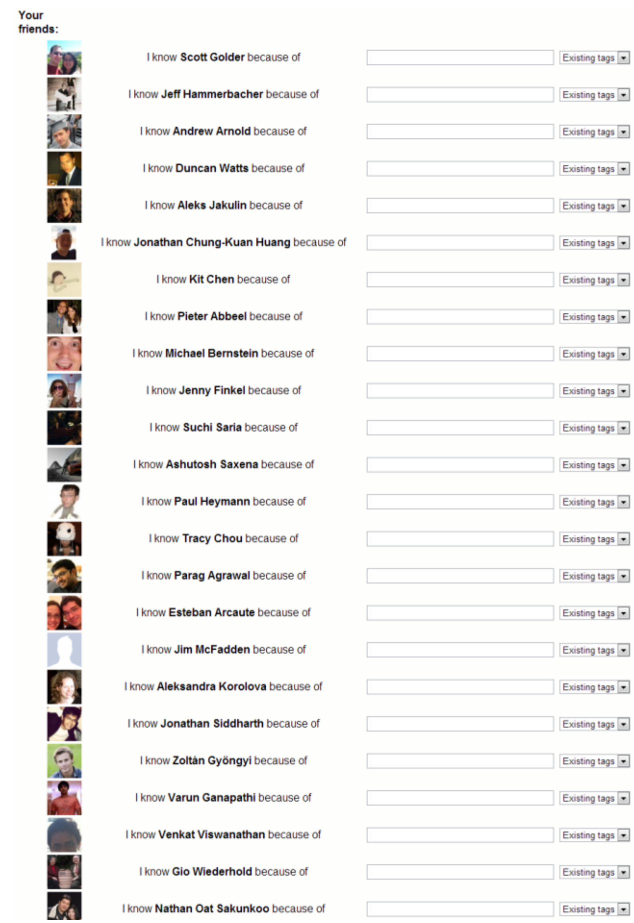
# Experiments: Facebook



- **Facebook:**
  - Ask people to go through their friend lists and hand label the circles




~30% circles don't overlap
~30% overlap
~30% are nested

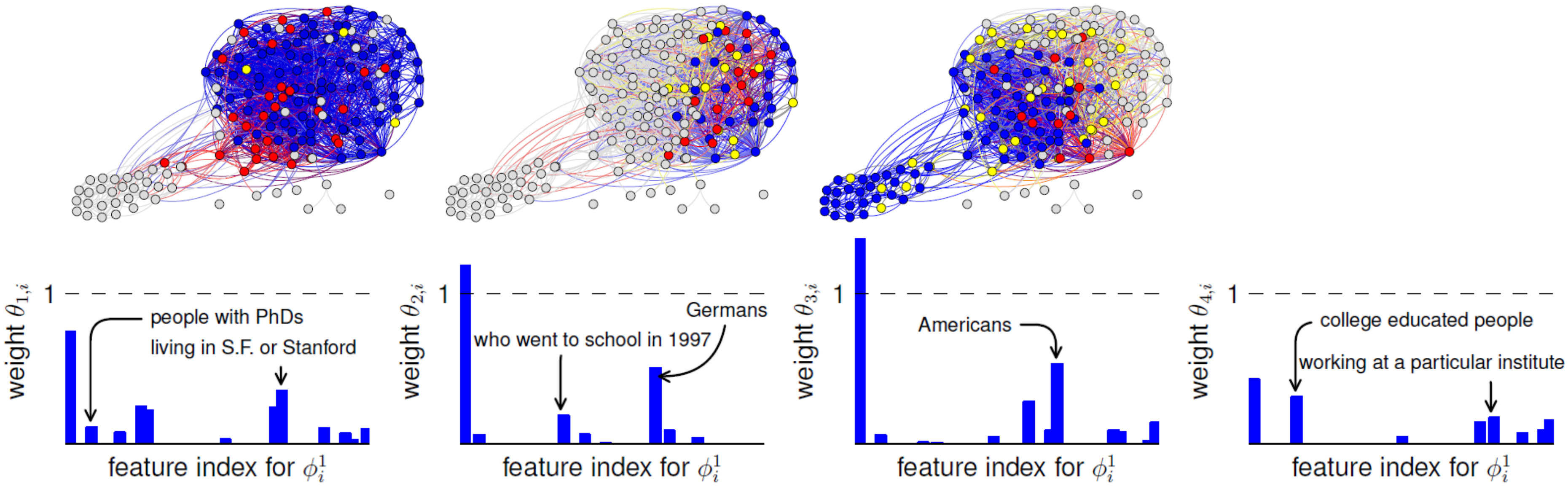


# Experiments: Facebook



- How well do we recover human identified circles?

- Social circles of a Stanford PG:



# FIGHTING SPAM

# Spam Problem

**Spam**

- Spam emails is still an open problem largely outnumbering legitimate ones
- In 2010, 89% of the emails were spams (262 billion spam messages daily) [1]
- Estimate cost of $130 billion in 2009
- Projected cost of $338 billion by 2013

**Common State-of-the-Art Strategies**

- Filter spam at the recipient's edge.
- Content-based filtering has turned spam problem into false +ve and -ve one.

# Goal

Stop the Arms race: Prevent spam transmission during SMTP time and accept only ***legitimate email from legitimate users***

# LENS

LENS, a novel spam protection system, leverages the social network of the recipient.

- Mitigates spam beyond recipient's social circles, by accepting only legitimate emails.
- Filter at the SMTP time to prevent transmission at the sender's edge.

There exists two types of communication

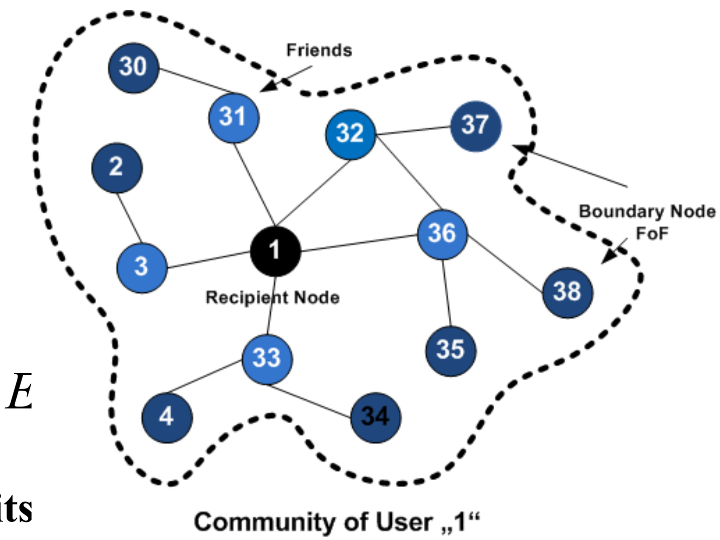
1. Within recipient's community (social network).
2. Outside recipient's community (rest of the world).

# Communication Within Community

- Emails within the community is delivered directly to the recipient.
- Community consists of two social hops
  - Friends and
  - Friends of Friends (FoF), also called boundary nodes (BN)

**Community Formation**

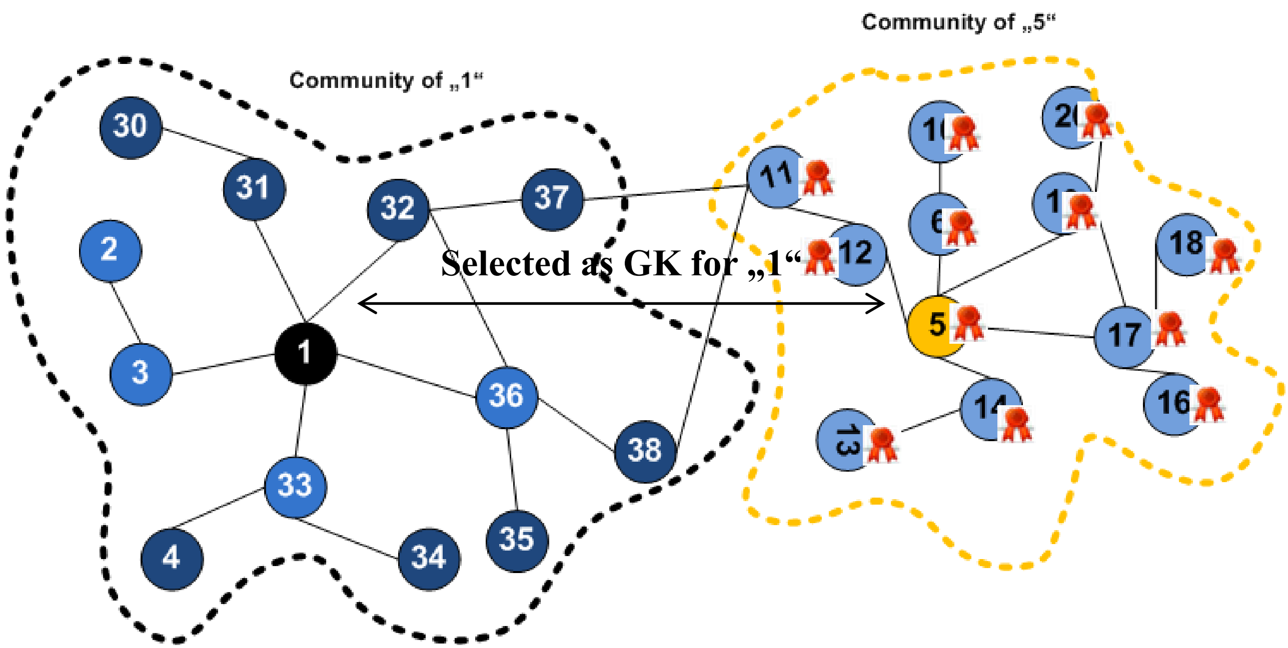
- A simple two step process
  - *Addition of friends*
  - *Addtion of FoF.*
- Process can be
  - ***Manual (User Involvement)***
  - *Automatic (Communication Pattern, E* *l*
    *Network*
- **Mail Server maintains the Community info of its**



# Communication Outside the Community

- Mail Server selects Trusted/Legitimate users, called Gate Keepers (GKs) at various hop counts away for the recipient.
- Mail Server uses the GK to vouch for legitimate users outside the community of the recipient, by issuing un-forgeable vouchers.
- GK can only vouch for his immediate community.

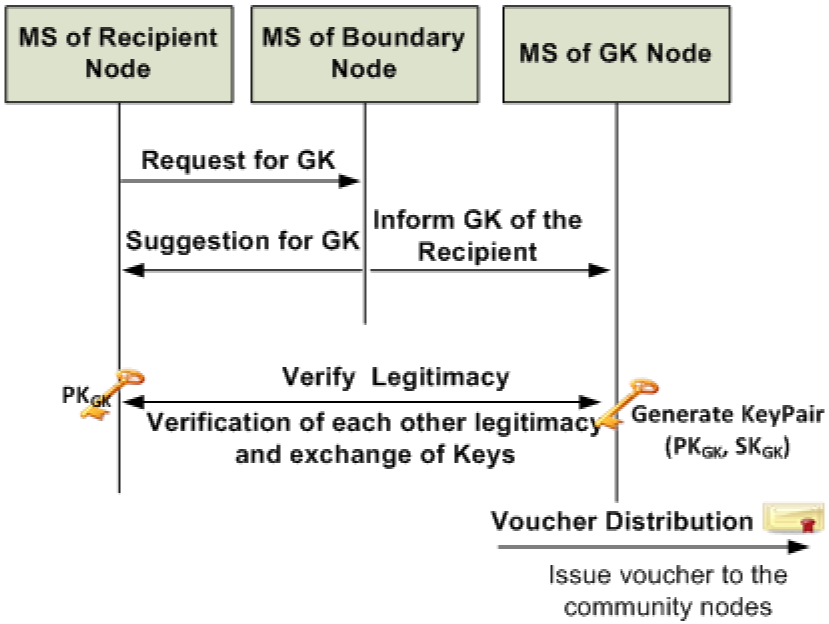
**GK is a virtual entity and its selection and voucher distribution are system process handled by the mail servers**



# GK Selection (1)

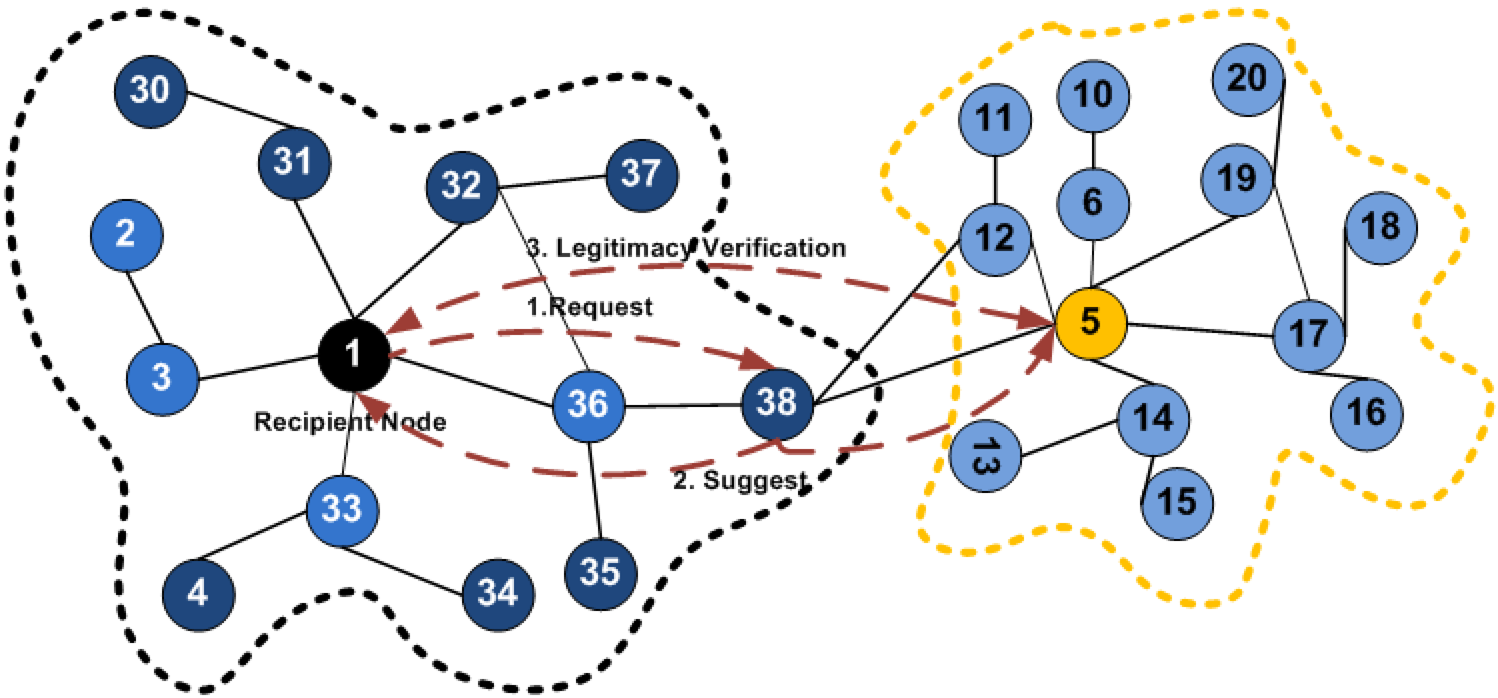
Stage 1 (Adjacent Communities)

- Run Transparently by MailServer
- Three Steps
  - Request
  - Suggestion
  - Legitimacy Verification



# GK Selection (2)

Stage 1 (Adjacent Communities)

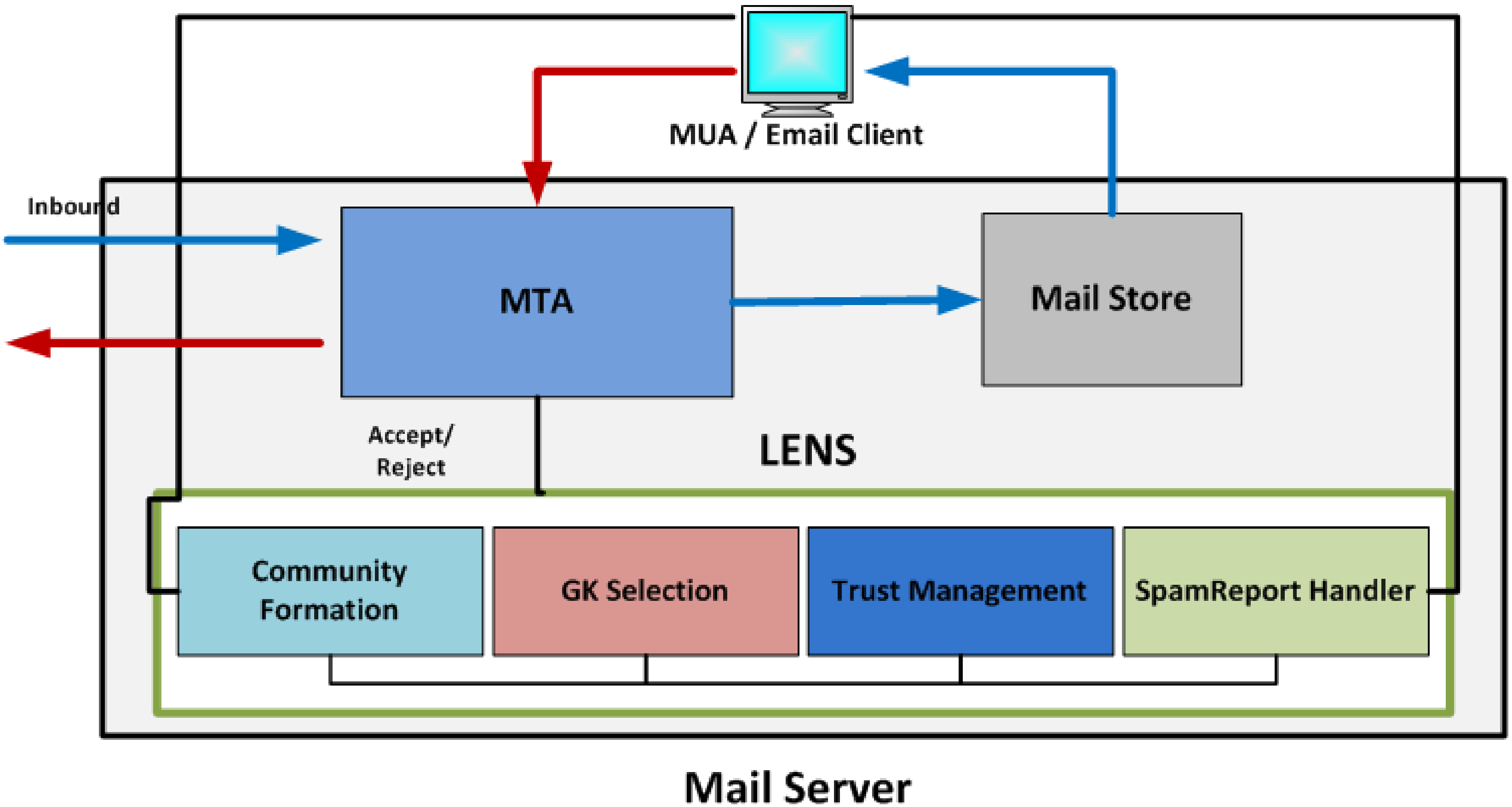


# GK Legitimacy

Legitimacy Verification of GK is a 2 step

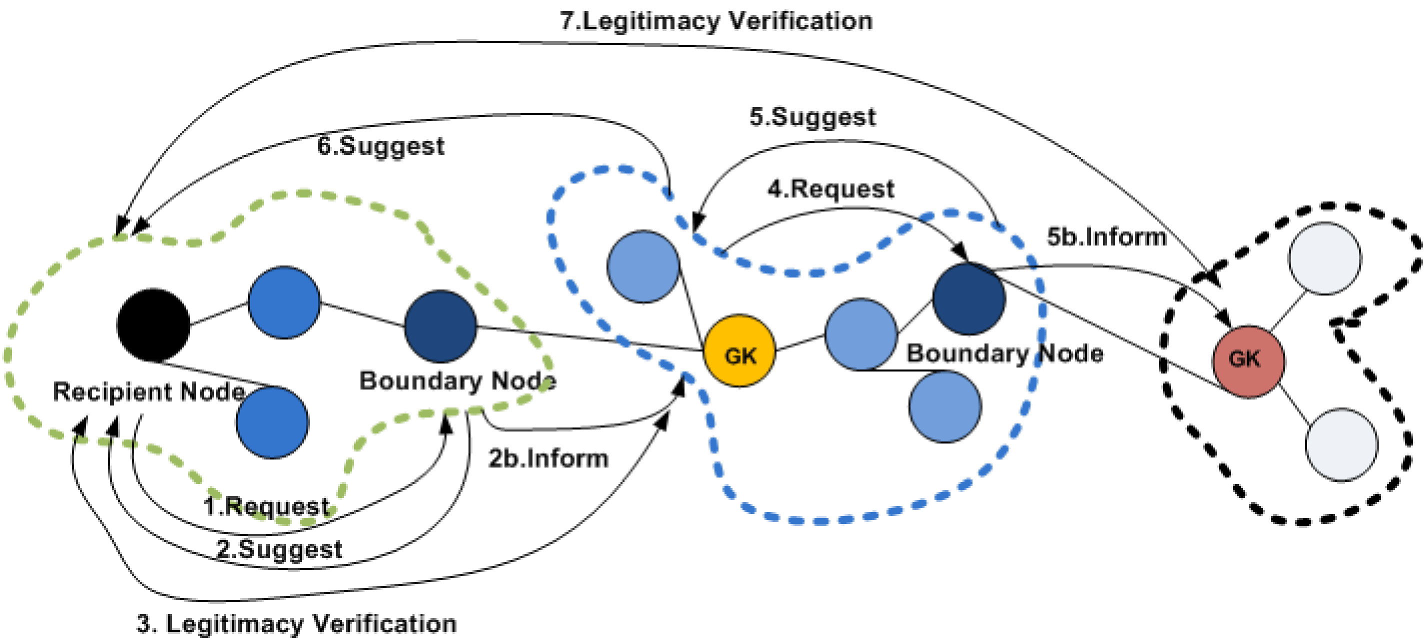
1. Legitimacy verificaton of the email service provicer
   - Identity verification using Certification Authority (done by all legitimate email provider, companies and universities)
   - Trust and Reputation measured over time
2. Legitimacy verification of a User (potential GK)
   - Based on the Trust Ratings of the user
   - Trust Rating is increased if a user is voted (receive emails) from other legitimate users

# LENS Architecture



# GK Selection (2)

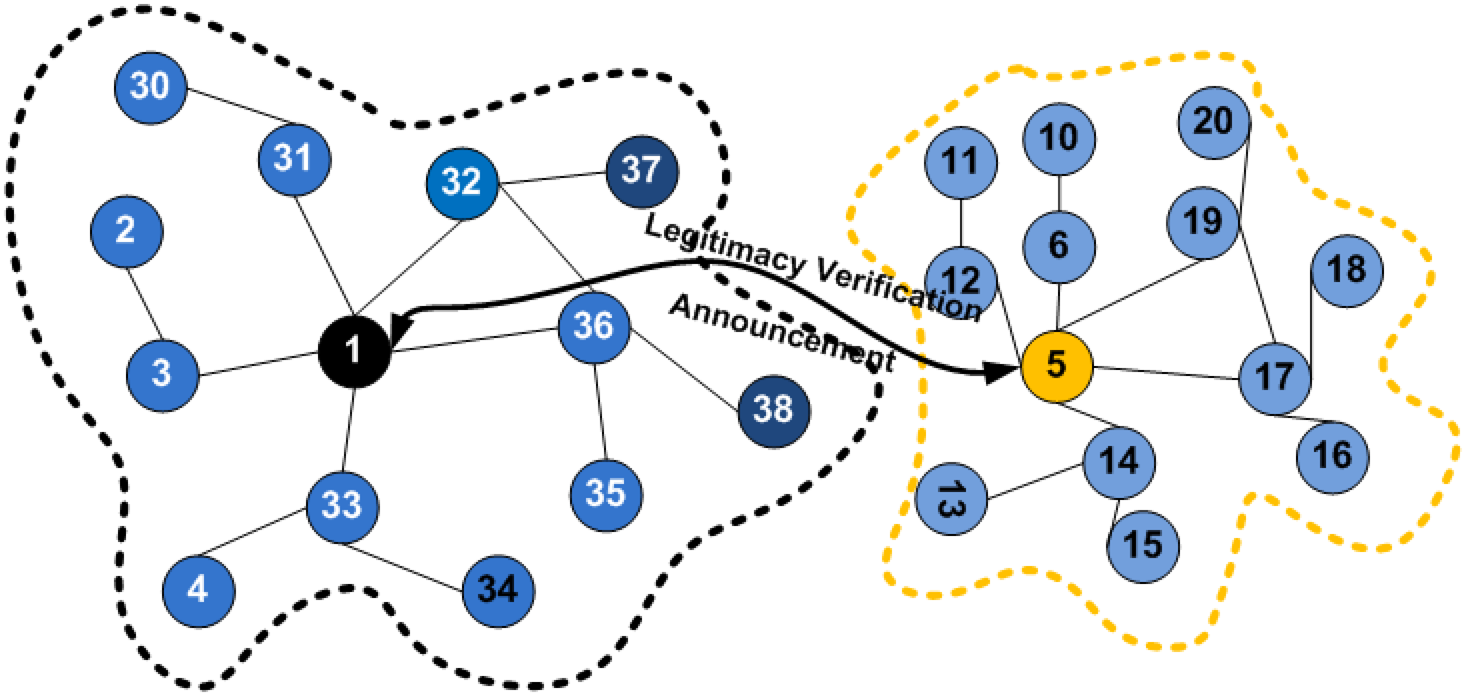
- Stage 2 (Beyond Ajacent Communities)



# GK Selection (3)

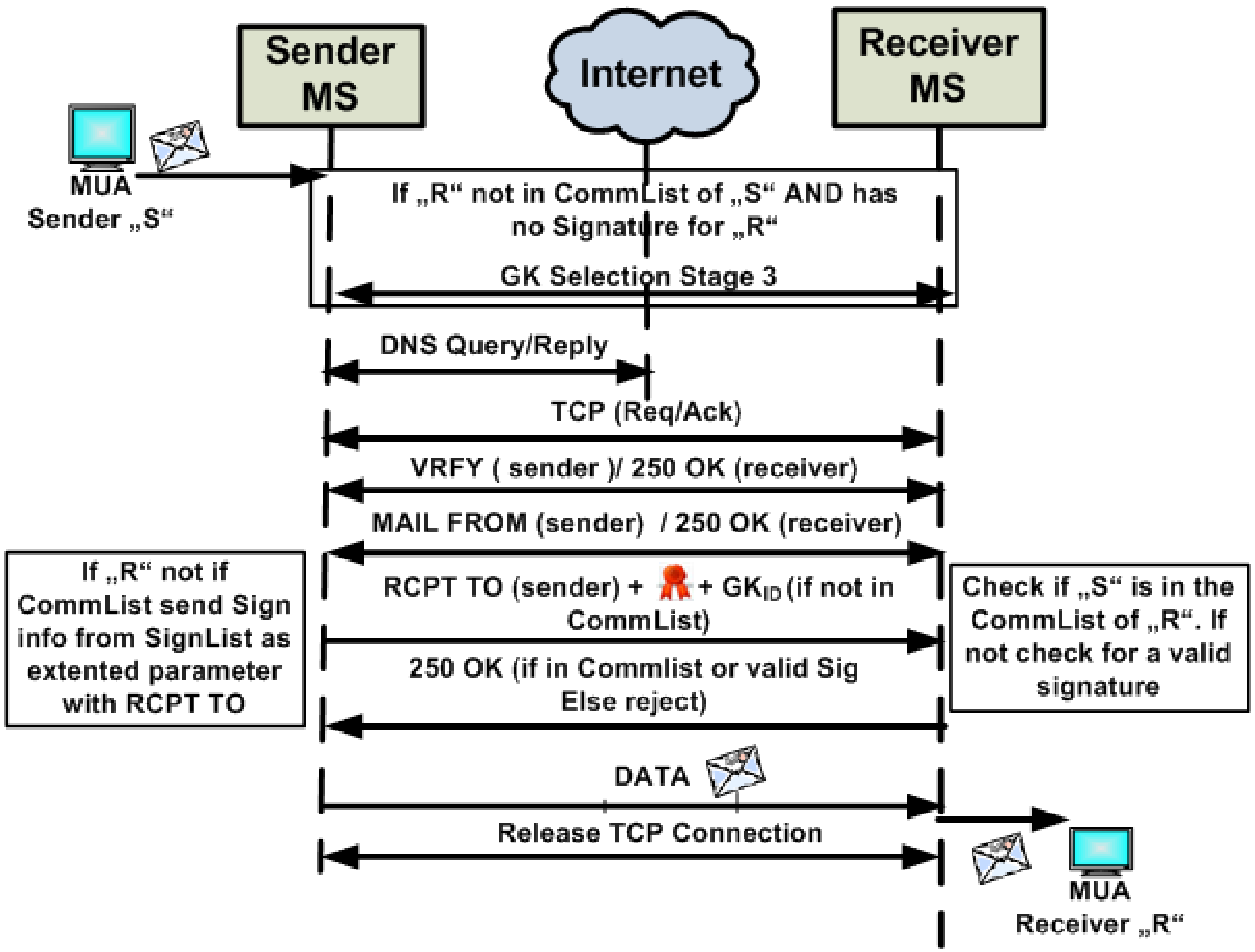
## Stage 3 (New Communication)

- Two Steps
  - Announce
  - Legitimacy Verification




Apply sender rate limit if reputation and trust ratings of user is low

# Email processing with LENS



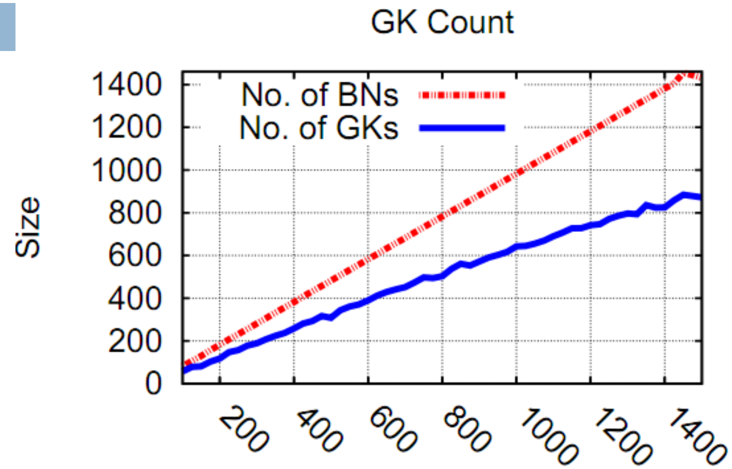
# Evaluations

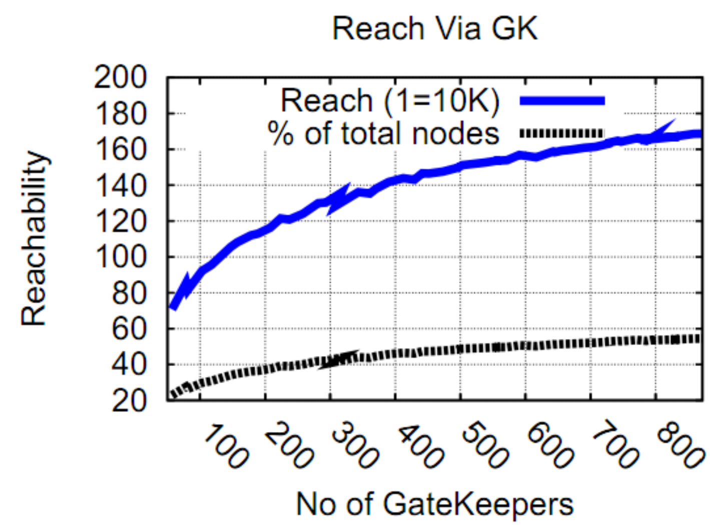
Interested in

- # of GKs for receiving messages
- Reachablity of recipient via GK
- Computational complexity of email processing with LENS

# Experiment on Facebook Dataset

- 3.1 M users, 23 M edges [3]
- Randomly select 4K users of community size 100-1500
- Number of GKs between 56-880
- Reachability between 710K - 1.7 million (23-55%)




Reliable email delivery from millions of potential users is possible using GKs in the order of hundred.