MailRank: Using Ranking for Spam Detection

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MailRank

- Introduction
- Motivation
- Related work
- Technical details
- Evaluation
- Advantages and limitations

Introduction

- Existing spam filters exhibit some problems:

- Maintenance
- Error rate
- Too many emails for some high-volume users

Motivation

- Motivation: address all the problems above

- Social network formed by email communication can be used
  as a strong foundation for spam detection

Motivation

MailRank

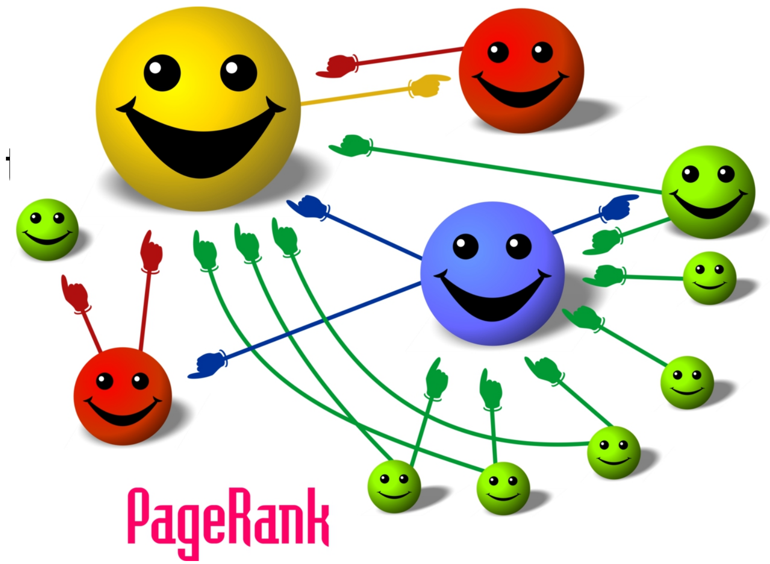
Basic MailRank

Personalized MailRank

Related work

- PageRank

a page has a high rank if the sum of t
ranks of its backlinks is high



$$PR(p) = c \cdot \sum_{q \in I(p)} \frac{PR(q)}{||O(q)||} + (1 - c) \cdot E(p)$$

- Personalized PageRank

Each user select her preferred pages. Then compute personalized rank vectors

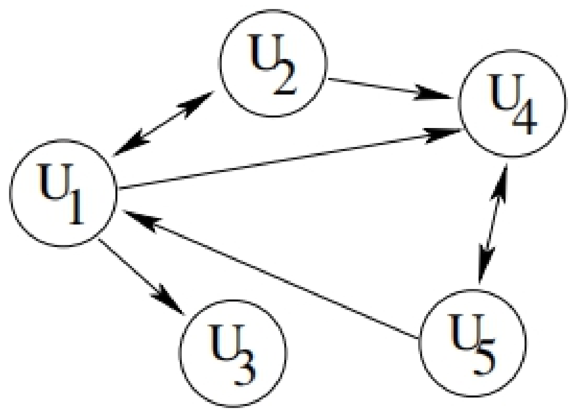
Related work

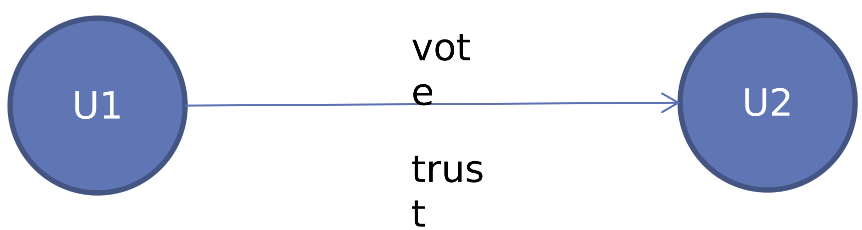
PageRank → **Basic MailRank**

Personalized PageRank → **Personalized MailRank**

MailRank

- Build a graph





- If U1 has sent an email to U2, add edge<U1, U2> ,which implies U1 trusts U2

Basic MailRank

- step1: determine the biased set
  - small set of users with high reputation
  - should not contain any spammer

- step2: apply power iteration algorithm

$$PR(p) = c \cdot \sum_{q \in I(p)} \frac{PR(q)}{||O(q)||} + (1-c) \cdot E(p)$$

Basic MailRank

power iteration algorithm:

Algorithm 3.1. The Basic MailRank Algorithm.

Client Side:
Each vote sent to the MailRank server comprises:
Addr(u) : The hashed version of the email address of the voter *u*.
TrustVotes(u) : Hashed version of all email addresses
u votes for (i.e., she has sent an email to)

Server Side:
1: Combine all received data into a global email network graph. Let T be the Markov chain transition probability matrix, computed as:
ForEach known email address i
If i is a registered address, i.e., user i has submitted her votes
ForEach trust vote from i to j
$T_{ji} = 1/\text{NumOfVotes}(i)$
Else ForEach known address j
$T_{ji} = 1/N$, where N is the number of known addresses.
3: Determine the biasing set B (i.e., the most popular email addr.)
3a: Manual selection or
3b: Automatic selection or
3c: Semi-automatic selection
4: Let $T' = c \cdot T + (1 - c) \cdot E$, with $c = 0.85$ and
$E[i] = [\frac{1}{||B||}]_{N \times 1}$, if $i \in B$, or $E[i] = [0]_{N \times 1}$, otherwise
5: Initialize the vector of scores $\vec{x} = [1/N]_{N \times 1}$, and the error $\delta = \infty$
6: **While** $\delta < \epsilon$, ϵ being the precision threshold
$\vec{x}' = T' \cdot \vec{x}$
$\delta = ||\vec{x}' - \vec{x}||$
7: Output $\vec{x}'$, the global MailRank vector.
8: Classify each email address in the MailRank network into:
'spammer' / 'non-spammer' based on the threshold T

Basic MailRank

Problem of basic MailRank:

too general with respect to user ranking

users want their acquaintances ranked higher than unknown users

Can we build a personalized ranking vector for every user?

Personalized MailRank

Each user decide a preference set

compute partial vectors for all common users and hub skeleton for each user

combine them to compute PPV(personalized pagerank vector)

Evaluation

build a power-law model for evaluation

Analysis on three issuse:

effectiveness in case of very sparse MailRank networks

exploitation of spam characteristics

attacks on MailRank

Evaluation

Effectiveness in case of very sparse MailRank networks

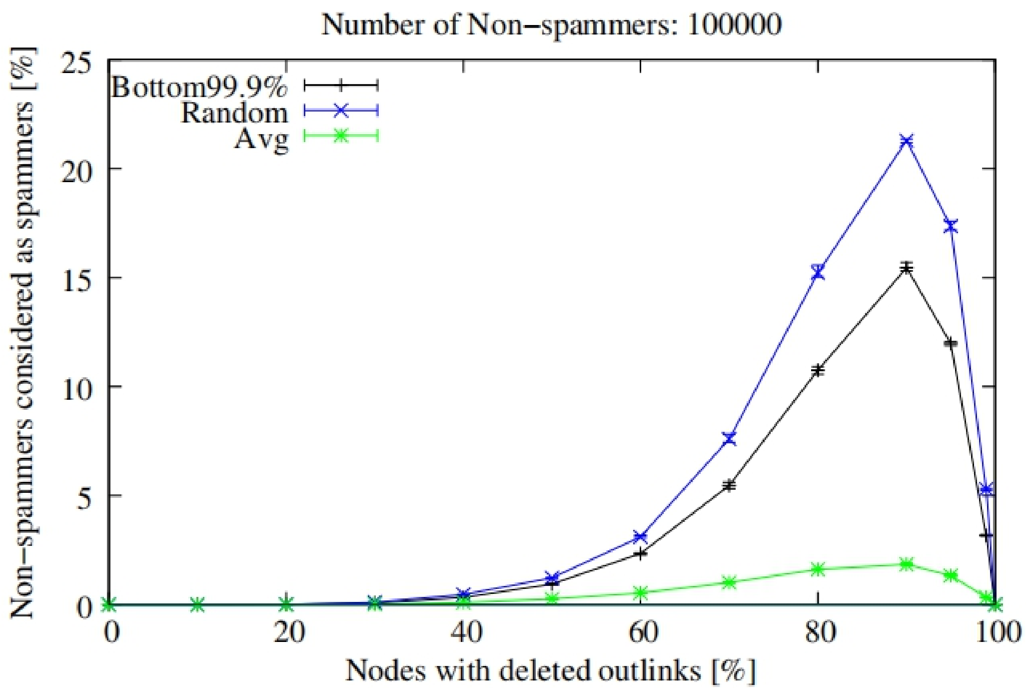


Figure 3: Very sparse MailRank networks

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Evaluation

Exploitation of spam characteristics

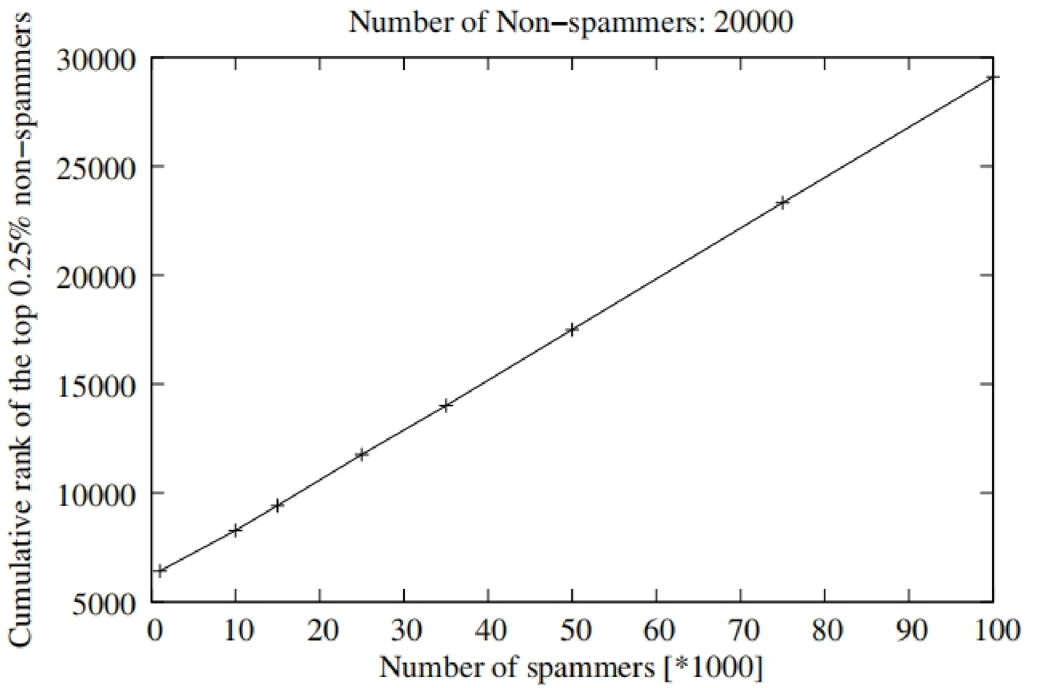

Figure 4: Rank increase of non-spammer addresses

Evaluation

Attacks on MailRank

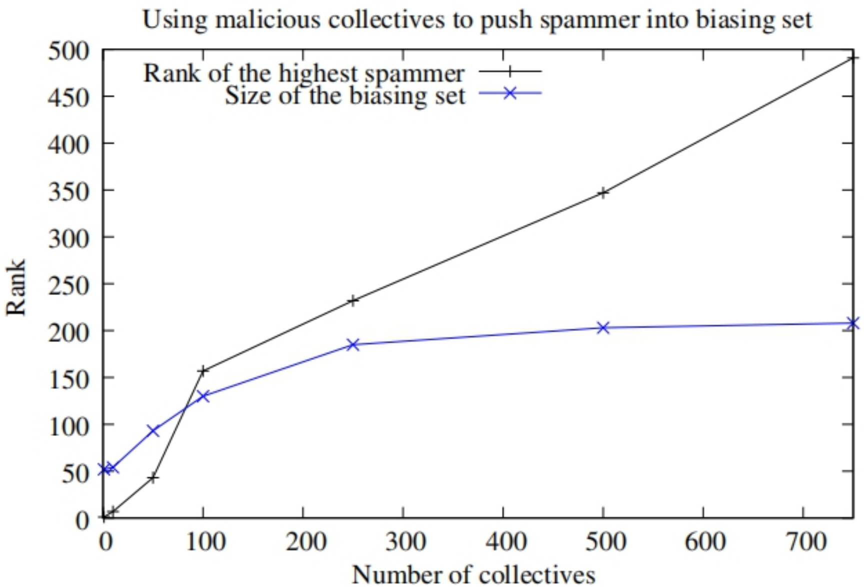

Figure 5: Automatic creation of the biasing set

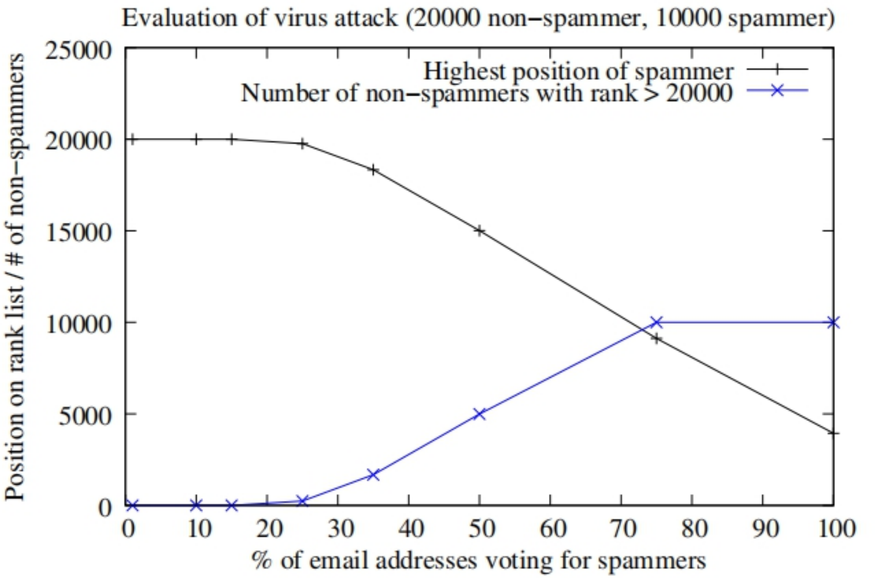

Figure 6: Simulation results: Virus attack

Advantages and limitation

Advantages:

Shorter individual cold-start phase

High attack resilience

Stable results

Partial participation

...

Limits:

cannot prevent address spoofing attack

may misdetect some special non-spammer users

highly rely on the central server

Thank you

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