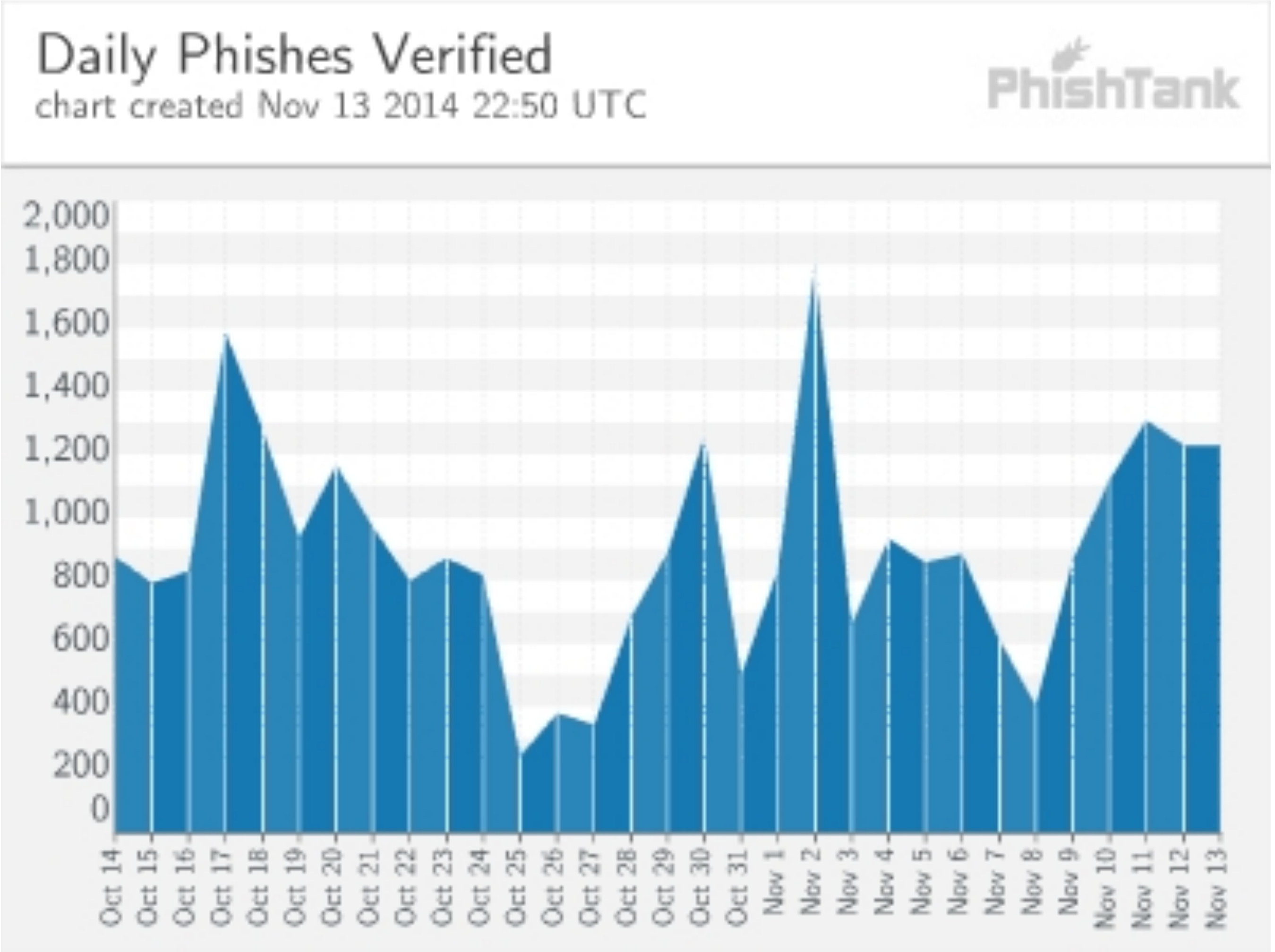
CS259D: Data Mining for Cybersecurity

Phishing

- Goal:
  - Account information
  - Logon credentials
  - Identity information
- Attack vectors:
  - Legitimate-looking emails
  - Legitimate-looking websites

Scale of the problem



Detection

- Toolbars
  - Spoofguard
  - Netcraft
- Email filtering
  - Examples:
    - SpamAssassin
    - Spamato
  - Advantages:
    - More complete context (content, headers, etc.)
    - Completely shield user from decision-making process

Phishing classification: Features

- IP-based URLs
  - Example:
    - http://192.168.0.1/paypal.cgi?fix account
  - Compromised PCs with no DNS entries
  - Binary feature
- Age of linked-to domain names
  - Registered legitimate-sounding domain names
    - Example: playpal.com, paypal-update.com
  - Typically short life-span
    - Registered using stolen credit cards, canceled by registrar
    - Domain caught by anti-phishing monitors
    - Often lasting only ~ 48 hours
  - Obtained using a WHOIS query
  - Binary feature: Lifetime < 60 days

Phishing classification: Features

- Non-matching URLs
  - Example: <a href="badsite.com"> paypal.com</a>
  - Binary feature: URL text different from HREF
- “Here” links to non-modal domain
  - Example: Click here to restore your account
  - Modal domain: domain most frequently linked to
  - Binary feature: link with text “link”, “click”, “here” that links to a domain other than modal domain

Phishing classification: Features

- HTML emails
  - Binary feature: email section with MIME type text/html
- Number of links
  - Numeric feature: # links in HTML part(s) of email
  - Link defined by an <a> tag with href attribute
    - Including mailto: links

Phishing classification: Features

- Number of domains
  - Domain names for URLs starting with http/https
  - Only the main part of the domain name
    - What registrar gets paid for
      - Not necessarily same as combination of top- & 2nd-level domain
    - Example:
      - **university.edu** for www.cs.university.edu
      - **company.co.jp** for www.company.co.jp
        - Top-level: **.jp**, second-level: **.co**
  - Numeric feature: #distinct domains

Phishing classification: Features

- Number of dots
  - Subdomains: http://www.my-bank.update.data.com
  - Redirection script: http://www.google.com/url?q=http://www.badsite.com
    - Looks to naïve user to be from google.com
    - Redirects browser to badsite.com
  - Numeric feature: Maximum number of dots in any of the links in the email

Phishing classification: Features

- Contains javascript
  - Binary feature: string “javascript” appears in email
- Spam filter output
  - Binary feature: class assigned to email by SpamAssassin

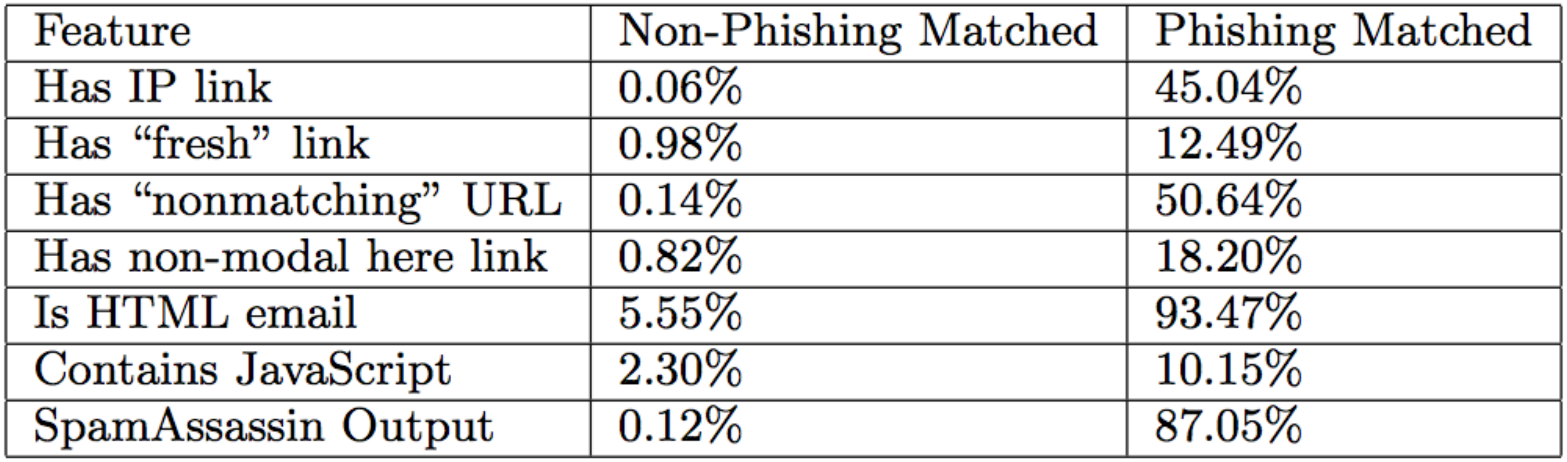
Evaluation

- 10-fold cross validation
- Classifier: Random forest
  - 10 decision trees
  - Each decision made on a random attribute
  - Trees pruned

Evaluation

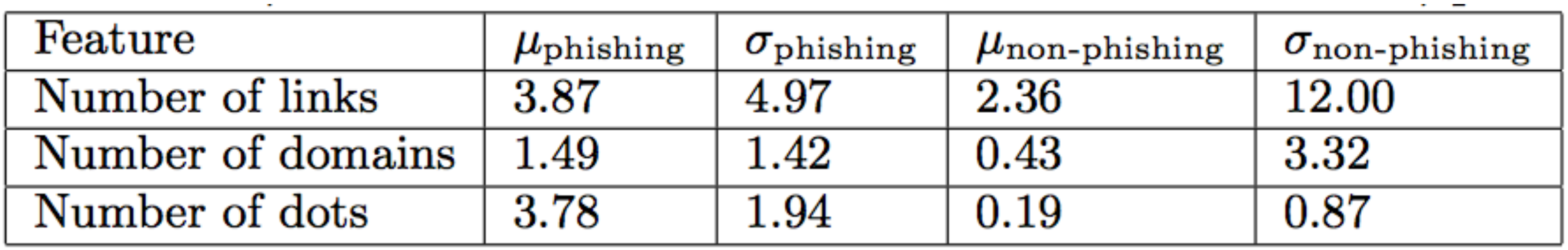
- SpamAssassin ham corpora
  - ~6950 non-phishing non-spam
- Publicly available phishingcorpus
  - ~ 860 phishing messages
  - Challenge with WHOIS queries
    - Only 505 domains out of 870 domains
    - Increases false negative rate

Evaluation



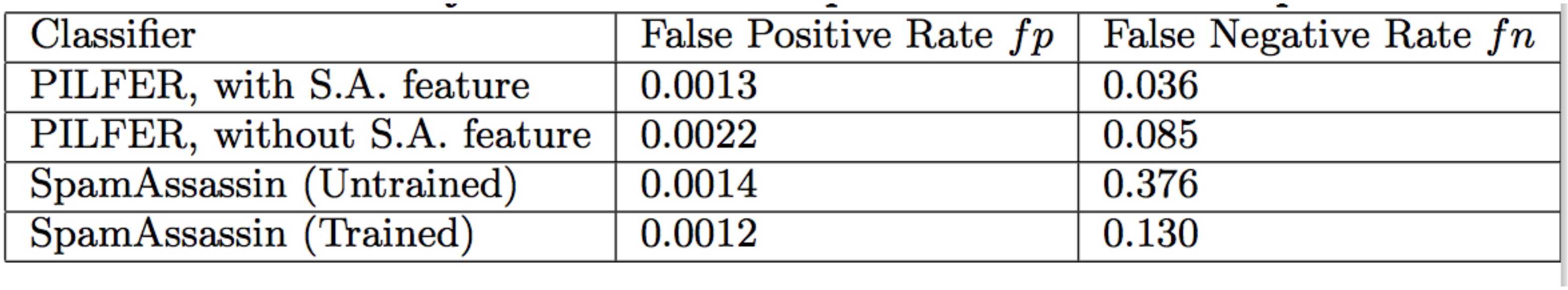
Feature	Non-Phishing Matched	Phishing Matched
Has IP link	0.06%	45.04%
Has “fresh” link	0.98%	12.49%
Has “nonmatching” URL	0.14%	50.64%
Has non-modal here link	0.82%	18.20%
Is HTML email	5.55%	93.47%
Contains JavaScript	2.30%	10.15%
SpamAssassin Output	0.12%	87.05%

Evaluation



Feature	μ_{phishing}	σ_{phishing}	$\mu_{\text{non-phishing}}$	$\sigma_{\text{non-phishing}}$
Number of links	3.87	4.97	2.36	12.00
Number of domains	1.49	1.42	0.43	3.32
Number of dots	3.78	1.94	0.19	0.87

Evaluation



Classifier	False Positive Rate fp	False Negative Rate fn
PILFER, with S.A. feature	0.0013	0.036
PILFER, without S.A. feature	0.0022	0.085
SpamAssassin (Untrained)	0.0014	0.376
SpamAssassin (Trained)	0.0012	0.130

Review of TF-IDF

- Measure importance of word in document
- TF = frequency of word in document
- IDF = measure popularity of word in corpus
  - Log(N/#{documents having the term})
- tf-idf (t, d, D) = tf(t, d) x idf(t, D)

Robust hyperlinks

- Lexical signatures for identifying URLs
- Signature words chosen using TF-IDF
- Experiments: 5 terms enough for unique page identification

Observation

- Minimal changes to original page detectable via robust hyperlinks
- Phishing sites often include brand names
  - Common on brand’s webpages
  - Rare on the web

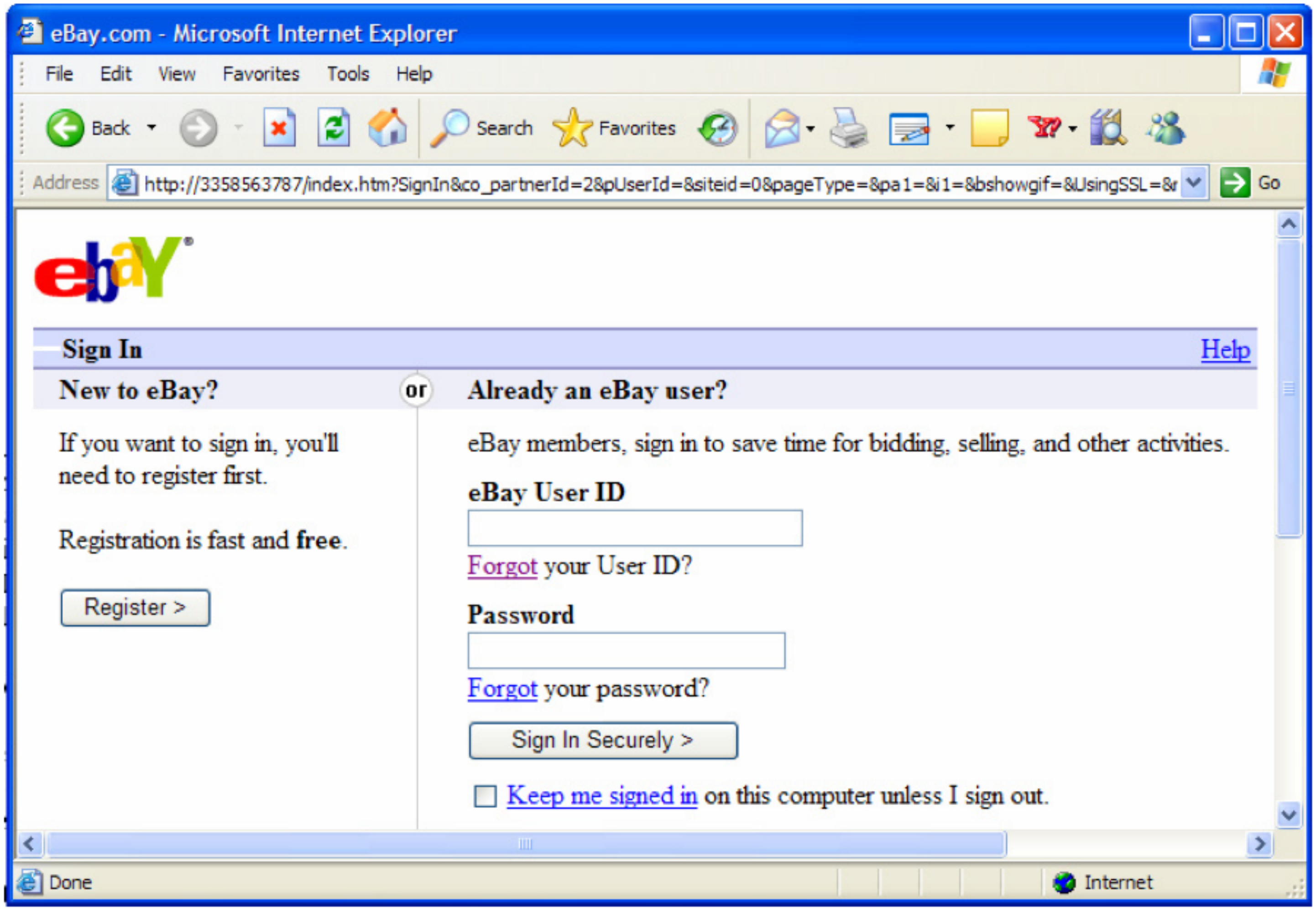
Algorithm

- Compute term TF-IDFs
- Find top 5 terms
- Submit terms as query to Google
- Check if domain is among top-N results
- Assumption: phishing pages have low pagerank

Lowering false positives

- Include domain name in lexical signature
- Heuristic: Zero results Means Phishing

Example



http://3358563787/index.htm?SignIn&co_partnerId=2&pUserId=&siteid=0&pageType=&pa1=&i1=&bshowgif=&UsingSSL=&r

Sign In Help

New to eBay? or **Already an eBay user?**

If you want to sign in, you'll need to register first.

Registration is fast and **free**.

eBay members, sign in to save time for bidding, selling, and other activities.

eBay User ID

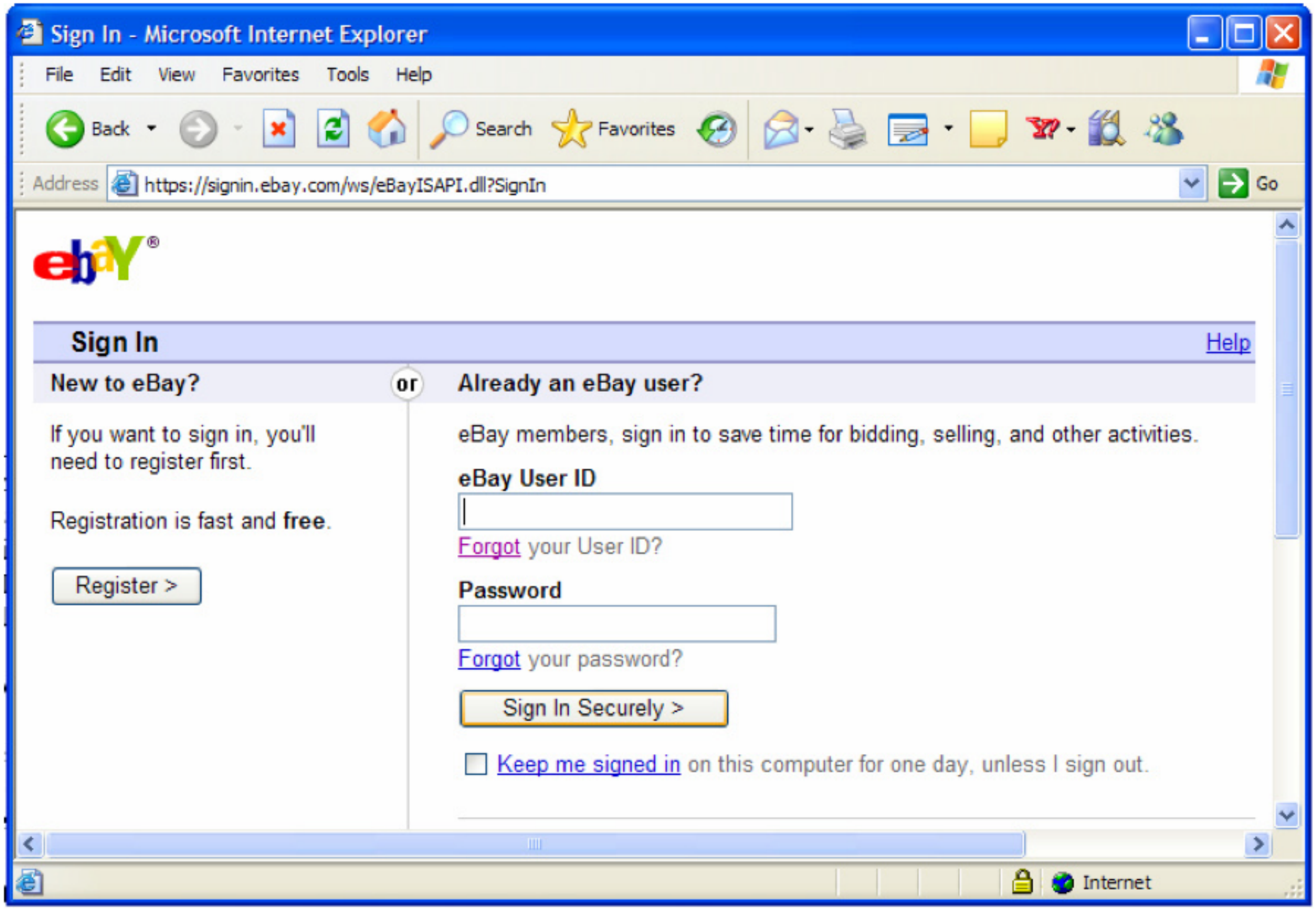
Forgot your User ID?

Password

Forgot your password?

□ Keep me signed in on this computer unless I sign out.

Example



Sign In - Microsoft Internet Explorer
File
Edit
View
Favorites
Tools
Help
Back
Search
Favorites
Address
https://signin.ebay.com/ws/eBayISAPI.dll?SignIn
Go
Internet

Sign In

Help

New to eBay? or **Already an eBay user?**

If you want to sign in, you'll need to register first.

Registration is fast and **free**.

Register >

eBay members, sign in to save time for bidding, selling, and other activities.

eBay User ID

Forgot your User ID?

Password

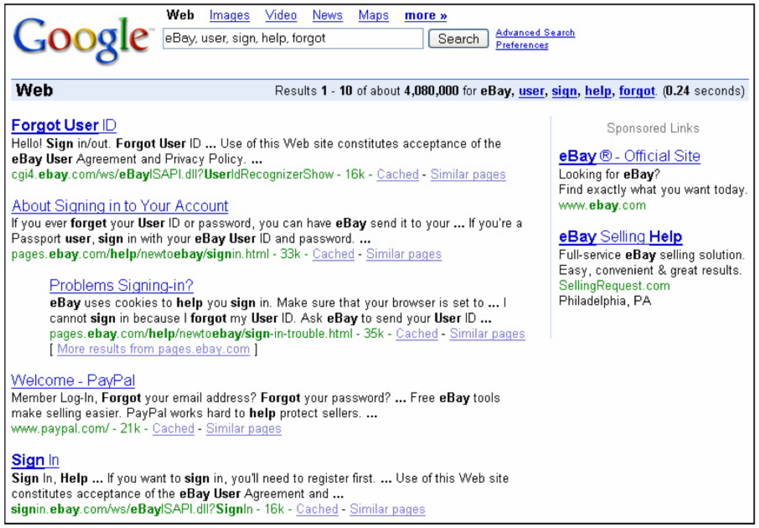
Forgot your password?

Sign In Securely >

□ Keep me signed in on this computer for one day, unless I sign out.

Example

- Top terms: eBay, user, sign, help, forgot



eBay, user, sign, help, forgot

Web Results **1** - **10** of about **4,080,000** for **eBay**, **user**, **sign**, **help**, **forgot**. (**0.24** seconds)

Forgot User ID
Hello! **Sign** in/out. **Forgot User** ID **...** Use of this Web site constitutes acceptance of the **eBay User** Agreement and Privacy Policy. **...**
cgi4.**ebay**.com/ws/**eBay**ISAPI.dll?**User**IdRecognizerShow - 16k - Cached - Similar pages

About Signing in to Your Account
If you ever **forget** your **User** ID or password, you can have **eBay** send it to your **...** If you're a Passport **user**, **sign** in with your **eBay User** ID and password. **...**
pages.**ebay**.com/**help**/newto**ebay**/**sign**in.html - 33k - Cached - Similar pages

Problems Signing-in?
eBay uses cookies to **help** you **sign** in. Make sure that your browser is set to **...** I cannot **sign** in because I **forgot** my **User** ID. Ask **eBay** to send your **User** ID **...**
pages.**ebay**.com/**help**/newto**ebay**/**sign**-in-trouble.html - 35k - Cached - Similar pages
[More results from pages.ebay.com]

Welcome - PayPal
Member Log-In, **Forgot** your email address? **Forgot** your password? **...** Free **eBay** tools make selling easier. PayPal works hard to **help** protect sellers. **...**
www.paypal.com/ - 21k - Cached - Similar pages

Sign In
Sign In, **Help ...** If you want to **sign** in, you'll need to register first. **...** Use of this Web site constitutes acceptance of the **eBay User** Agreement and **...**
signin.**ebay**.com/ws/**eBay**ISAPI.dll?**Sign**In - 16k - Cached - Similar pages

Sponsored Links

eBay ® - Official Site
Looking for **eBay**?
Find exactly what you want today.
www.**ebay**.com

eBay Selling **Help**
Full-service **eBay** selling solution.
Easy, convenient & great results.
SellingRequest.com
Philadelphia, PA

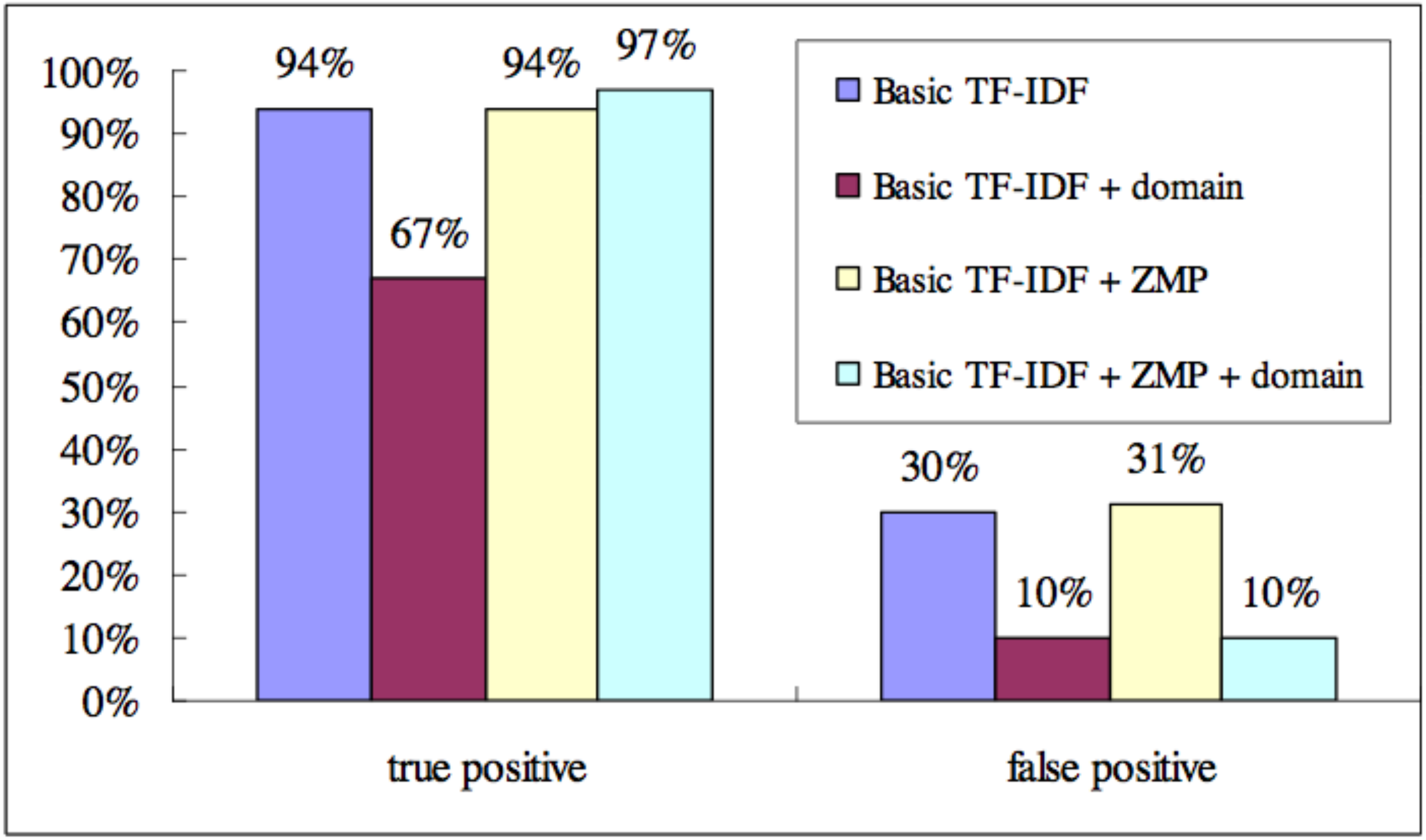
Other features

- Age of domain
- Known images
  - Presence of inconsistent well-known logos
  - Top-10 identified targets: eBay, PayPal, Citibank, Bank of America, Fifth Third Bank, Barclays Bank, ANZ Bank, Chase Bank, and Wells Fargo Bank
- Suspicious URL
  - Contains @ or – in domain name

Other features

- Suspicious links
  - Same as suspicious URLs
- IP address as domain
- Dots in URL
  - Binary: #Dots > 5
- Forms
  - HTML <input> tag, with text such as "credit card", "password"

Evaluation


100%
90%
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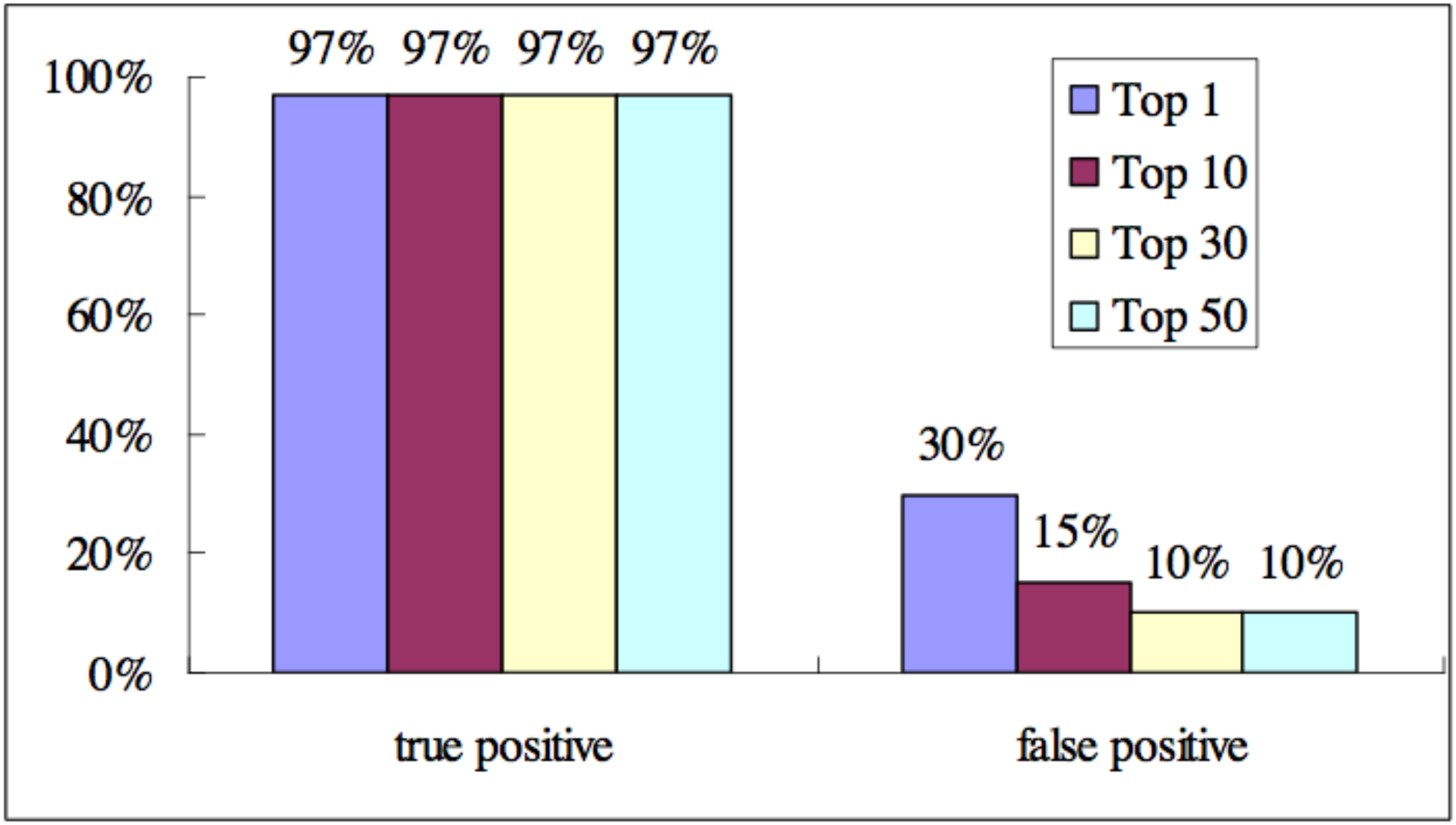
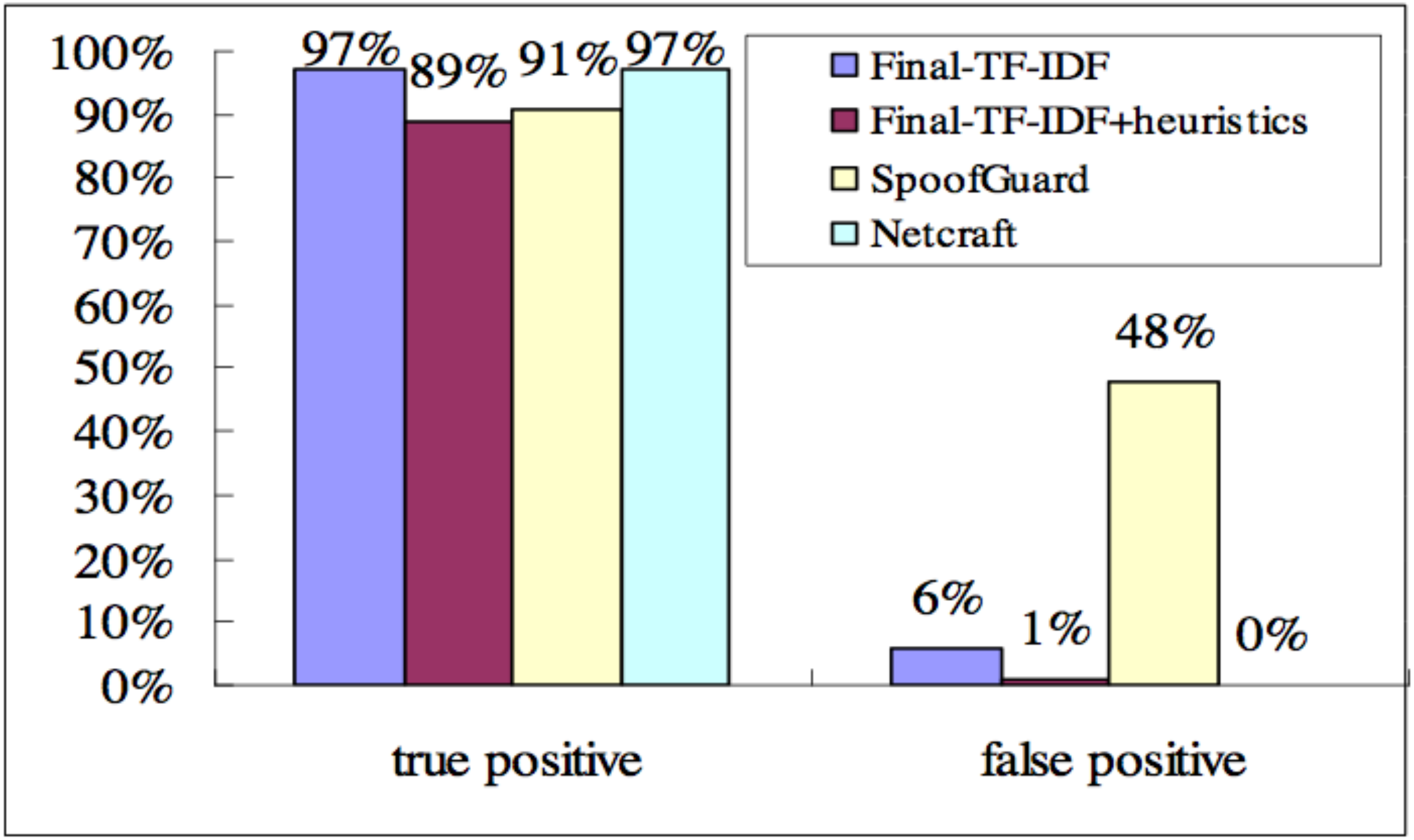
70%
60%
50%
40%
30%
20%
10%
0%
94%
67%
94%
97%
30%
10%
31%
10%
Basic TF-IDF
Basic TF-IDF + domain
Basic TF-IDF + ZMP
Basic TF-IDF + ZMP + domain
true positive
false positive

Evaluation


100%
80%
60%
40%
20%
0%
97% 97% 97% 97%
30%
15%
10% 10%
Top 1
Top 10
Top 30
Top 50
true positive
false positive

Evaluation


100%
90%
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70%
60%
50%
40%
30%
20%
10%
0%
97%
89%
91%
97%
6%
1%
48%
0%
true positive
false positive
Final-TF-IDF
Final-TF-IDF+heuris tics
SpoofGuard
Netcraft

References

- “Learning to Detect Phishing Emails”, Fette et al, 2007
- “Cantina: A content-based approach to detecting phishing websites”, Zhang et al, 2007