Measuring Similarity to Detect Qualified Links

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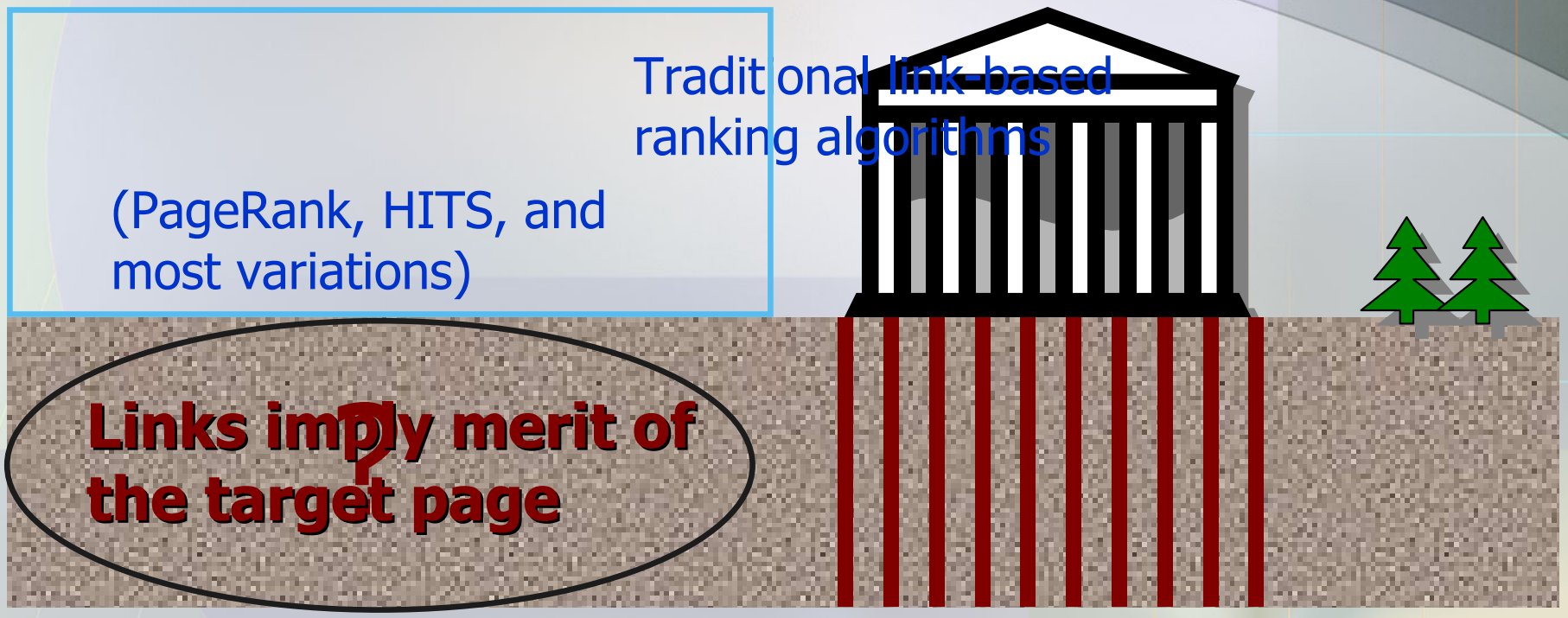
- **Introduction**
- **Approach**
- **Experiments**
- **Discussion & Conclusion**

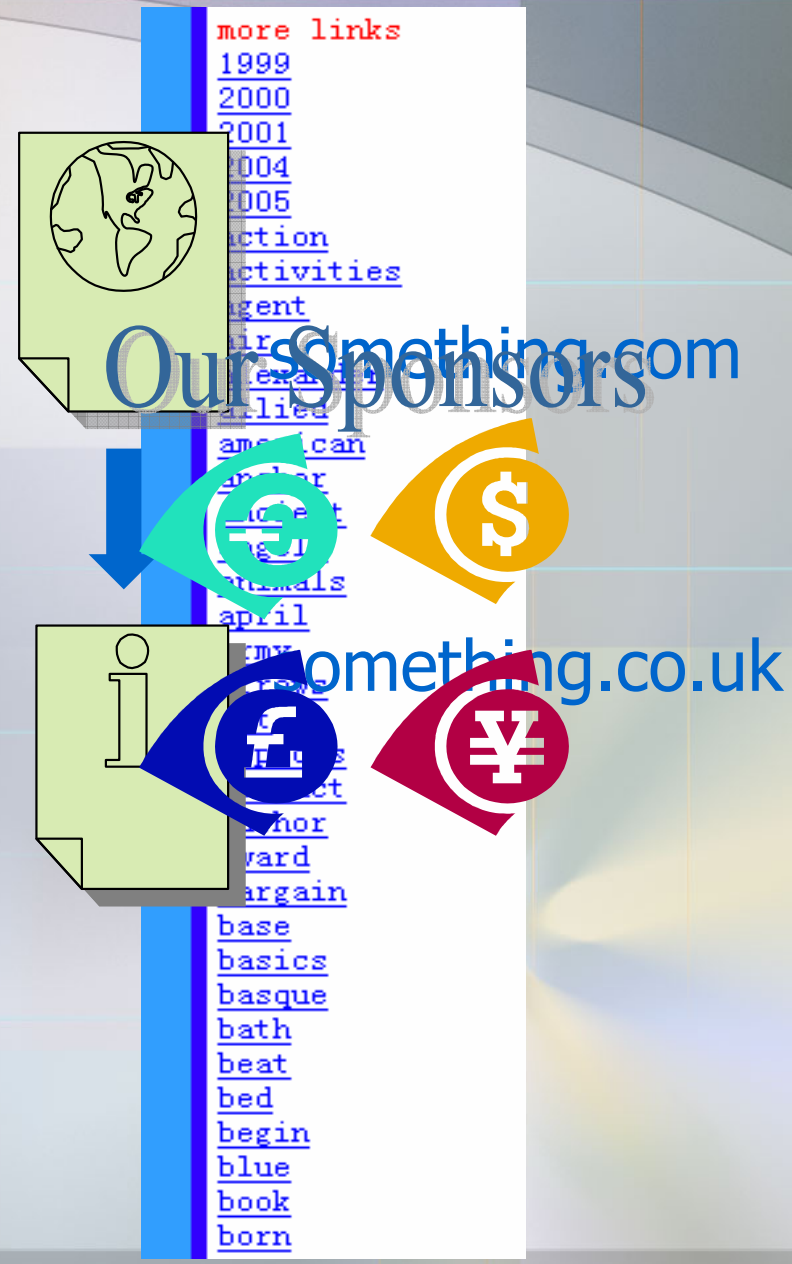
Traditional link-based ranking algorithms

(PageRank, HITS, and most variations)



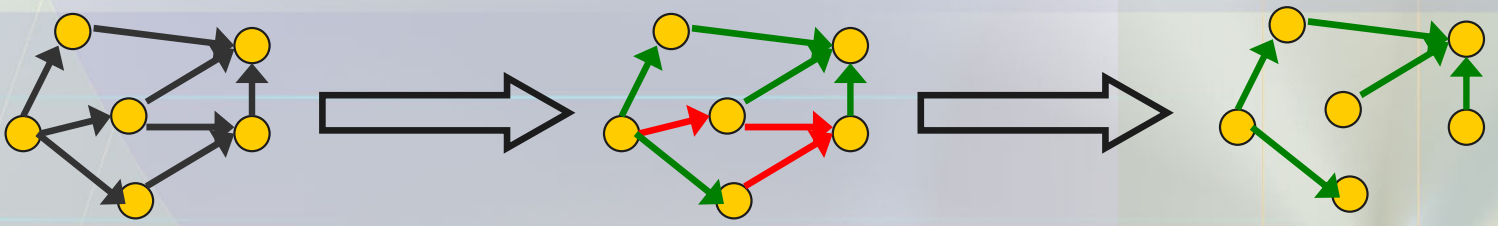
Is this always true? **No!**

- **Spam links**
- **Navigational links**
- **Advertising links**
- **Other irrelevant links**



- **These links**
  - **may be useful for humans;**
  - **are effectively noise for link analysis.**
- **Traditional link analysis algorithms do not distinguish them from useful links.**
  - **As a result, the target pages of these links could get unmerited higher ranking.**

- "Qualified links"
  - Links that are qualified to make a recommendation regarding the target page
- Our proposed approach
  1. Identify and filter out "unqualified links"
  2. Perform link analysis on the reduced link graph



- In our experiments, this approach can boost ranking performance.

Background

- **Hyperlink-Induced Topic Search (HITS) [Kleinberg 1997-1999]**
  - **–The score of a hub (authority) depends on the sum of the connected authorities (hubs)**

$$A(p) = \sum_{q:q \to p} H(q) \quad \text{and} \quad H(p) = \sum_{q:p \to q} A(q)$$

- **Bharat and Henzinger (1998)**
  - **–A number of improvements to HITS**
  - ***–imp***
    - **•Re-weight links involved in mutual reinforcement**
    - **•Drop links within the same host**

Background (Cont.)

- **PageRank**
  - **Random surfer model**

$$PR(i) = (1-d)\sum_{j:j\to i}\frac{PR(j)}{O(j)} + d\frac{1}{N}$$

Related work

- Chakrabarti et al. (1998) improving HITS by adjusting the weights of links according to their anchor text and surrounding text.
- Davison (2000) proposed automatic recognition of nepotistic links using hand-crafted features.
- Lempel and Moran (2000) defined the tightly-knit community (TKC) effect.
- Li et al. (2002) pointed out the small-in, large-out communities could dominate HITS results.
- Wu and Davison (2005) proposed a two-step algorithms to identify link farms.
- Benczur et al. (2006) proposed to detect nepotistic links using language models.
- Carvallo et al. (2006) proposed to detect noisy links at the site level by examining link structure among web sites.

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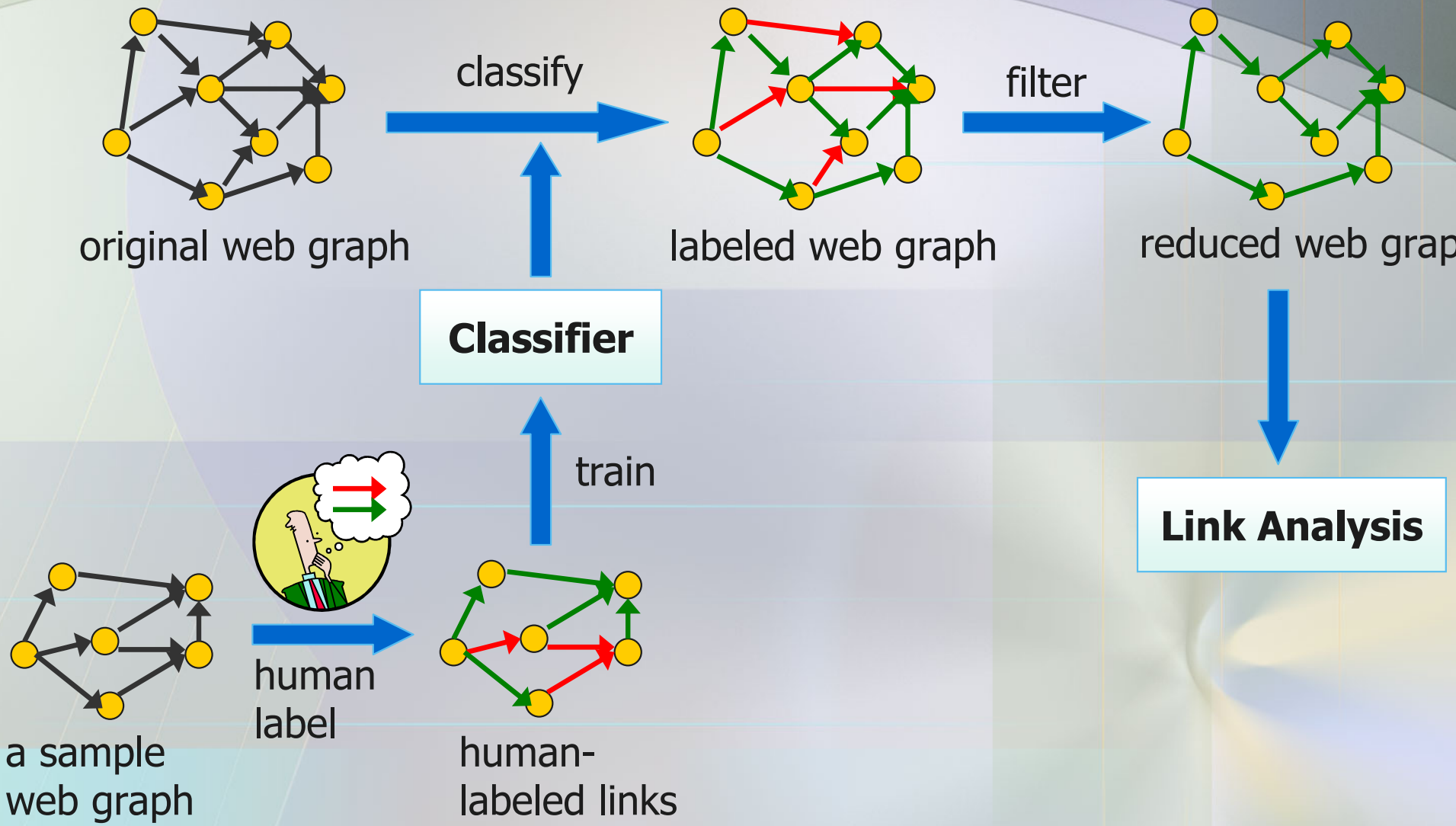
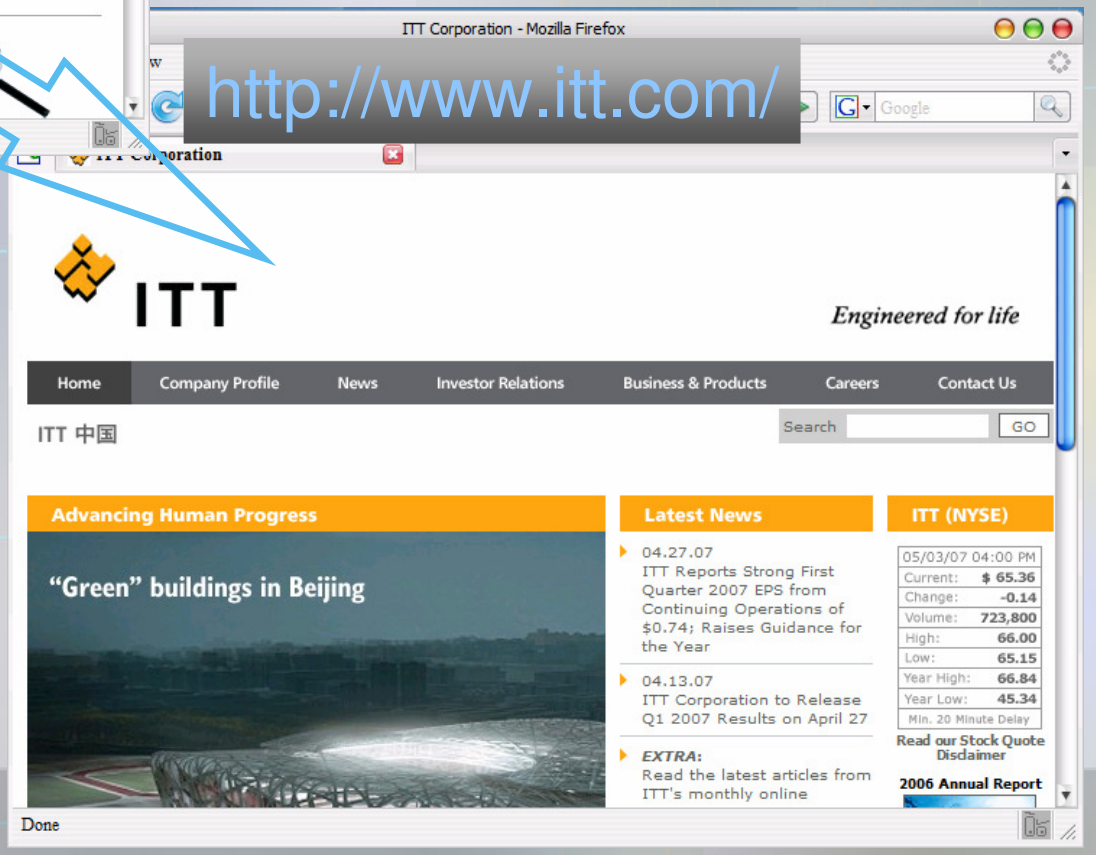
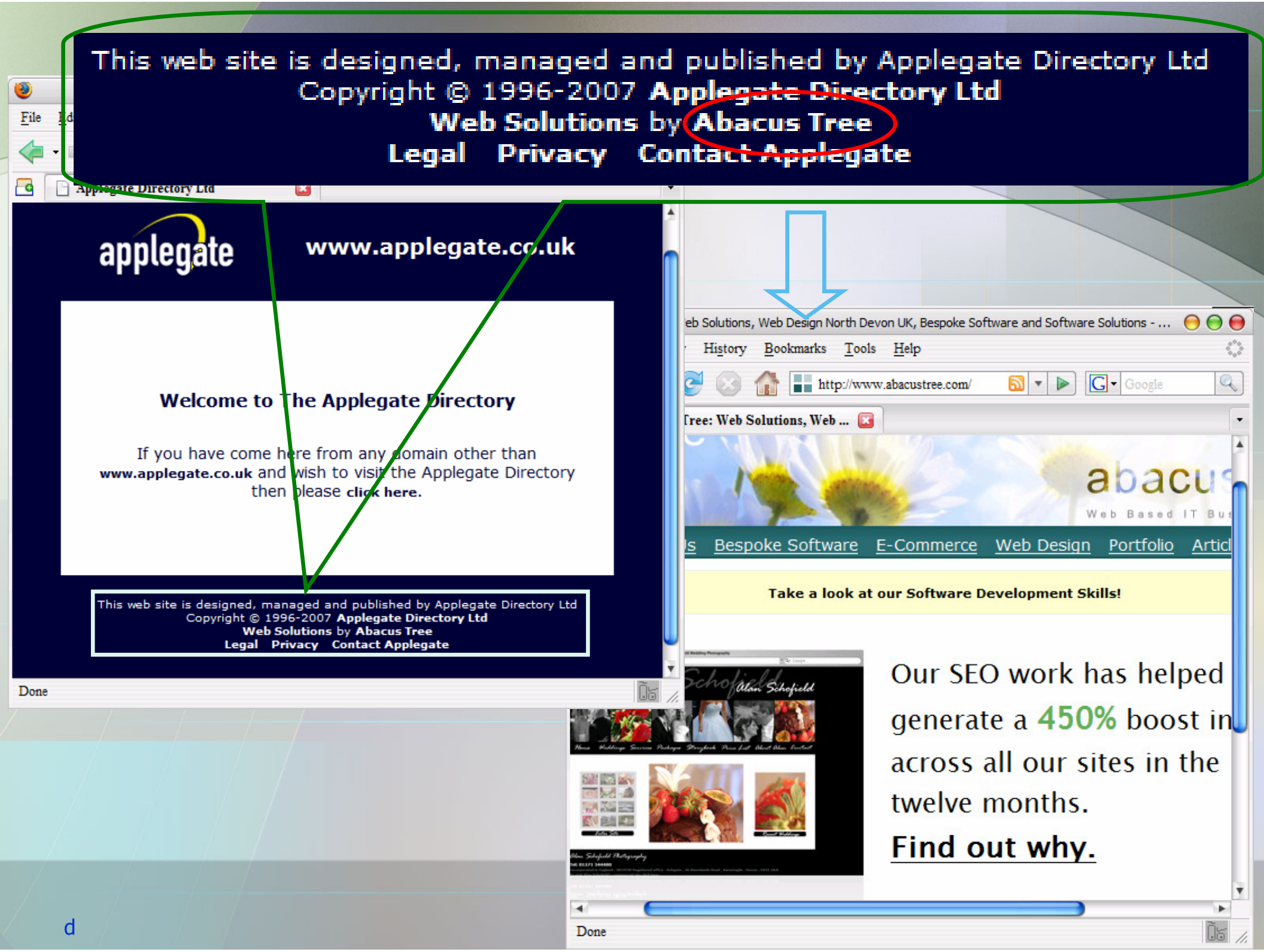

classify
filter
original web graph
labeled web graph
reduced web graph
Classifier
train
Link Analysis
human
label
a sample
web graph
human-
labeled links



A navigational link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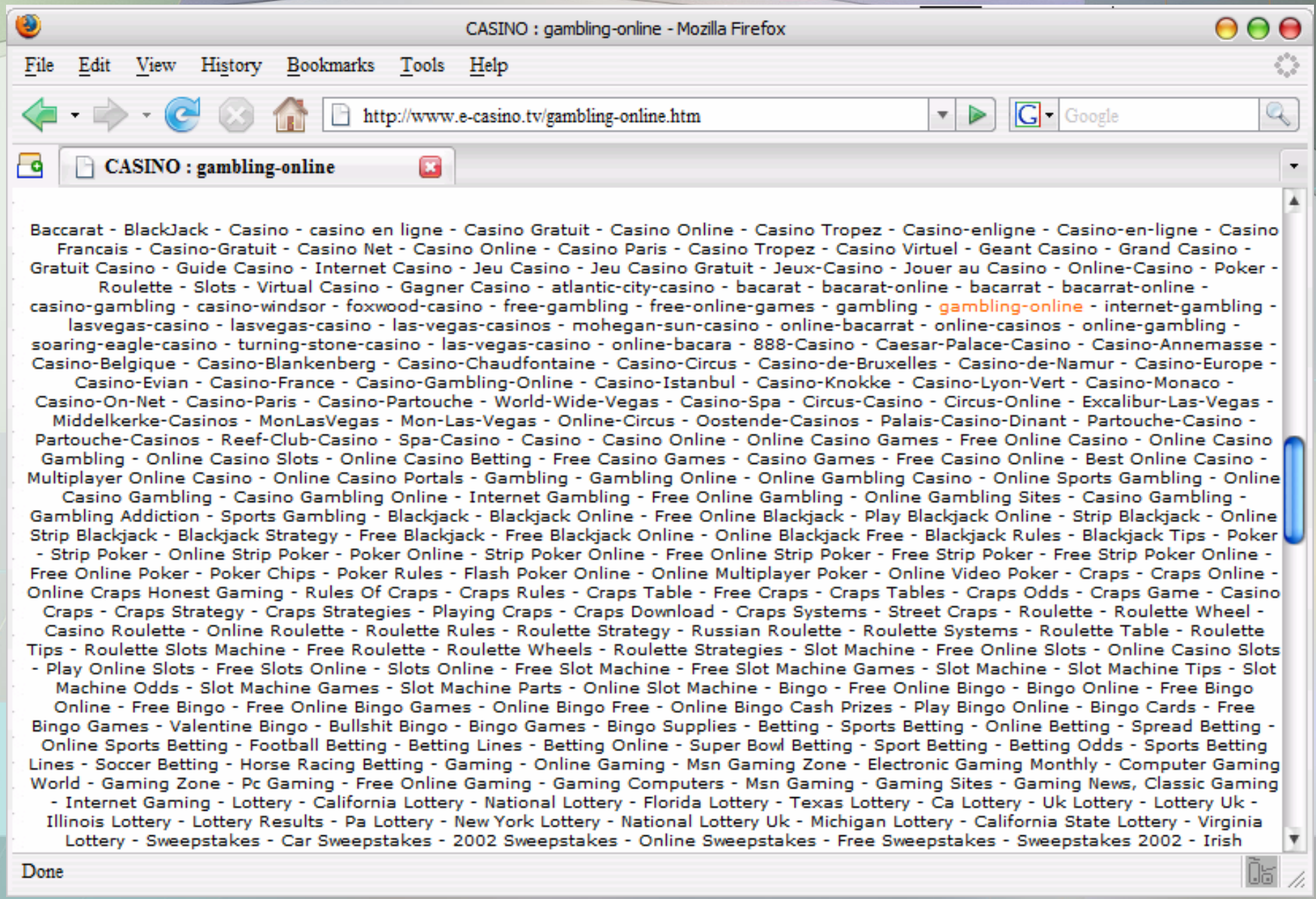
Find out why.
Done

Spam links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Done

How to determine whether a link is qualified?

- There are many features that can be used.
- In this preliminary work, we studied six similarity measures between the source and target pages.
  - Hostname, URL, topic vector, tfidf content, anchor text, non-anchor text

Similarity measures

- **Hostname similarity**
  - The portion of common substrings of two hostnames

$$Sim_{host}(x,y) = \frac{2 \times |Substr(host_x, r) \cap Substr(host_y r)|}{|Substr(host_x, r)| + |Substr(host_y r)|}$$

- **URL similarity**
  - Analogous to hostname similarity
  - The portion of common substrings of two URLs

Similarity measures (Cont.)

- **Topic vector similarity**
  - Cosine similarity of two topic vectors

$$\mathrm{Sim}_{\mathrm{topic}}(x,y) = \sum_{i=1}^{n} v_{x,i} \times v_{y,i}$$

  - A topic vector $v_x = (v_{x,1}, v_{x,2}, \cdots, v_{x,n})$
  - Each component is the probability that page x is on topic t
  - Can be computed using a classifier

- **Tfidf content similarity**
  - Cosine similarity of the two tfidf vectors

$$\mathrm{Sim}_{\mathrm{content}}(x,y) = \frac{\sum_{t \in T} (x_t \times y_t)}{\sqrt{\sum_{t \in T} x_t^2} \times \sqrt{\sum_{t \in T} y_t^2}}$$

Similarity measures (Cont.)

- **Anchor text similarity**
  - **Analogous to content similarity**
  - **Similarity (tfidf cosine) of anchor text on the two pages**
- **Non-anchor text similarity**
  - **Analogous to content similarity**
  - **Similarity of non-anchor text on the two pages**

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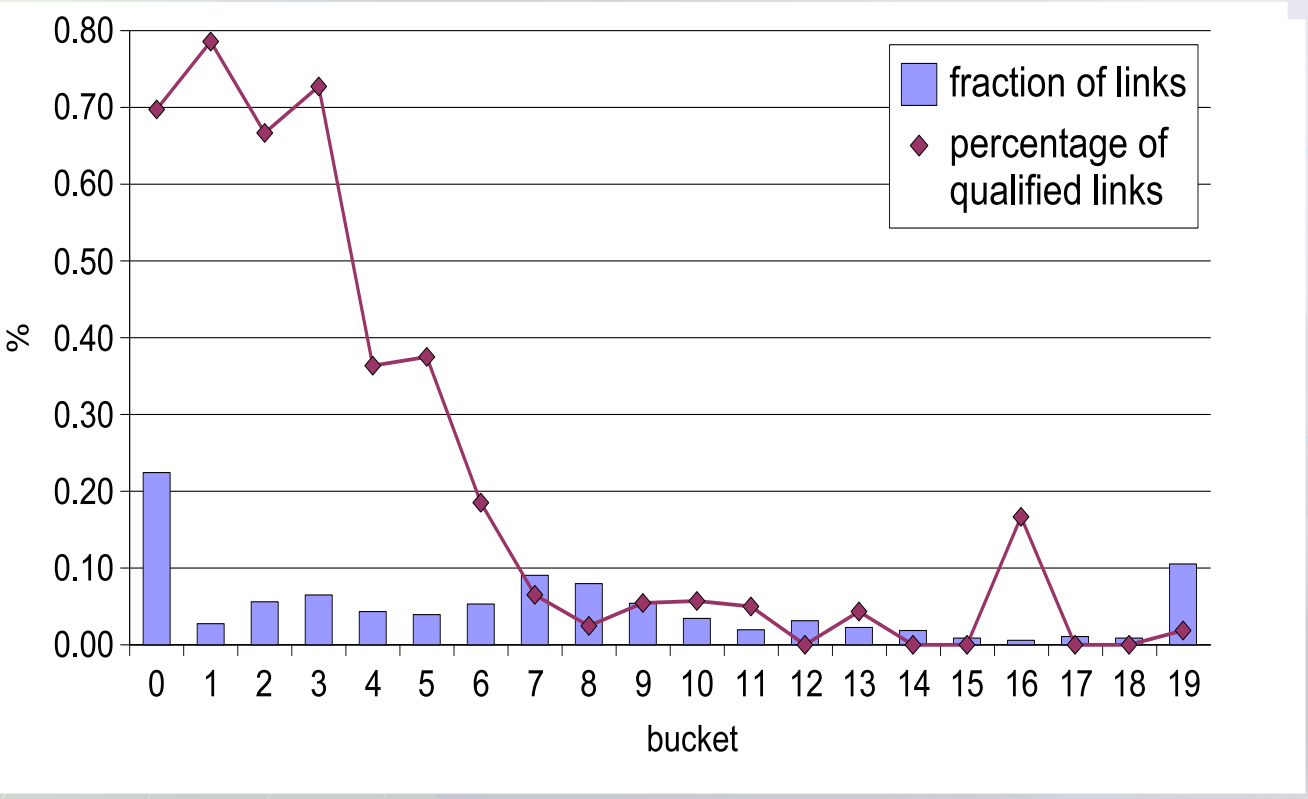
Datasets

- **Query-specific datasets**
  - **Collected and used by [Wu and Davison 2005]**
  - **58 queries used in previous research, from ODP category names, and popular queries**
- **Global dataset**
  - **A 2005 crawl from the Stanford WebBase**

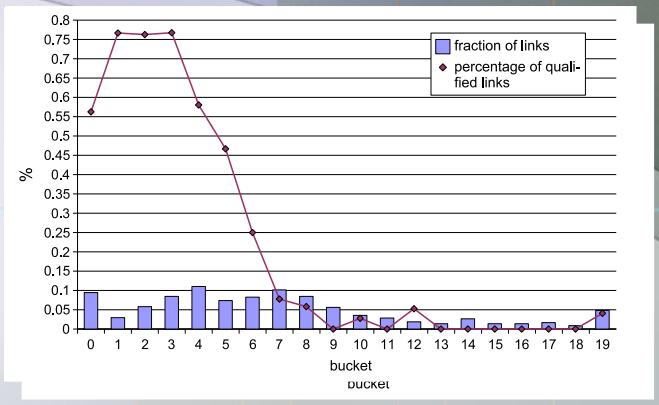
Link classification

- **Human labeling of links**
  - **More than a thousand links randomly selected from five query-specific datasets**
  - **Two human editors**
- **Link classification based on all features**
  - **A linear SVM classifier using SVM^{light}**
  - **Two fold cross validation**
  - **Average accuracy 83.8%**

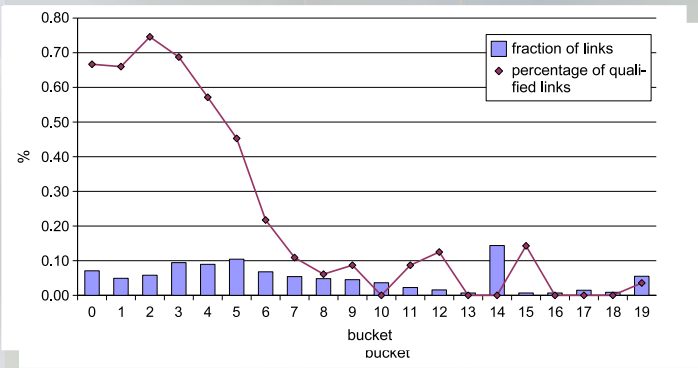
Link classification (Cont.)



Anchor text similarity



Content similarity

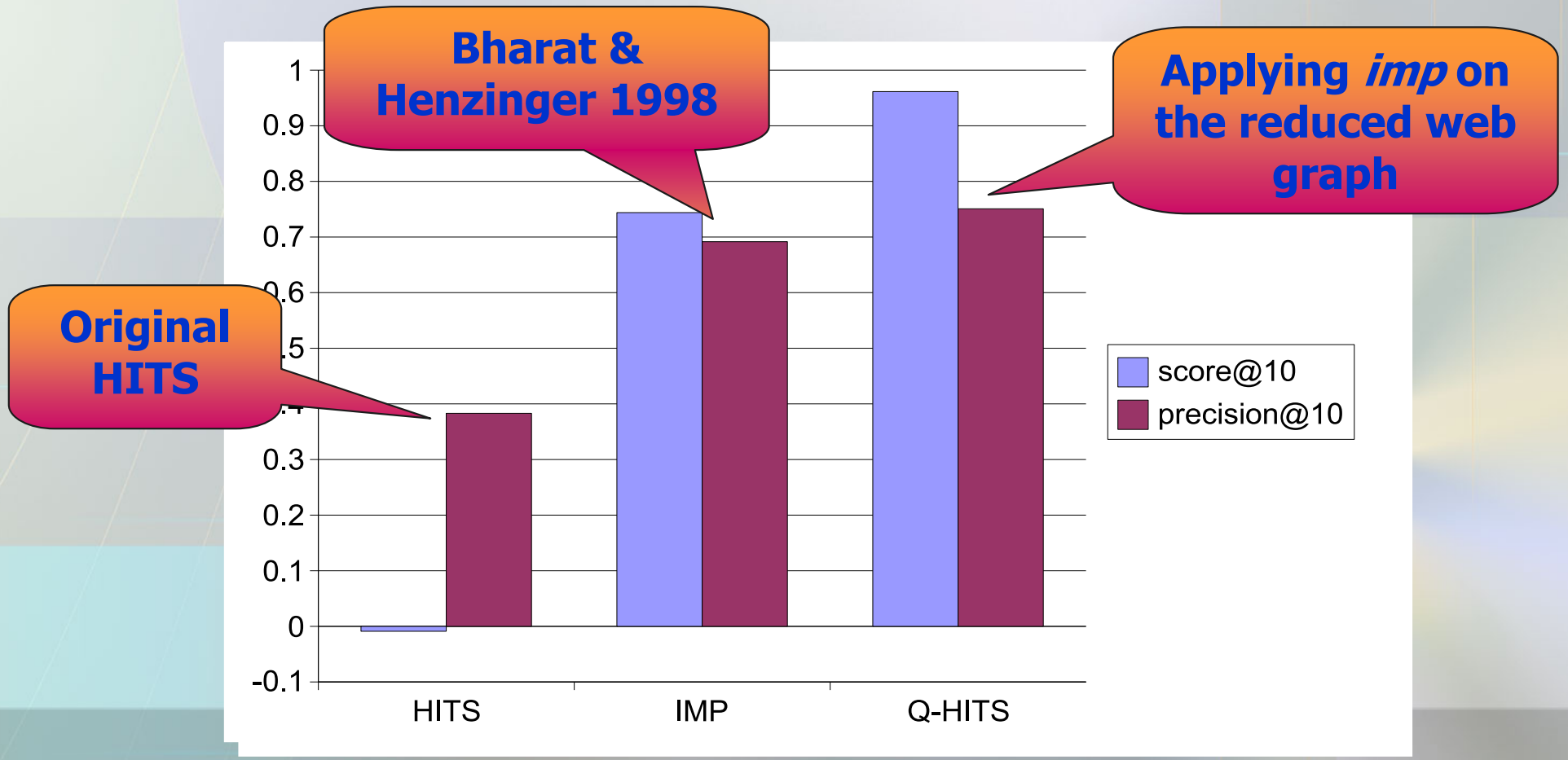


Non-anchor text similarity

Anchor text similarity was found to be the most discriminative feature.

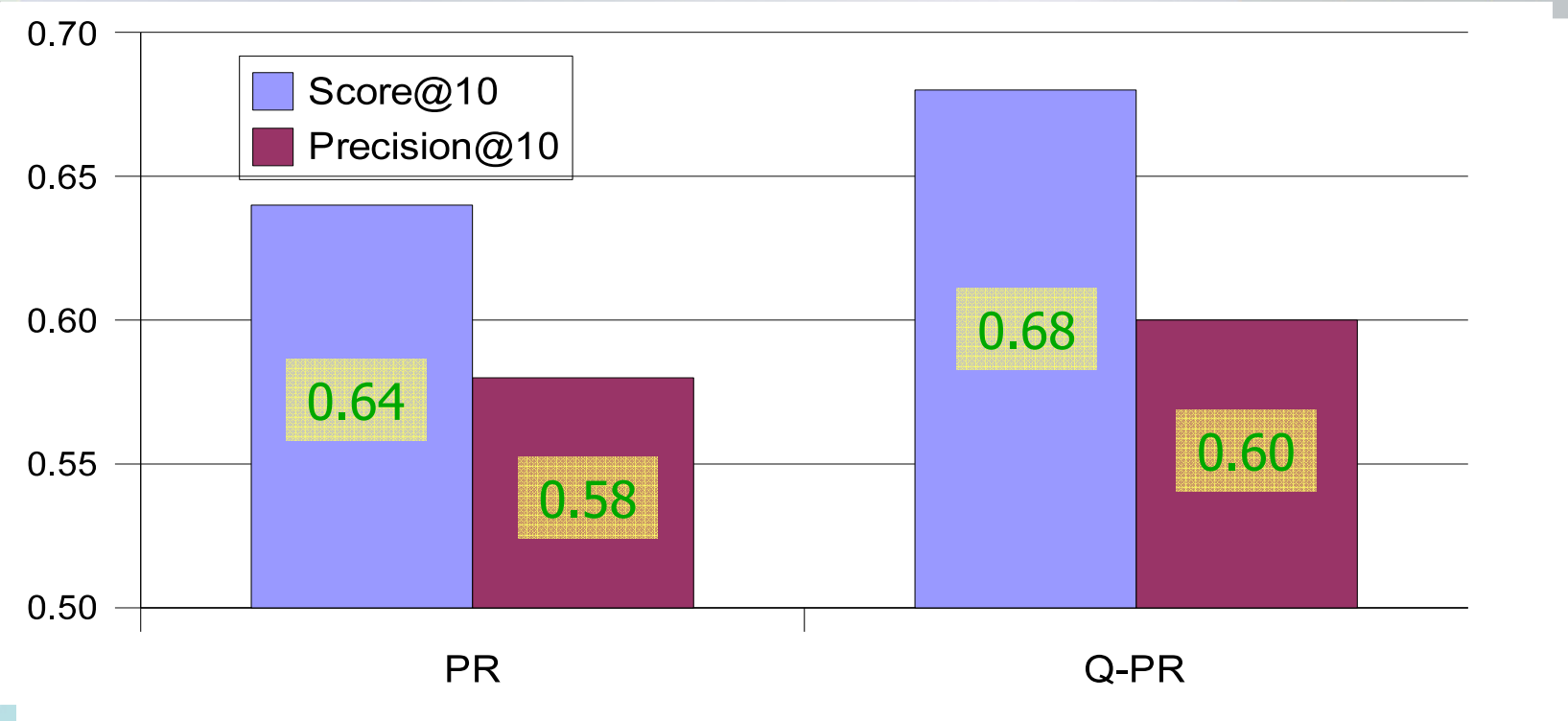
Qualified HITS

- Performed on query-specific datasets.
- Unqualified links, identified by the classifier, are removed.
- *imp* is performed on the reduced link graph.
- In this experiment, 37% of the links are removed.



Qualified PageRank

- Performed on WebBase dataset.
- Unqualified links, identified by the classifier, are removed.
- *PageRank* is performed on the reduced link graph.
- In this experiment, 0.4% of the links are removed.



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Conclusion

- **Summary of approach**
  - **Remove noise (unqualified links) from link graph before link analysis is applied**
  - **Identify unqualified links by measuring similarities between their source and target pages**
- **Qualified HITS is able to improve precision by 9% over Bharat and Henzinger's *imp*.**

Discussion

- How to determine the qualification of a link is an open question.
  - We used similarities between source and target page to demonstrate the potential of the idea.
  - What about other similarity measures?
  - What about non-similarity features?
- A closer look at link classification.
  - We trained a multi-class classifier to distinguish between qualified, spam, navigational, advertising, and other irrelevant links.
  - The classifier is effective in finding spam links
    - Not very helpful for other types.

Thank you!

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