PageRank Algorithm and Quiz Review

Announcement

- March 3, guest lecturer Ross Dimassimo with the help of William Garnes III
- March 3, Quiz 4
- Bonus 2 Project: Python Art for T-shirt, due today

Quiz 4 Review

Quiz 4: Sorting

- [ ] Selection Sort
- [ ] Insertion Sort
- [ ] Merge Sort

Review 1: Selection Sort

Algorithm for Selection Sort

Input: a list, *Unsorted*, of unordered items
Initialization: set *Sorted* to empty

while (items remain in *Unsorted*)
    find the smallest item in *Unsorted*
    put that item on the end of *Sorted*

Output: the finished list *Sorted*

Selection Sort Example

Unsorted	Min	Sorted
5 2 1 4 3	1	1
5 2 4 3	2	1 2
5 4 3	3	1 2 3
5 4	4	1 2 3 4
5	5	1 2 3 4 5
-	-	1 2 3 4 5

Selection Sort Exercise

Unsorted List	Min	Sorted list
25, 8, 42, 16, 77		
–	–	

Selection Sort Exercise

Unsorted List	Min	Sorted list
25, 8, 42, 16, 77	8	8
25, 42, 16, 77	16	8, 16
25, 42, 77	25	8, 16, 25
42, 77	42	8, 16, 25, 42
77	77	8, 16, 25, 42, 77
–	–	8, 16, 25, 42, 77

Review 2: Insertion Sort

Unsorted	Top Value	Insert After	Sorted
5 2 1 4 3	5	front	5
2 1 4 3	2	front	2 5
1 4 3	1	front	1 2 5
4 3	4	2	1 2 4 5
3	3	2	1 2 3 4 5
-		-	1 2 3 4 5

Insertion Sort Exercise

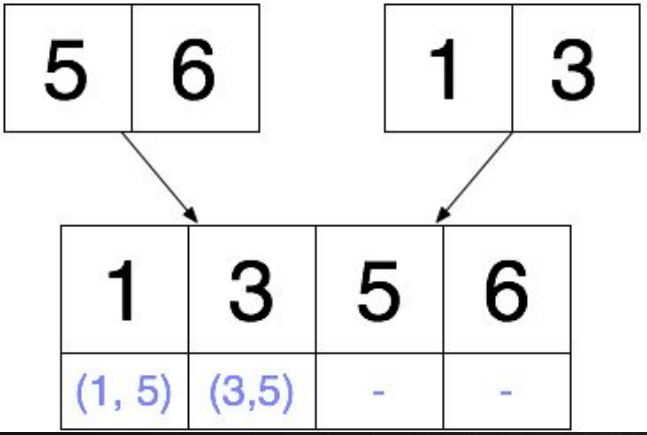
Unsorted List	Top Value	Insert After	Sorted list
25, 8, 42, 16, 77			
–	–	–	

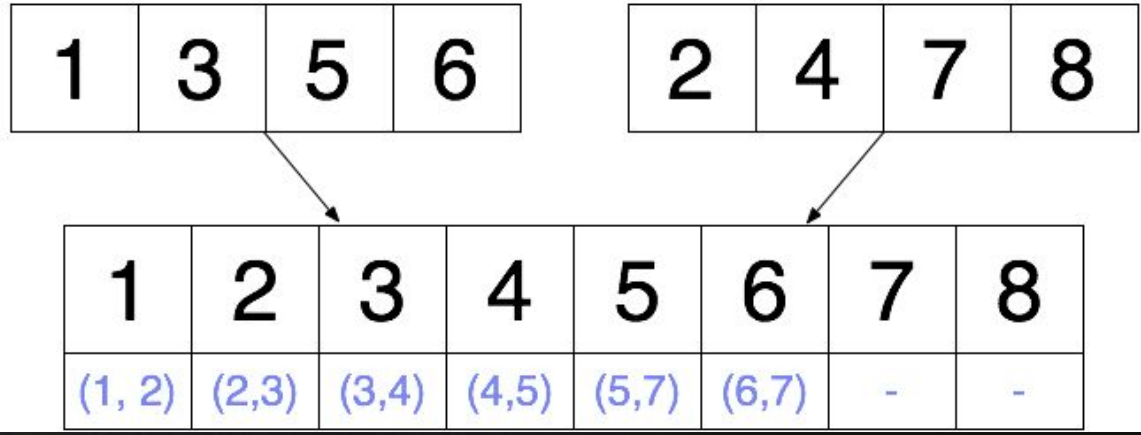
Insertion Sort Exercise

Unsorted List	Top Value	Insert After	Sorted list
25, 8, 42, 16, 77	25	front	25
8, 42, 16, 77	8	front	8, 25
42, 16, 77	42	25	8, 25, 42
16, 77	16	8	8, 16, 25, 42
77	77	42	8, 16, 25, 42,77
–	–	–	8, 16, 25, 42,77

Review 3: Merge Sort

Key step: Merge 2 sorted List





Merge Sort: exercise

12	25	36	42

11	24	37	41

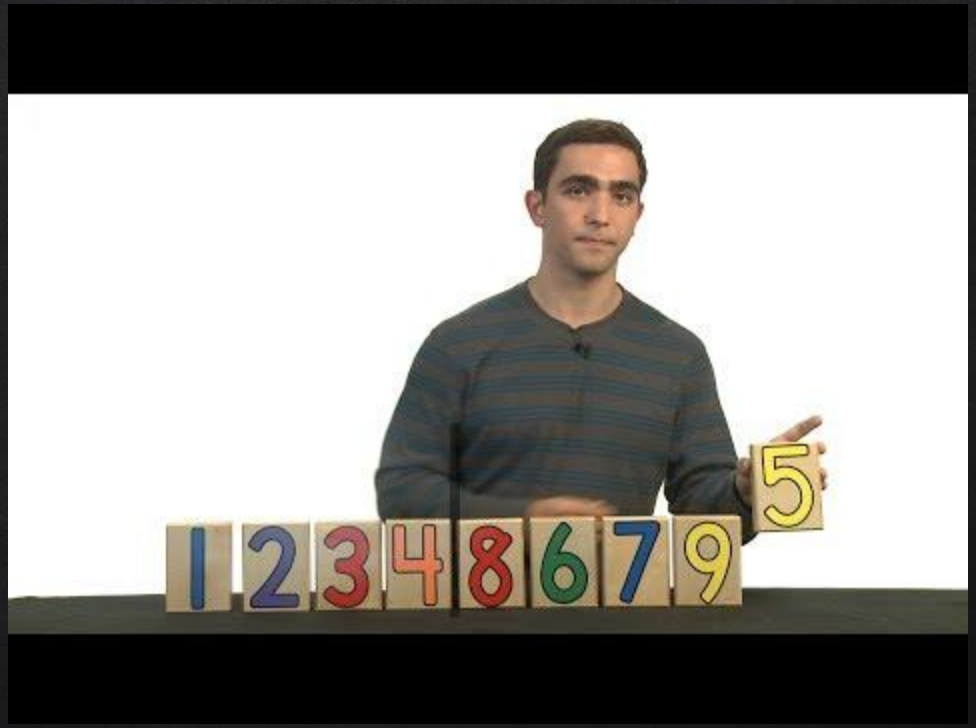
Merge Sort: exercise

12	25	36	42

11	24	37	41

11	12	24	25	36	37	41	42
(11, 12)	(12,24)	(24, 25)	(25, 37)	(36, 37)	(37,42)	(41,42)	–

Quicksort



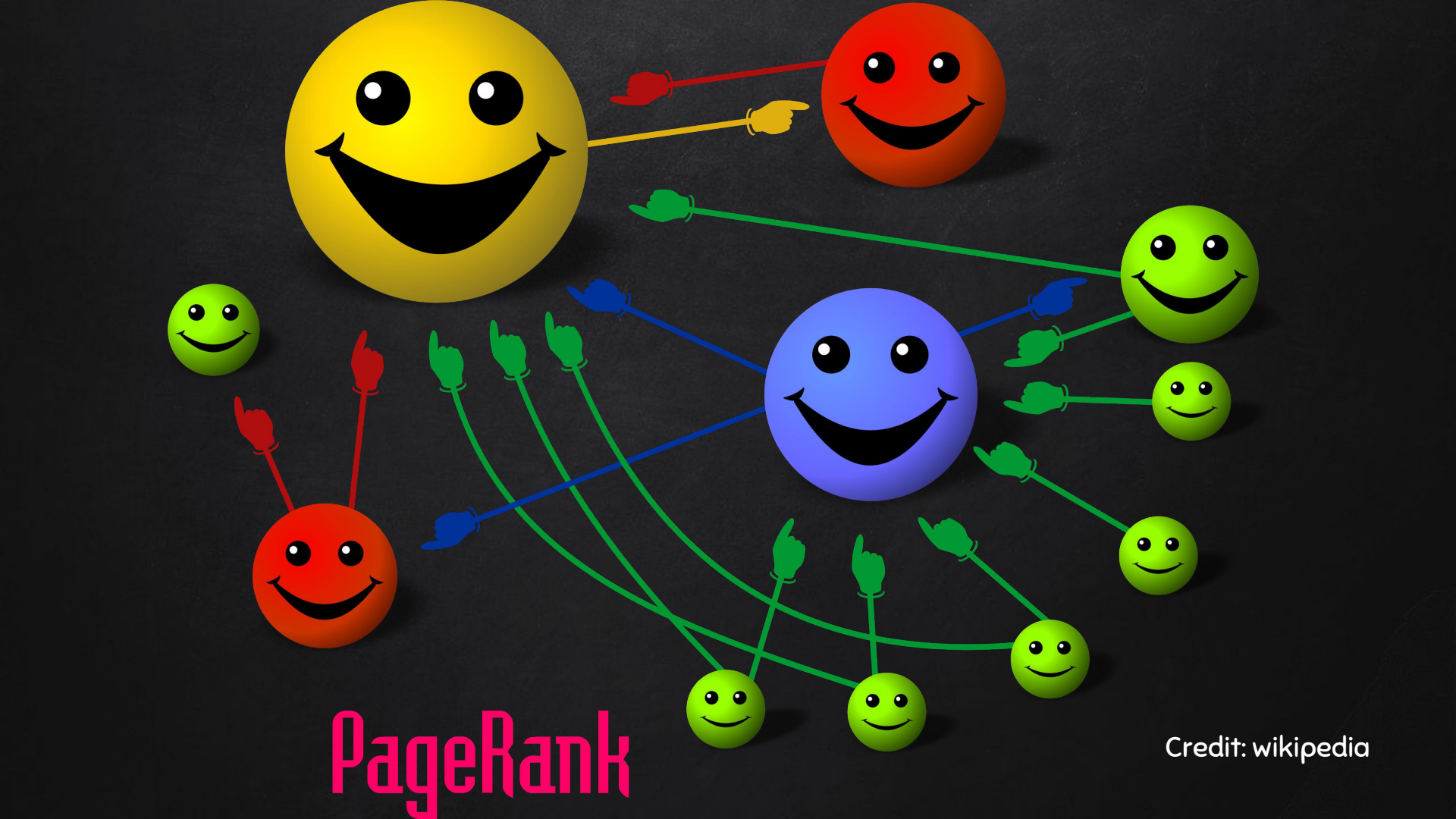
https://www.youtube.com/watch?v=aQiWF4E8flQ
http://me.dt.in.th/page/Quicksort/

Quicksort

1. partition the array into two parts around a pivot
2. quicksort those smaller arrays
3. concatenate the two sorted arrays end to end

PageRank
The Basics

Readings:
http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm
http://interestingwebs.blogspot.com/2009/05/simple-explain-of-google-pagerank.html
http://www.sirgroane.net/google-page-rank/



PageRank

Credit: wikipedia

What is PageRank?

- How Google determines a page's relevance or importance.
- "PageRank" or "PR": a term to indicate the popularity of a page.
- The PR is determined by the number of links from other pages on the World Wide Web that point to this page.
- PR is like a vote by other pages in terms of its importance
- More votes, more important
- PR of the voters are also important in the computation
- Higher PR of voter page means better PR for the voted page

PageRank in Google

- PR does not directly influence a web page's ranking in the search engine results.
- PR doesn't determine which webpages are included in the search results when a search term is entered
- The search results ranking is determined by the relevance of titles, keywords and phrases contained within those pages.
- When two web pages have the same relevance to a search term, PR will determine which page is displayed first in the search results.
- PR is very important for **search engine optimization** (SEO)

Check pagerank

Use a PR Checker
http://www.prchecker.info/check_page_rank.php

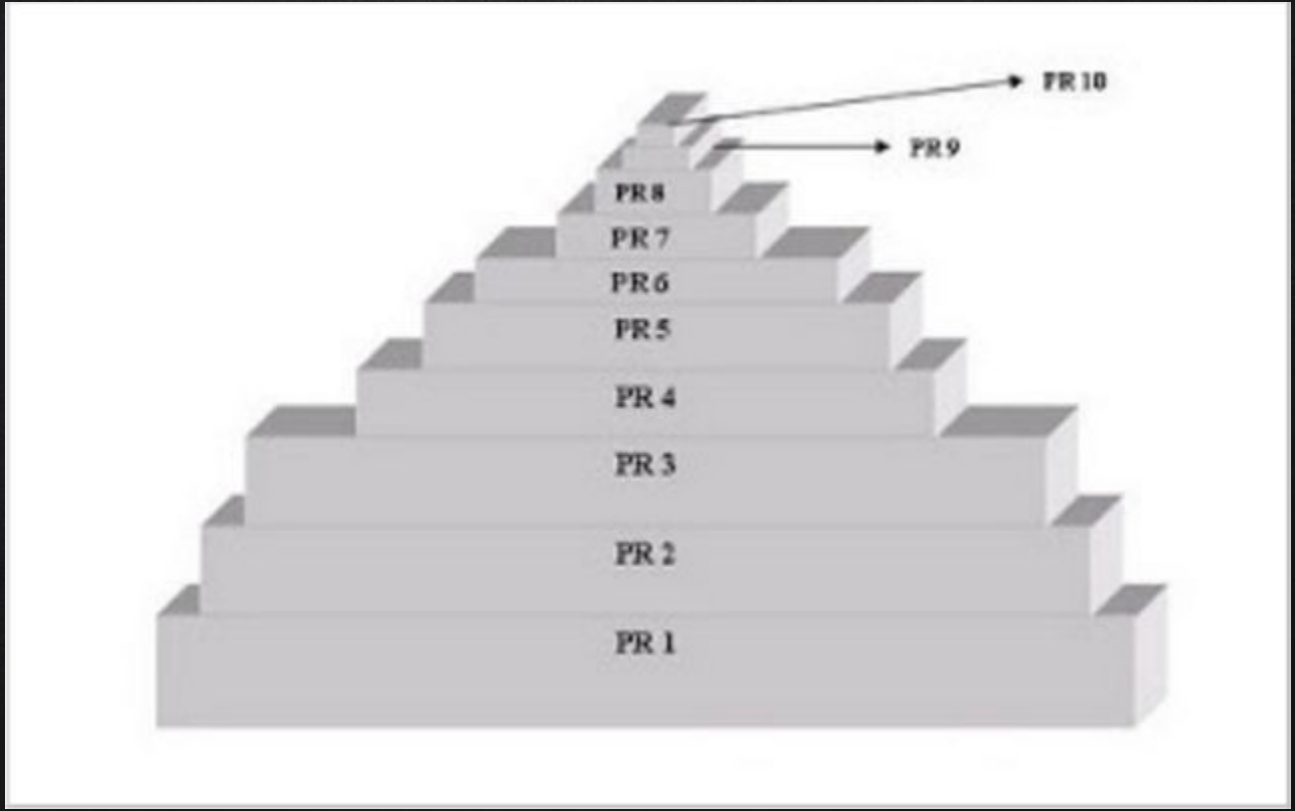
The Values of PageRank

- Each PR level (1 – 10) is progressively harder to reach.
- PR is believed to be calculated on a logarithmic scale.

Toolbar PageRank (log base 10)	Real PageRank
0	0 - 10
1	100 - 1,000
2	1,000 - 10,000
3	10,000 - 100,000
4	and so on...

Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Number of websites with different PR values



Credit: http://interestingwebs.blogspot.com/2009/05/simple-explain-of-google-pagerank.html

Classification based on PR

- 0 – 3: new webpages or those with very few back links
- 4 – 5: popular pages with a lot of back links from similar sites
- 6: exceptionally popular sites with hundreds of links from authority sites
- 7 – 10: usually media brands, big corporations, or government sites
- check out: cnn.com, whitehouse.gov, utah.edu

How PR is calculated?

- Backlink: a link pointing to a page
- PR of a page is roughly based on the quantity of backlinks and the RP of the pages providing the links (voter pages).
- Other factors: relevance of search words on the page, actual visits to the page also influence the PR.
- No specific details are known about these factors
- To prevent manipulation, spoofing and spamdexing

How PR is calculated?

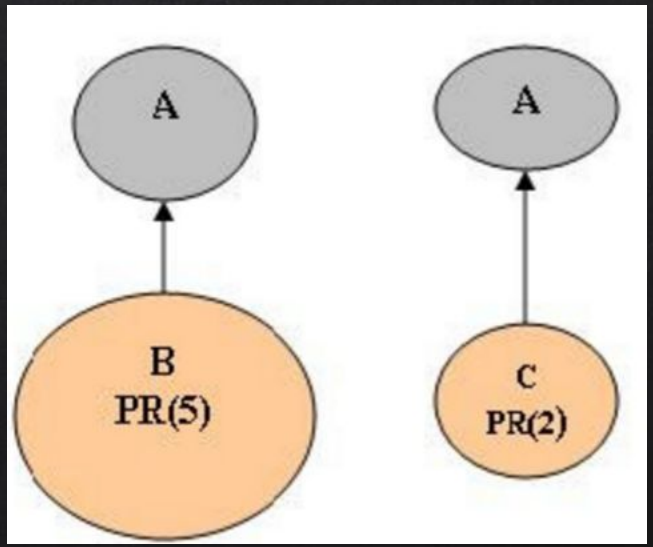
- Spoofing: falsifying the origin of an internet communication (emails, webpages) in order to mislead the recipient
- **Spamdexing** (search engine spam, search engine poisoning, Black-Hat SEO, search spam or web spam): deliberate manipulation of search engine indexes

Main Factors that Influences PR

- Number, relevance and quality of backlinks (incoming links)
  - The more backlinks the better
  - The more relevant and better quality of backlinks, the better

Main Factors that Influences PR

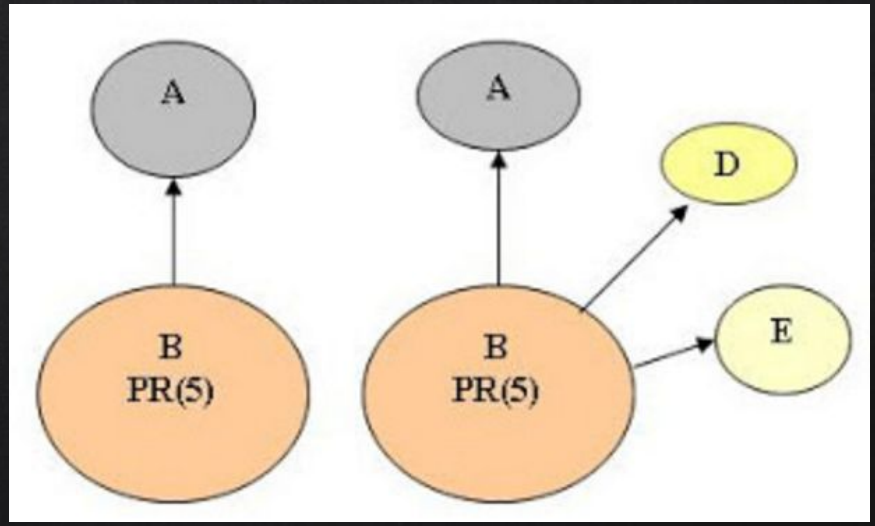
- PR of voter pages (where backlinks coming from)



Credit: http://interestingwebs.blogspot.com/2009/05/simple-explain-of-google-pagerank.html

Main Factors that Influences PR

- Outbound links of voter edges (more outbound links, worse the PR)



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Other Facts on PageRank (PR)

- Bad backlinks, content of webpage do not impact RP
- PR does not rank web sites as a whole, but is determined for each page individually
- PRs are computed permanently, update every few months
- Efficient internal onsite linking has an impact on PR
- No one knows for sure how PR is calculated now
- PR can decrease
- Site can be banned if it links to banned sites

PageRank Algorithm

Readings:
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm
http://interestingwebs.blogspot.com/2009/05/simple-explain-of-google-pagerank.html
http://www.sirgroane.net/google-page-rank/

PageRank or PR(A) can be calculated using a simple iterative algorithm, and corresponds to the principal eigenvector of the normalized link matrix of the web.

--- The original Google PageRank Paper

The Formula

$$PR(A) = (1-d) + d\,(PR(T1)/C(T1) + PR(T2)/C(T2) \ \ldots + PR(Tn)/C(Tn))$$

- PR(A) is the PageRank of page A
- PR(Ti) is the PageRank of pages Ti which link to page A
- C(Ti) is the number of outbound links on page Ti
- d is a damping factor which can be set between 0 and 1, treat it as probability math magic, e.g. 0.85
- PR(Ti)/C(Ti): share of vote from page Ti

Principle

PageRank can be calculated using a simple iterative algorithm and corresponds to the principal eigenvectors of the normalized link matrix of the web.

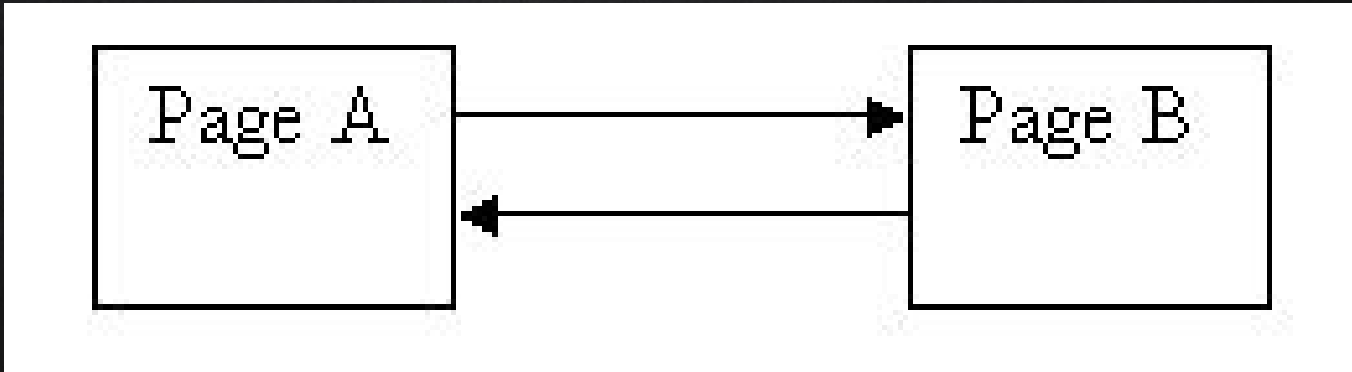
We can calculate a page's PR without knowing the final value of the PR of the other pages.

Each time we run the computation, we get one step closer to the final value.

A simple Example

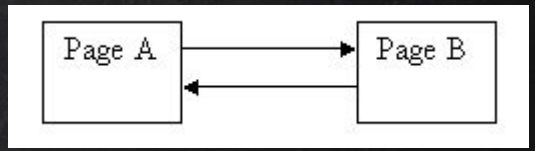
Guess the PR of the following 2 pages.

C(A) = 1, C(B) = 1 (# of outgoing links)



Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Guess 1



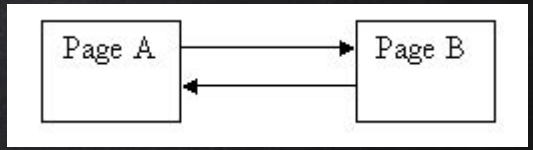
d = 0.85, guess PR(A) = 1, and PR(B) = 1

PR(A) = (1–d) + d(PR(B)/1) = 0.15 + 0.85 * 1 = 1
PR(B) = (1–d) + d(PR(A)/1) = 0.15 + 0.85 * 1 = 1

The guessed numbers did not change! We got away with a lucky guess!

Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Guess 2



d = 0.85, guess PR(B) = 0

Step 1:

PR(A) = (1–d) + d(PR(B)/1) = 0.15 + 0.85 * 0 = 0.15

PR(B) = (1–d) + d(PR(A)/1) = 0.15 + 0.85 * 0.15 = 0.2775 #Use new PR(A)

Step 2:

PR(A) = 0.15 + 0.85 * 0.2775 = 0.385875

PR(B) = 0.15 + 0.85 * 0.385875 = 0.47799375

Step 3:

PR(A) = 0.15 + 0.85 * 0.47799375 = 0.5562946875

PR(B) = 0.15 + 0.85 * 0.5562946875 = 0.622850484375

The values for PR(A) and PR(B) will converge to 1.

Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

PageRank Algorithm: Rough Idea

Start with some random guess, iteratively update the PR until convergence (things settle down).

PageRank Algorithm: Random Walk Version

PR assigns a value to each web page, denoting the "importance" of a page under two assumptions:

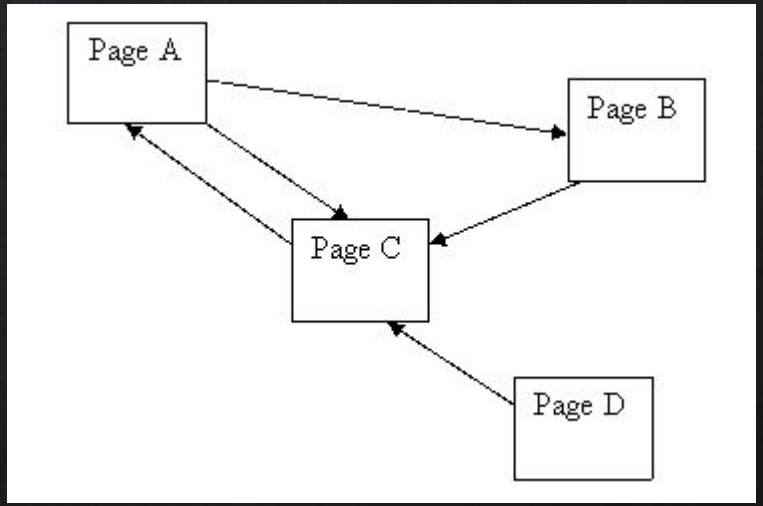
1. For some fixed probability a, a surfer at a web page jumps to a random web page with probability a and goes to a linked web page with probability 1 – a.
2. The importance of a web page v is the expected sum of the importance of all the web pages u that precede v.

MORE ON THIS LATER: Bonus Project

Principle

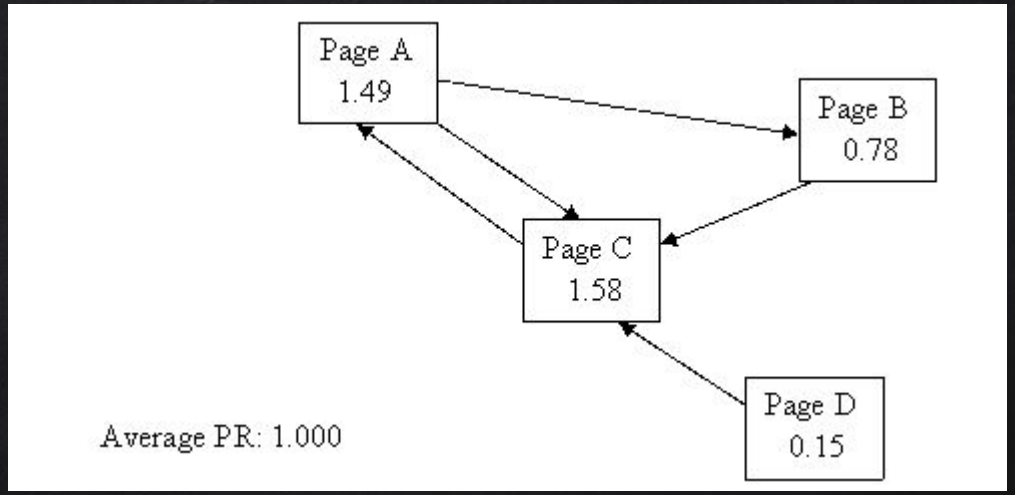
It does not matter where you start your guess, once the PR calculation settles down, the normalized probability distribution (the average PR for all pages) will be 1.0.

Example 2



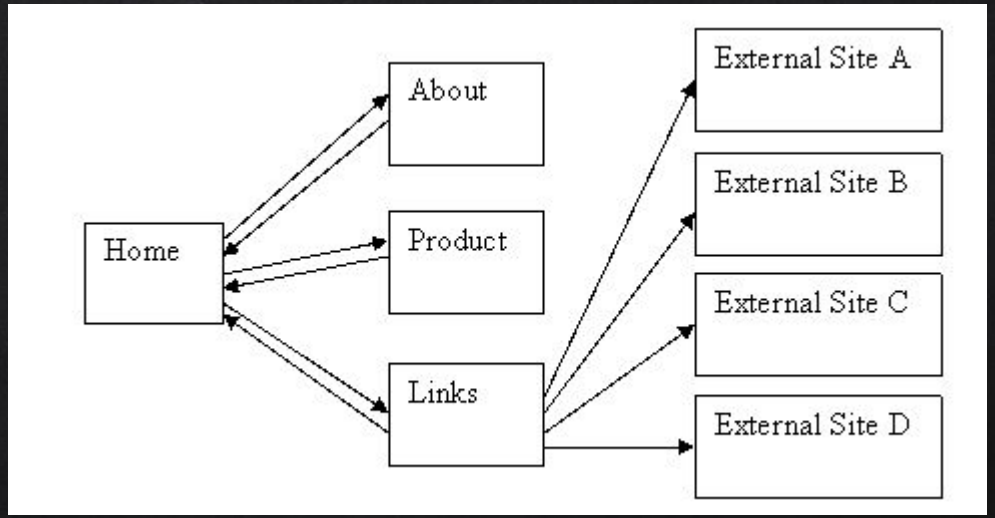
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 2



Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 3



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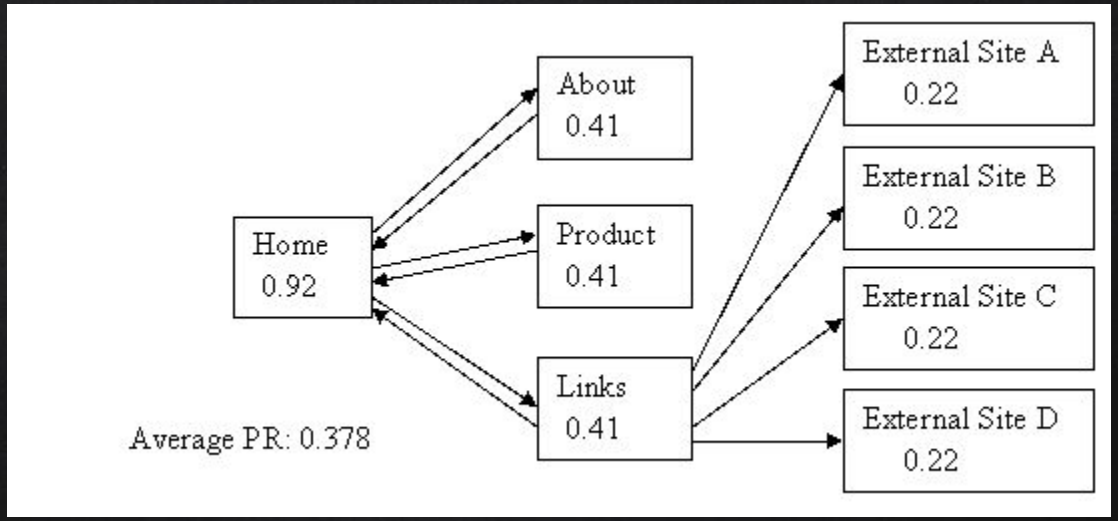
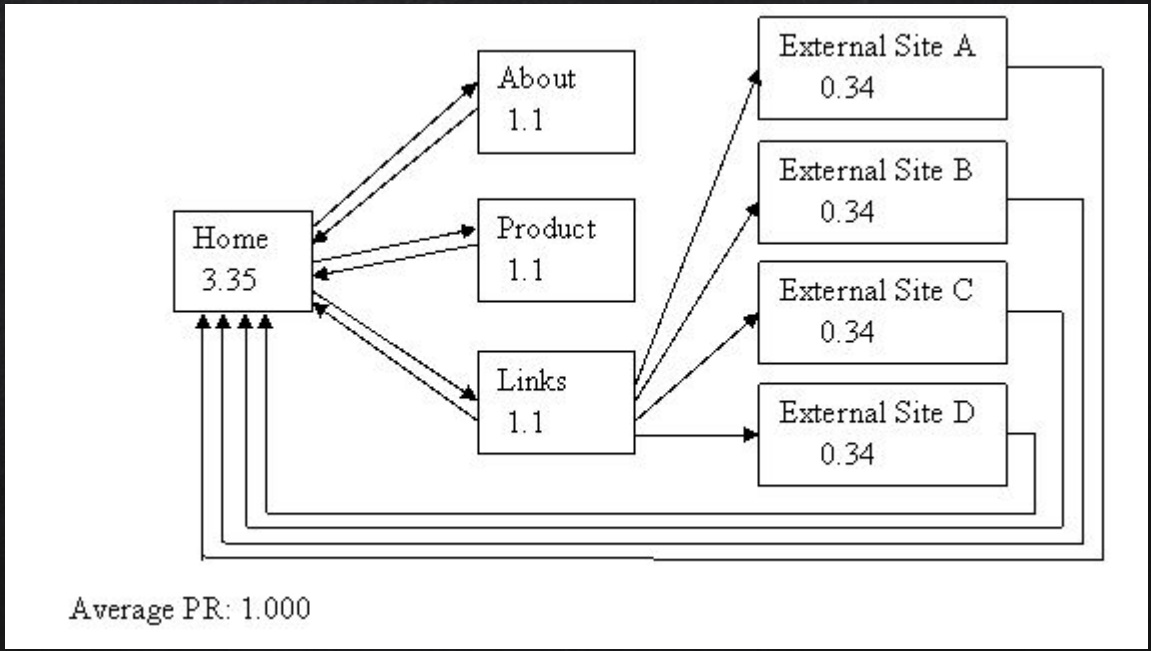
Example 3



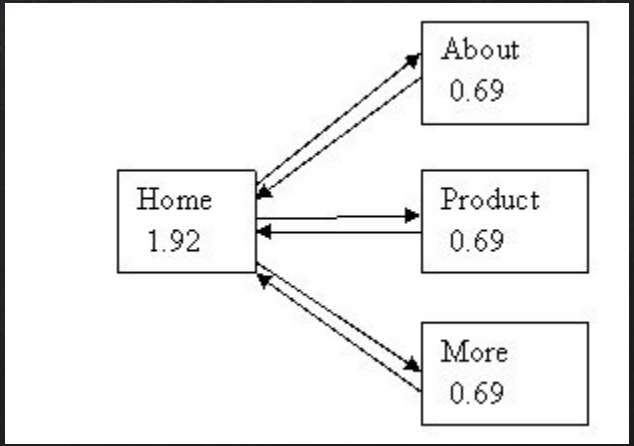
Note: external sites here wasted their PR by not voting for anyone else!
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 4



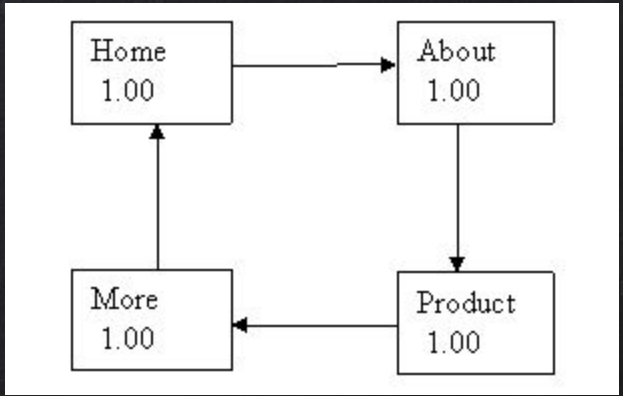
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 5



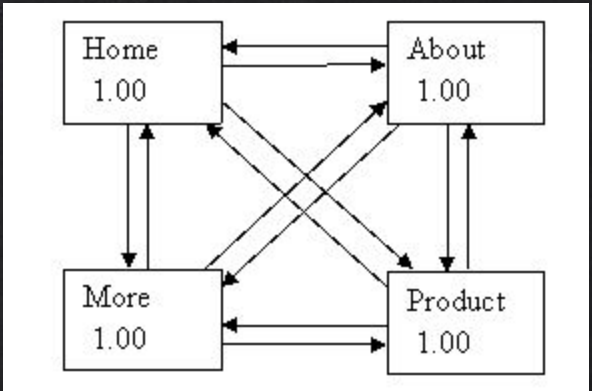
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 6: Loop



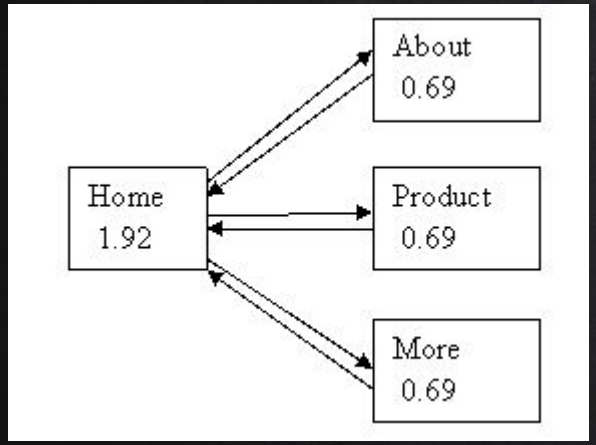
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

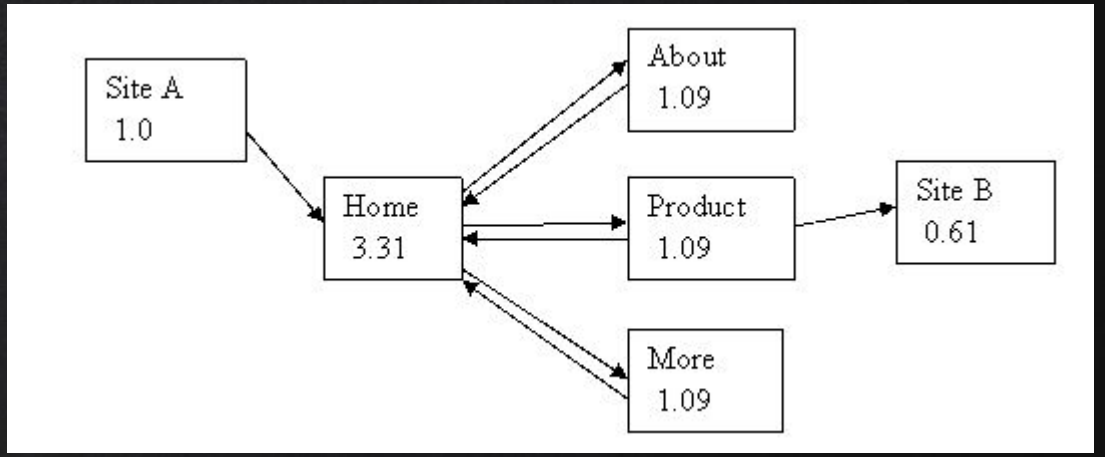
Example 7



Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

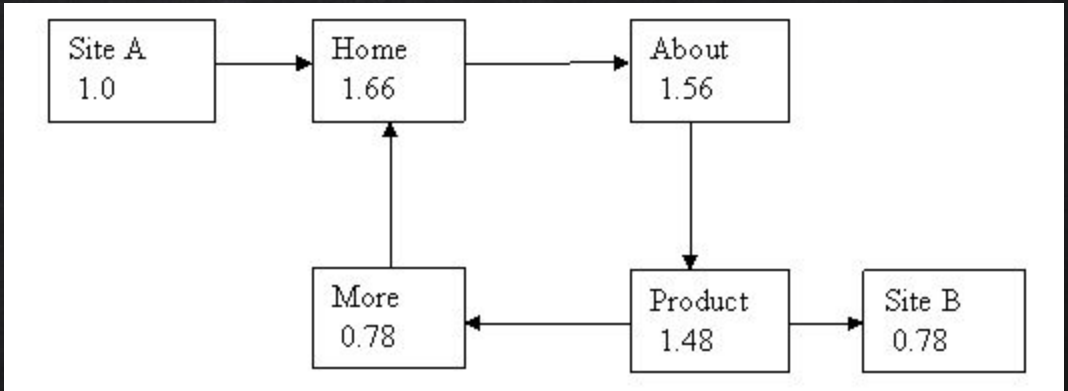
Example 8





Our HOME page PR has increased!
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 9



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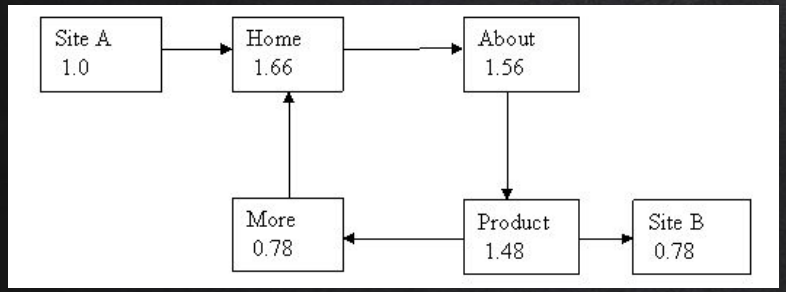
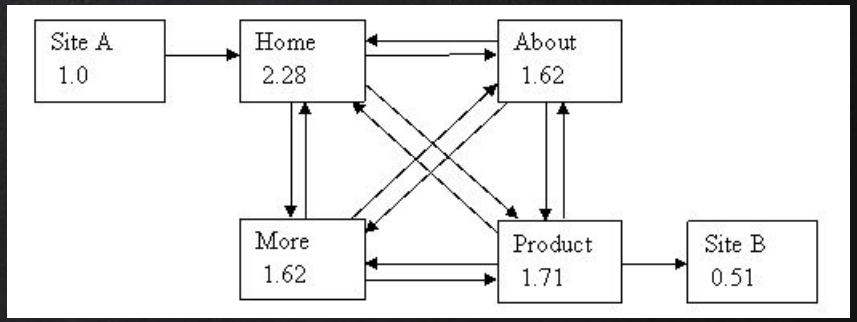
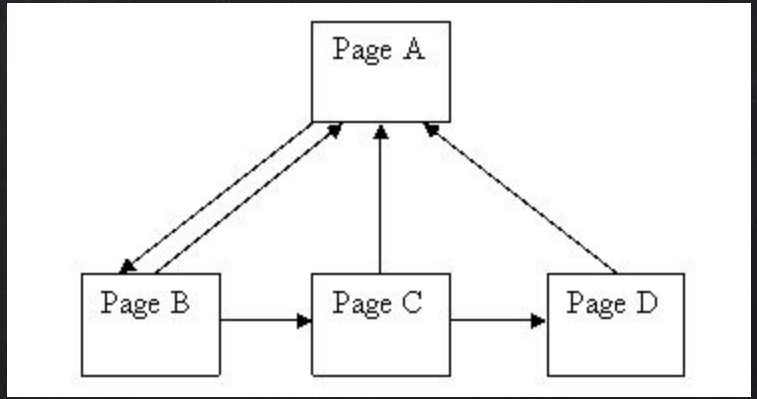




Increasing the internal links in your site can minimize the damage to your PR when you give away votes by linking to external site.

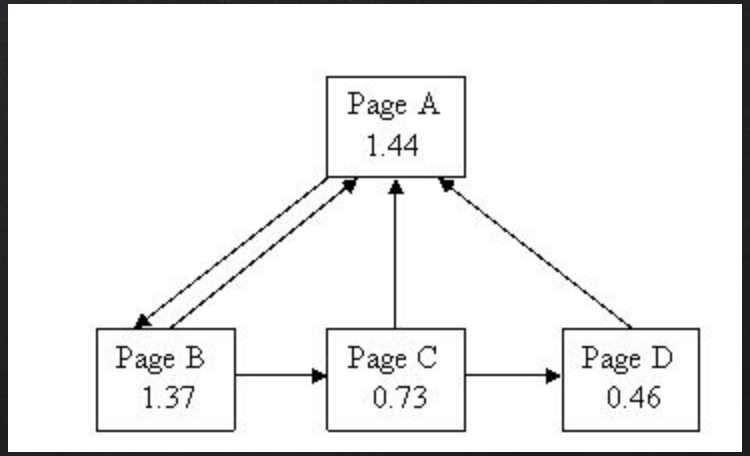
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 10: Site Map



Guess who has the highest PR?
Credit: http://www.cs.princeton.edu/~chazelle/courses/BIB/pagerank.htm

Example 10: Site Map



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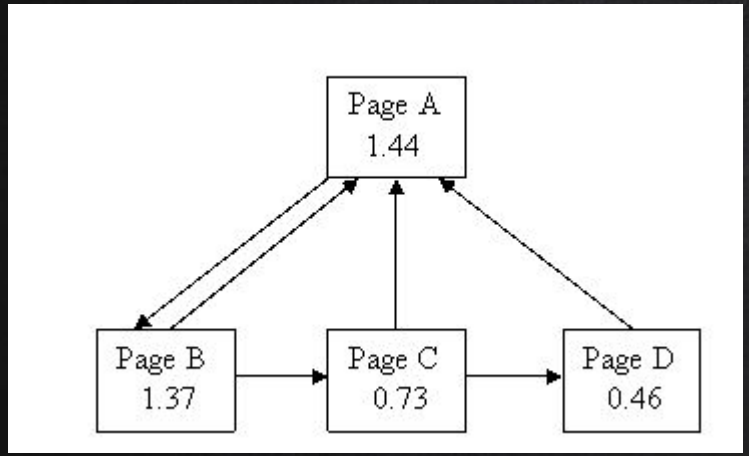

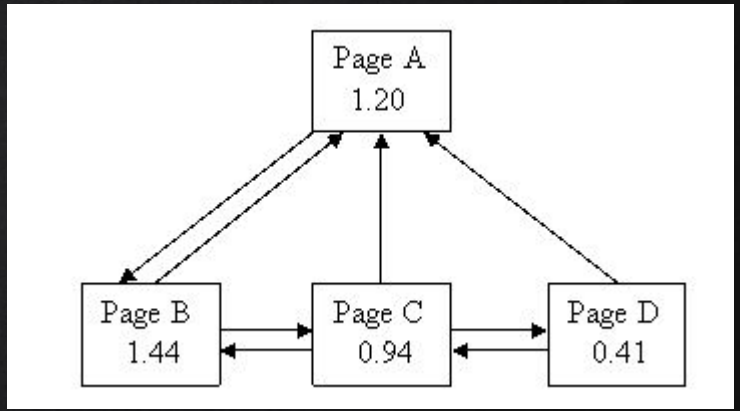

Guess who has the highest PR?
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More ideas on increasing PR

1. Be a Mega-Site: many pages with rich content and links back to the parent/home page, e.g. news.bbc.co.uk
2. Content is King!
3. Make it worthwhile for other pages to use your content/tools
4. Getting thousands of links from sites with small PR may worth more than 1 link from a single site with large PR

THANKS!

Any questions?

You can find me at
beiwang@sci.utah.edu

http://www.sci.utah.edu/~beiwang/teaching/cs1060.html

Credits

Special thanks to all the people who made and released these awesome resources for free:

- Presentation template by SlidesCarnival
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