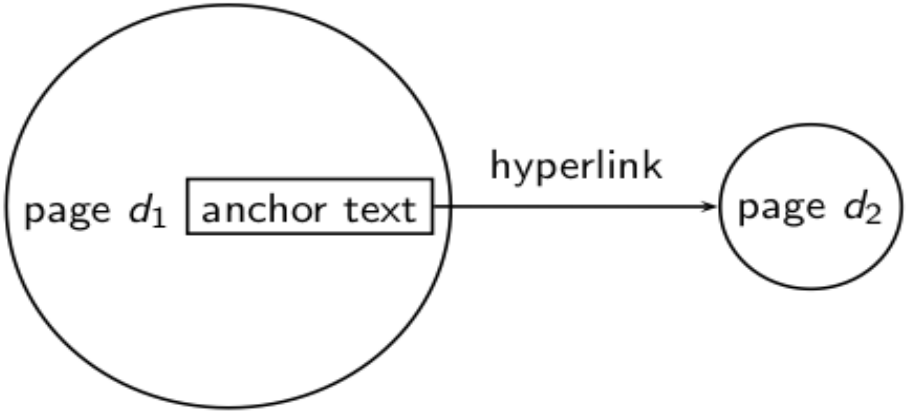
مبانی بازیابی اطلاعات و جستجوی وب

Link analysis -۱۳

The web as a directed graph

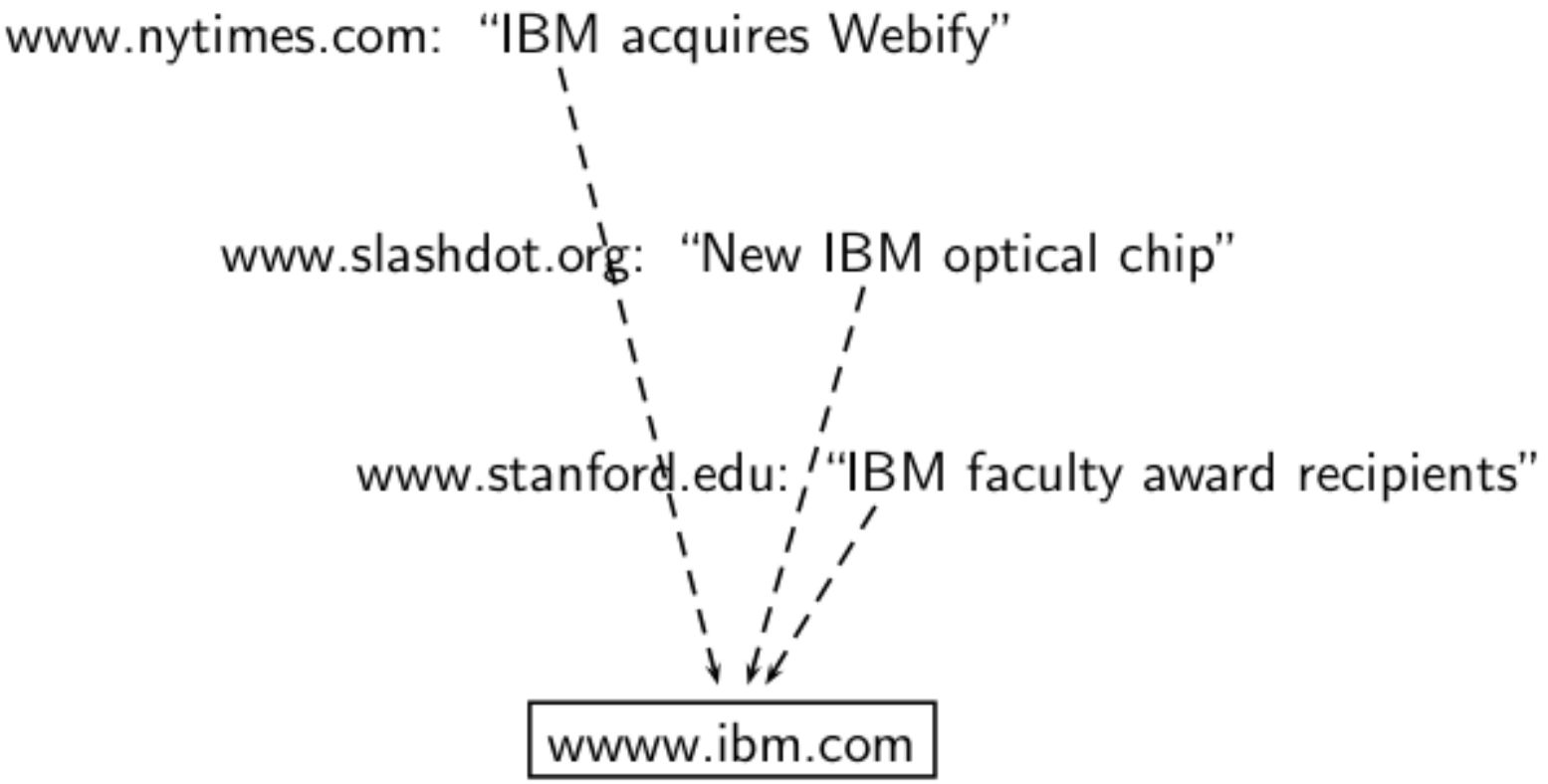


- Assumption 1: A hyperlink is a quality signal.
  - The hyperlink $d_1 \rightarrow d_2$ indicates that d_1's author deems d_2 high-quality and relevant.
- Assumption 2: The anchor text describes the content of d_2.
  - We use anchor text somewhat loosely here for: the text surrounding the hyperlink .
  - Example: "You can find cheap cars <a href =http://…>here . "
  - Anchor text: "You can find cheap here"

[text of d_2] only vs. [text of d_2] + [anchor text → d_2]

- Searching on [text of d_2] + [anchor text → d_2] is often more effective than searching on [text of d_2] only.
- Example: Query *IBM*
  - Matches IBM's copyright page
  - Matches many spam pages
  - Matches IBM wikipedia article
  - May not match IBM home page!
  - … if IBM home page is mostly graphics
- Searching on [anchor text → d_2] is better for the query *IBM*.

Anchor text containing *IBM* pointing to www.ibm.com



PageRank

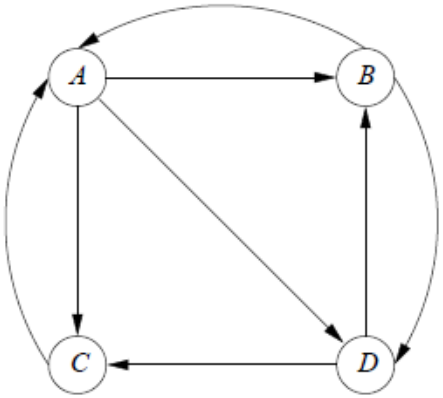
Model behind PageRank: Random walk

- Imagine a web surfer doing a random walk on the web
  - Start at a random page
  - At each step, go out of the current page along one of the links on that page, equiprobably
- In the steady state, each page has a long-term visit rate.
- This long-term visit rate is the page's PageRank.
- PageRank = long-term visit rate = steady state probability.
- The behavior of a random surfer indicates which pages users of the Web are likely to visit. Users are more likely to visit useful pages than useless pages.

Definition of PageRank

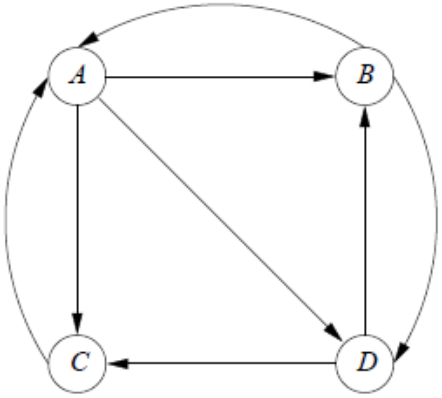
- PageRank is a function that assigns a real number to each page in the Web

- Think of the Web as a directed graph



ماتریس احتمال انتقال

- ماتریس M دارای ابعاد n*n است که n تعداد صفحات (نودهای گراف) است. عنصر mij در ردیف i و ستون j دارای مقدار 1/k است اگر صفحه j دارای k لینک خروجی باشد که یکی از آنها به صفحه i وارد میشود، در غیر اینصورت مقدار mij صفر است.



$$M = \begin{bmatrix} 0 & 1/2 & 1 & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$

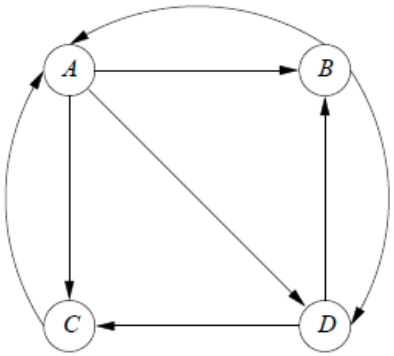
Definition of PageRank

- توزیع احتمال برای یک random surfer یک بردار ستونی است که jامین عنصر آن احتمال حضور surfer در صفحه j است .
- این احتمال همان تابع ایده آل page rank است.

- we start a random surfer at any of the n pages of the Web with equal probability. V_0 will have 1/n for each component.

- The distribution of the surfer
  - Mv_0 , after one step.
  - $M(Mv_0) = M^2v_0$, after two step.
  - multiplying the initial vector v_0 by M a total of i times will give us the distribution of the surfer after i steps

- Example:



$$M = \begin{bmatrix} 0 & 1/2 & 1 & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \\ 1/4 \end{bmatrix}, \begin{bmatrix} 9/24 \\ 5/24 \\ 5/24 \\ 5/24 \end{bmatrix}, \begin{bmatrix} 15/48 \\ 11/48 \\ 11/48 \\ 11/48 \end{bmatrix}, \begin{bmatrix} 11/32 \\ 7/32 \\ 7/32 \\ 7/32 \end{bmatrix}, \ldots, \begin{bmatrix} 3/9 \\ 2/9 \\ 2/9 \\ 2/9 \end{bmatrix}$$

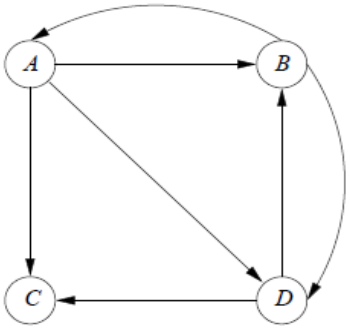
- PageRank is usually modified to prevent anomalies:

  1-**dead end**, a page that has no links out

  2-groups of pages that all have outlinks but they never link to any other pages. These structures are called **spider traps**

Dead Ends

- Example:



$$M = \begin{bmatrix} 0 & 1/2 & 0 & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$

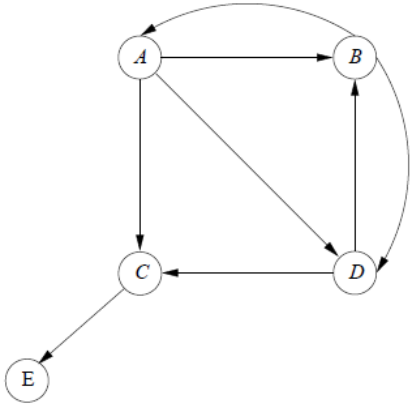
$$\begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \\ 1/4 \end{bmatrix}, \begin{bmatrix} 3/24 \\ 5/24 \\ 5/24 \\ 5/24 \end{bmatrix}, \begin{bmatrix} 5/48 \\ 7/48 \\ 7/48 \\ 7/48 \end{bmatrix}, \begin{bmatrix} 21/288 \\ 31/288 \\ 31/288 \\ 31/288 \end{bmatrix}, \ldots, \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

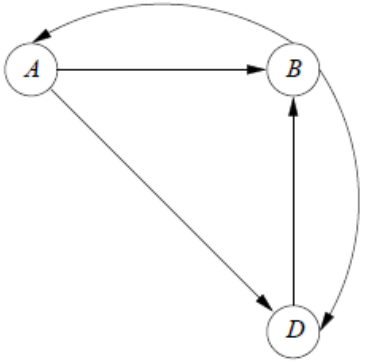
- There are two approaches to dealing with dead ends:

  1-We can drop the dead ends from the graph, and also drop their incoming arcs…..

  2-We can modify the process by which random surfers are assumed to move about the Web. This method, which we refer to as “taxation,” also solves the problem of spider traps

- مثال: مقابله با dead end با حذف نودهای dead end





$$M = \begin{bmatrix} 0 & 1/2 & 0 \\ 1/2 & 0 & 1 \\ 1/2 & 1/2 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1/3 \\ 1/3 \\ 1/3 \end{bmatrix}, \begin{bmatrix} 1/6 \\ 3/6 \\ 2/6 \end{bmatrix}, \begin{bmatrix} 3/12 \\ 5/12 \\ 4/12 \end{bmatrix}, \begin{bmatrix} 5/24 \\ 11/24 \\ 8/24 \end{bmatrix}, \ldots, \begin{bmatrix} 2/9 \\ 4/9 \\ 3/9 \end{bmatrix}$$

After adding C

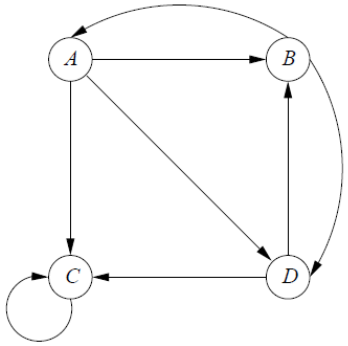
$$\frac{1}{3} \times \frac{2}{9} + \frac{1}{2} \times \frac{3}{9} = 13/54.$$

E=13/54

Spider Traps and Taxation

- A spider trap is a set of nodes with no dead ends but no arcs out.
- Example:

$$M = \begin{bmatrix} 0 & 1/2 & 0 & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 1 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$



$$\begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \\ 1/4 \end{bmatrix}, \begin{bmatrix} 3/24 \\ 5/24 \\ 11/24 \\ 5/24 \end{bmatrix}, \begin{bmatrix} 5/48 \\ 7/48 \\ 29/48 \\ 7/48 \end{bmatrix}, \begin{bmatrix} 21/288 \\ 31/288 \\ 205/288 \\ 31/288 \end{bmatrix}, \ldots, \begin{bmatrix} 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$$

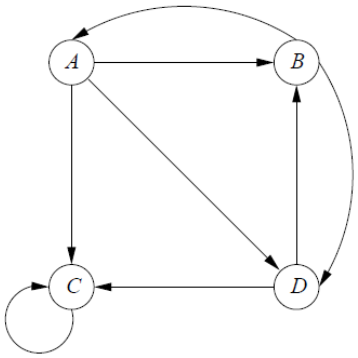
Spider Traps and Taxation

- we modify the calculation of PageRank by allowing each random surfer a small probability of teleporting to a random page, rather than following an out-link from their current page.

$$\mathbf{v}' = \beta M \mathbf{v} + (1 - \beta)\mathbf{e}/n$$

β is a chosen constant, usually in the range 0.8 to 0.9,
e is a vector of all 1's with n components,
n is the number of nodes in the Web graph.

- Example 5.6 $\beta = 0.8$



$$M = \begin{bmatrix} 0 & 1/2 & 0 & 0 \\ 1/3 & 0 & 0 & 1/2 \\ 1/3 & 0 & 1 & 1/2 \\ 1/3 & 1/2 & 0 & 0 \end{bmatrix}$$

$$\mathbf{v}' = \begin{bmatrix} 0 & 2/5 & 0 & 0 \\ 4/15 & 0 & 0 & 2/5 \\ 4/15 & 0 & 4/5 & 2/5 \\ 4/15 & 2/5 & 0 & 0 \end{bmatrix} \mathbf{v} + \begin{bmatrix} 1/20 \\ 1/20 \\ 1/20 \\ 1/20 \end{bmatrix}$$

$$\begin{bmatrix} 1/4 \\ 1/4 \\ 1/4 \\ 1/4 \end{bmatrix}, \begin{bmatrix} 9/60 \\ 13/60 \\ 25/60 \\ 13/60 \end{bmatrix}, \begin{bmatrix} 41/300 \\ 53/300 \\ 153/300 \\ 53/300 \end{bmatrix}, \begin{bmatrix} 543/4500 \\ 707/4500 \\ 2543/4500 \\ 707/4500 \end{bmatrix}, \ldots, \begin{bmatrix} 15/148 \\ 19/148 \\ 95/148 \\ 19/148 \end{bmatrix}$$

منابع

- فصل بیست و یکم کتاب An introduction to information retrieval