

CC5212-1

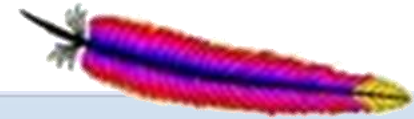
PROCESAMIENTO MASIVO DE DATOS
OTOÑO 2020

Lecture 8

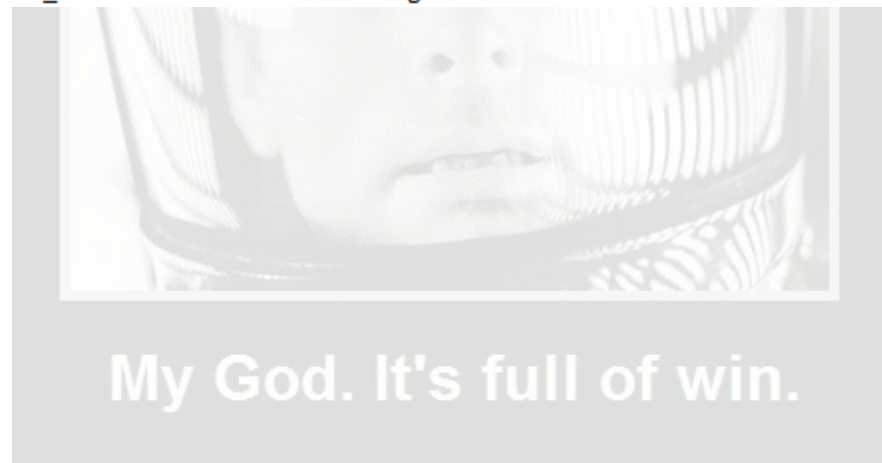
Information Retrieval: Ranking

Aidan Hogan
aidhog@gmail.com

Apache Lucene

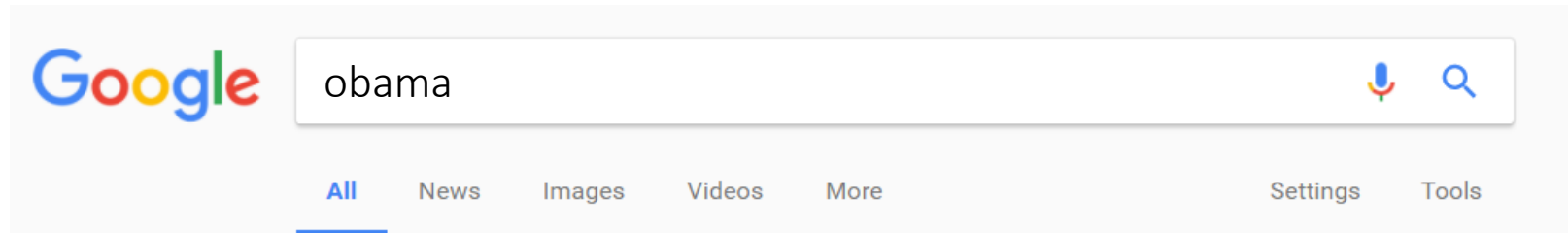


```
Tasks Console
SearchWikiIndex [Java Application] C:\Program Files\Java\jre1.8.0_65\bin\javaw.exe (03-05-2017 12:45:22 a. m.)
Opening directory at lucene
Enter a keyword search phrase:
obama
Running query: obama
Parsed query: TITLE:obam^5.0 ABSTRACT:obam
Matching documents: 255
Showing top 10 results
1 http://es.wikipedia.org/wiki/Obama_Republican Obama Republican
2 http://es.wikipedia.org/wiki/Obama_(Fukui) Obama (Fukui)
3 http://es.wikipedia.org/wiki/Republicanos_por_Obama Republicanos por Obama
4 http://es.wikipedia.org/wiki/Engonga_Obame Engonga Obame
5 http://es.wikipedia.org/wiki/Barack_Obama Barack Obama
6 http://es.wikipedia.org/wiki/Michelle_Obama Michelle Obama
7 http://es.wikipedia.org/wiki/Cartel_%22Hope%22_de_Obama Cartel "Hope" de Obama
8 http://es.wikipedia.org/wiki/Transición_presidencial_de_Barack_Obama Transición presidencial de Barack Obama
9 http://es.wikipedia.org/wiki/Por_qué_Obama_ganará_en_2008_y_en_2012 Por qué Obama ganará en 2008 y en 2012
10 http://es.wikipedia.org/wiki/Ricardo_Mangue_Obama_Nfubea Ricardo Mangue Obama Nfubea
```



INFORMATION RETRIEVAL: RANKING

How Does Google Get Such Good Results?



About 462,000,000 results (0.71 seconds)


Barack Obama (@BarackObama) · Twitter

<https://twitter.com/BarackObama> 

Well said, Jimmy. That's exactly why we fought so hard for the ACA, and why we need to protect it for kids like Billy. And congratulations! [twitter.com/jimmykimmel...](https://twitter.com/jimmykimmel)

11 hours ago · Twitter

The Office of Barack and Michelle Obama

<https://www.barackobama.com/> 

Welcome to the Office of Barack and Michelle **Obama**. We Love You Back. Play video. The Office of Barack and Michelle **Obama**. © 2017 | Legal & Privacy.

Barack Obama - Wikipedia

https://en.wikipedia.org/wiki/Barack_Obama 

Barack Hussein **Obama** II is an American politician who served as the 44th President of the United States from 2009 to 2017. He is the first African American to ...



How does Google Get Such Good Results?

Google that one movie where the guy breaks his leg and spies on his neighbor

Web Videos News Images Shopping More Search tools

About 64,700,000 results (0.91 seconds)

[Rear Window \(1954\) - IMDb](#)
www.imdb.com/title/tt0047396/ - Internet Movie Database
★★★★★ Rating: 8.6/10 - 274,497 votes

Google da da da dum symphony

Web Videos News Shopping Images More Search tools

About 107,000 results (0.36 seconds)



Beethoven - Symphony No. 5 in C Minor (1) - YouTube
www.youtube.com/watch?v=W2qW6fOtAMY



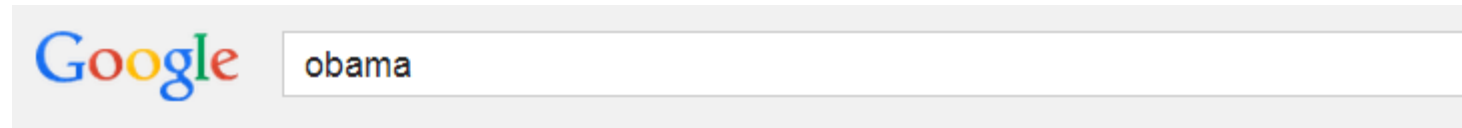
sometimes when i'm

- sometimes when i'm **alone i use comic sans**
- sometimes when i'm **alone i google myself**
- sometimes when i'm **alone i cry**
- sometimes when i'm **all alone**
- sometimes when i'm **dreaming**
- sometimes when i'm **sad i like to cut myself**
- sometimes when i'm **dreaming lyrics**
- sometimes when i'm **alone**
- sometimes when i'm **driving on the road at night**
- sometimes when i'm **alone i wonder**

Google Search I'm Feeling Lucky

TWO ASPECTS OF RANKING:
RELEVANCE VS. IMPORTANCE

Two Sides to Ranking: Relevance



Web Images News Videos More ▾ Search tools

About 16,700,000 results (0.23 seconds)

Broccoli - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Broccoli ▾

Broccoli is an edible green plant in the cabbage family, whose large flowering head is used as a vegetable. The word **broccoli** comes from the Italian plural of ...

[Cauliflower](#) - [Romanesco broccoli](#) - [Broccoli \(disambiguation\)](#) - [Broccolini](#)

Broccoli - The World's Healthiest Foods

www.whfoods.com/genpage.php?tname=foodspice&dbid=9 ▾

Broccoli can provide you with some special cholesterol-lowering benefits if you will cook it by steaming. The fiber-related components in **broccoli** do a better job ...

News for broccoli

Mistakes We All Make With Spaghetti, Steak And ...

Huffington Post - 2 days ago

But in her new book *Brassicas: Cooking the World's Healthiest Vegetables*, she says plunking **broccoli**, cauliflower or Brussels sprouts into ...



Two Sides to Ranking: Importance



Google

obama

Web Images News Videos More Search tools

About 48,100,000 results (0.26 seconds)

Mount Obama - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Mount_Obama

Mount Obama (known as **Boggy Peak** until August 4, 2009) is the highest point in the nation of Antigua and Barbuda and on the island of Antigua. It lies in the far ...

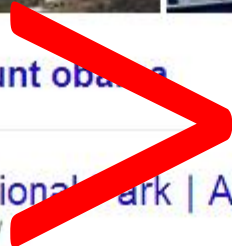
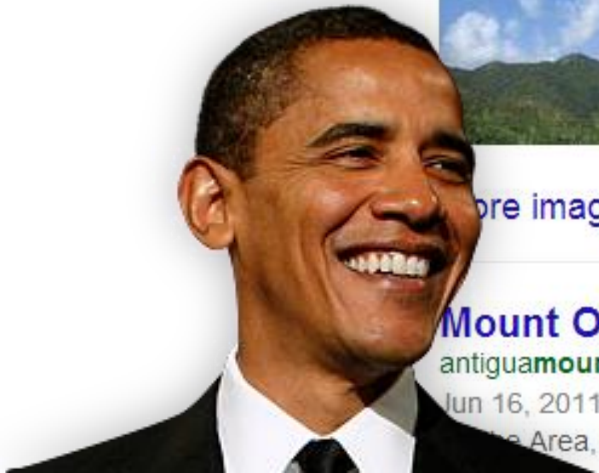
Images for mount obama Report images



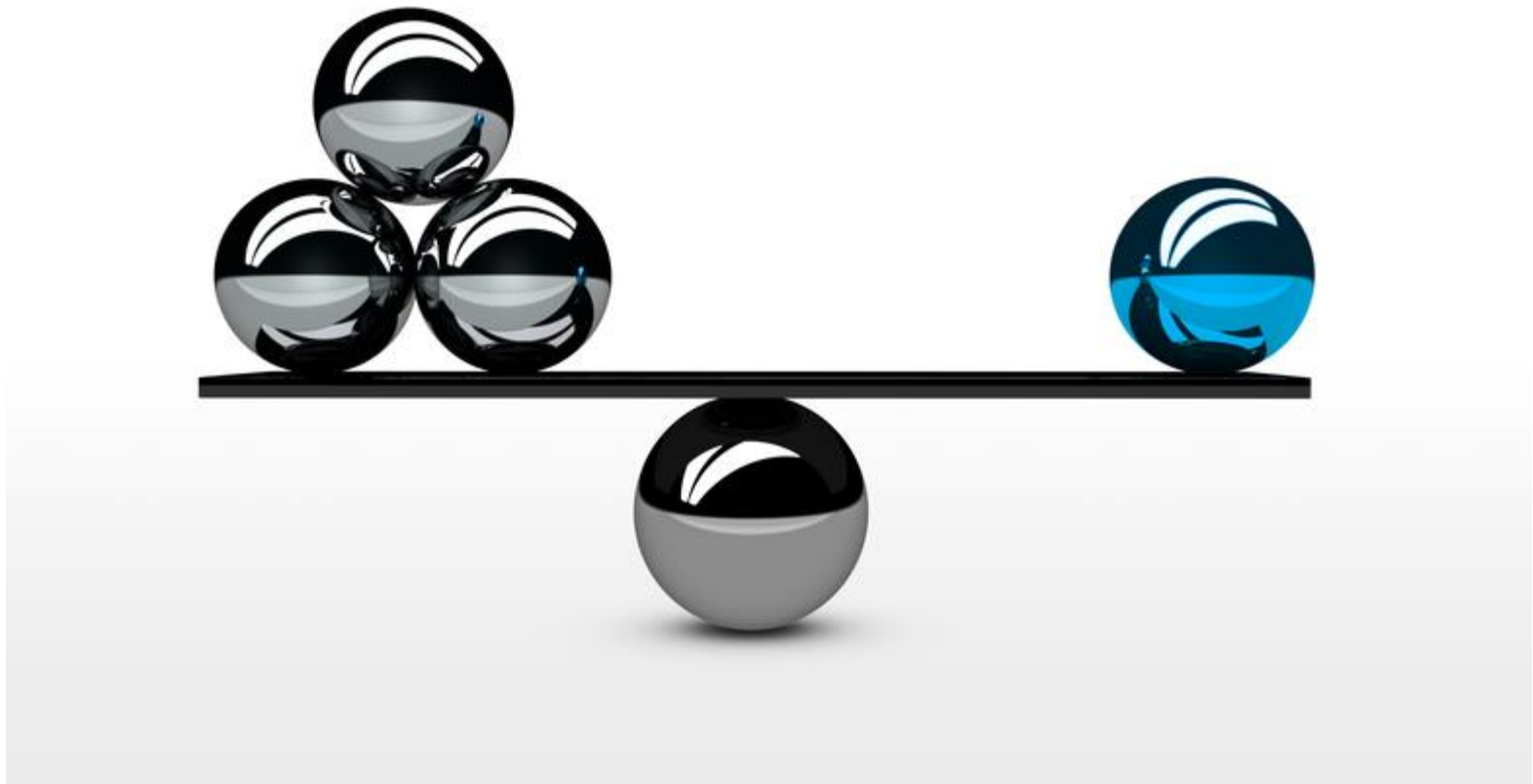
More images for mount obama

Mount Obama National Park | Antigua and Barbuda
antiguamountobama.com/

Jun 16, 2011 - As the **Mount Obama** Committee continues its work in the Mount Obama National Park Area, the committee organized a site visit to the O...



Relevance vs. Importance: A Balancing Act



RANKING:

RELEVANCE

Example Query

Which of these three keyword terms is most “important”?




Google

movie freedom wallace

Web Images News Videos More Search tools

About 4,290,000 results (0.29 seconds)

[Braveheart In Defiance Of The English Tyranny! BRAVO ...](#)

 www.youtube.com/watch?v=WLrrBs8JBQo
Feb 25, 2008 - Uploaded by popthetime
... actor starring as the "William **Wallace**" character in the **movie** - B...
... Braveheart **Freedom** Speech (HD) by ...

[Braveheart - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Braveheart
Braveheart is a 1995 epic historical drama war **film** directed by and starring Mel Gibson. Gibson portrays ... **Wallace** instead shouts the word "**Freedom!**" and the ...

[Braveheart \(1995\) - Quotes - IMDb](#)
www.imdb.com/title/tt0112573/quotes
... (1995) Quotes on IMDb: Memorable quotes and exchanges from **movies**, TV series and more... ... William **Wallace**: It's all for nothing if you don't have **freedom**.

Matches in a Document

The image shows a screenshot of a web browser displaying the Wikipedia page for 'Braveheart'. The browser's address bar shows the URL 'https://en.wikipedia.org/wiki/Braveheart'. The page title is 'Braveheart' and the subtitle is 'From Wikipedia, the free encyclopedia'. The main content area contains the following text:

For other uses, see [Braveheart \(disambiguation\)](#).

Braveheart is a 1995 American [epic war film](#) directed by and starring [Mel Gibson](#). Gibson portrays [William Wallace](#), a 13th-century Scottish warrior who led the Scots in the First War of Scottish Independence against King Edward I of England. The story is inspired by [Blind Harry's epic poem *The Actes and Deidis of the Illustre and Vallyeant Campioun Schir William Wallace*](#) and was adapted for the screen by [Randall Wallace](#).

The film was nominated for ten [Academy Awards](#) at the 68th Academy Awards and won five: [Best Picture](#), [Best Director](#), [Best Cinematography](#), [Best Makeup](#), and [Best Sound Editing](#).

On the right side of the page, there is a movie poster for 'Braveheart' featuring Mel Gibson. The poster includes the text 'MEL · GIBSON' at the top, the quote 'Every man dies, not every man really lives.' in the middle, and 'BRAVEHEART' at the bottom.

The search results for 'freedom' are highlighted in red. The search bar at the top right shows 'freedom' and '1 de 7'. A red box at the bottom left of the page contains the text 'freedom' and '• 7 occurrences'.

Matches in a Document

The image shows a screenshot of the Wikipedia page for 'Braveheart'. The browser address bar shows the URL 'https://en.wikipedia.org/wiki/Braveheart'. The page title is 'Braveheart' and the subtitle is 'From Wikipedia, the free encyclopedia'. The main text describes the 1995 American epic war film directed by and starring Mel Gibson. A search bar in the top right corner shows the search term 'movie' with 3 de 16 results. Two red boxes highlight search results for 'freedom' (7 occurrences) and 'movie' (16 occurrences). A movie poster for 'Braveheart' is also visible on the right side of the page.

W Braveheart - Wikipedia x

Es seguro | https://en.wikipedia.org/wiki/Braveheart

Not log movie 3 de 16

Article Talk Read Edit View history Search Wikipedia

Braveheart

From Wikipedia, the free encyclopedia

For other uses, see [Braveheart \(disambiguation\)](#).

Braveheart is a 1995 American [epic war film](#) directed by and starring [Mel Gibson](#). Gibson portrays [William Wallace](#), a 13th-century Scottish warrior who led the Scots in the First War of Scottish Independence against King Edward I of England. The story is inspired by [Blind Harry's epic poem *The Actes and Deidis of the Illustre and Vallyeant Campioun Schir William Wallace*](#) and was adapted for the screen by [Randall Wallace](#).

The film was nominated for ten [Academy Awards](#) at the 68th Academy Awards and won five: [Best Picture](#), [Best Director](#), [Best Cinematography](#), [Best Makeup](#), and [Best Sound Editing](#).

Contents [hide]

1 Plot

2 Cast

3 Production

Upload file

freedom

- 7 occurrences

movie

- 16 occurrences

Braveheart

MEL · GIBSON

Every man dies,
not every man
really lives.

Braveheart

Matches in a Document

The image shows a screenshot of a web browser displaying the Wikipedia page for 'Braveheart'. The browser's address bar shows the URL 'https://en.wikipedia.org/wiki/Braveheart'. The page title is 'Braveheart' and the subtitle is 'From Wikipedia, the free encyclopedia'. The main text of the article is visible, including the opening sentence: 'Braveheart is a 1995 American epic war film directed by and starring Mel Gibson. Gibson portrays William Wallace, a 13th-century Scottish warrior who led the Scots in the First War of Scottish Independence against King Edward I of England. The story is inspired by Blind Harry's epic poem *The Actes and Deidis of the Illustre and Vallyeant Campioun Schir William Wallace* and was adapted for the screen by Randall Wallace.' The text contains several instances of the word 'Wallace' highlighted in yellow. A search bar in the top right corner shows the search term 'wallace' and the result count '44 de 88'. Three colored boxes are overlaid on the page: a red box at the bottom left containing the word 'freedom' and '7 occurrences'; an orange box at the bottom center containing the word 'movie' and '16 occurrences'; and a green box at the bottom right containing the word 'wallace' and '88 occurrences'. The green box is positioned over a movie poster for 'Braveheart' featuring Mel Gibson.

W Braveheart - Wikipedia x

Es seguro | https://en.wikipedia.org/wiki/Braveheart

Not log wallace 44 de 88

Article Talk Read Edit View history Search Wikipedia

Braveheart

From Wikipedia, the free encyclopedia

For other uses, see [Braveheart \(disambiguation\)](#).

Braveheart is a 1995 American epic war film directed by and starring Mel Gibson. Gibson portrays William Wallace, a 13th-century Scottish warrior who led the Scots in the First War of Scottish Independence against King Edward I of England. The story is inspired by Blind Harry's epic poem *The Actes and Deidis of the Illustre and Vallyeant Campioun Schir William Wallace* and was adapted for the screen by Randall Wallace.

The film was nominated for ten Academy Awards at the 68th Academy Awards and won five: Best Picture, Best Director, Best Cinematography, Best Makeup, and Best Sound Editing.

Contents [hide]

1 Plot

2 Cast

3 Production

Upload file

freedom

- 7 occurrences

movie

- 16 occurrences

wallace

- 88 occurrences

Usefulness of Words

Google

movie freedom wallace

Google

movie

Web Images Videos News More Search tools

About 835,000,000 results (0.34 seconds)

movie

- occurs very frequently

Google

freedom

Web Images Videos Books More Search tools

About 198,000,000 results (0.32 seconds)

freedom

- occurs frequently

Google

wallace

Web Images Books News More Search tools

About 49,200,000 results (0.31 seconds)

wallace

- occurs occasionally

Estimating Relevance

- Rare words more important than common words
 - **wallace** (49M) more important than **freedom** (198M)
more important than **movie** (835M)
- Words occurring more frequently in a document indicate higher relevance
 - **wallace** (88) more matches than **movie** (16) more matches than **freedom** (7)

Relevance Measure: TF-IDF

- TF: Term Frequency

- Measures occurrences of a term in a document

- $tf(t, d)$... various options

- Raw count of occurrences

$$tf(t, d) = \text{count}(t, d)$$

- Logarithmically scaled

$$tf(t, d) = \log(\text{count}(t, d) + 1)$$

- Normalised by document length

$$tf(t, d) = \frac{\text{count}(t, d)}{\sum_{t' \in d} \text{count}(t', d)}$$

$$tf(t, d) = \frac{\text{count}(t, d)}{\max_{t' \in d} \text{count}(t', d)}$$

- A combination / something else 😊

Relevance Measure: TF-IDF

- **IDF: Inverse Document Frequency**
 - How common a term is across **all** documents
 - $\text{idf}(t, D)$...
 - Logarithmically scaled document occurrences

$$\text{idf}(t, D) = \log\left(\frac{|D|+1}{|\{d \in D : t \in d\}|+1}\right)$$

- Note: The more rare, the larger the value

Relevance Measure: TF-IDF

- **TF-IDF**: Combine Term Frequency and Inverse Document Frequency:

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

- Score for a query
 - Let query $q = (t_1, \dots, t_n)$
 - Score for a query: $\text{score}(q, d) = \sum_{t \in q} \text{tf-idf}(t, d)$(There are other possibilities)

Relevance Measure: TF-IDF



Term Frequency

$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|+1}{|\{d \in D : t \in d\}|+1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$
movie	16
freedom	7
wallace	43

Relevance Measure: TF-IDF



Term Frequency

$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$	$ \{d \in D : t \in d\} $
movie	16	835,000,000
freedom	7	198,000,000
wallace	43	49,200,000

Relevance Measure: TF-IDF



Term Frequency

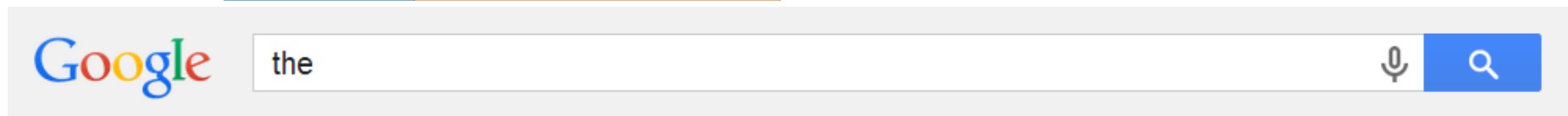
$$tf(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$idf(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$tf-idf(t, d) = tf(t, d) \times idf(t, D)$$

t	$tf(t, d)$	$ \{d \in D : t \in d\} $	$\frac{ D +1}{ \{d \in D : t \in d\} +1}$
movie	16	835,000,000	
freedom	7	198,000,000	
wallace	43	49,200,000	



About 11,410,000,000 results (0.27 seconds)

$$|D| = 11,410,000,000$$

Relevance Measure: TF-IDF



Term Frequency

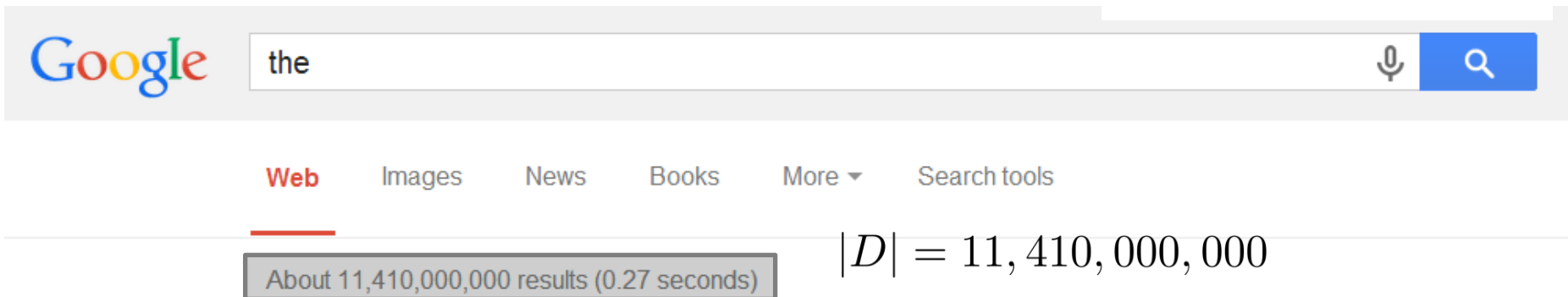
$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$	$ \{d \in D : t \in d\} $	$\frac{ D +1}{ \{d \in D : t \in d\} +1}$
movie	16	835,000,000	13.66
freedom	7	198,000,000	57.63
wallace	43	49,200,000	231.91



Relevance Measure: TF-IDF



Term Frequency

$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$	$ \{d \in D : t \in d\} $	$\frac{ D +1}{ \{d \in D : t \in d\} +1}$	$\text{idf}(t, d)$
movie	16	835,000,000	13.66	3.77
freedom	7	198,000,000	57.63	5.85
wallace	43	49,200,000	231.91	7.86

Relevance Measure: TF-IDF



Term Frequency

$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$	$ \{d \in D : t \in d\} $	$\frac{ D +1}{ \{d \in D : t \in d\} +1}$	$\text{idf}(t, d)$	$\text{tf-idf}(t, d)$
movie	16	835,000,000	13.66	3.77	60.36
freedom	7	198,000,000	57.63	5.85	40.94
wallace	43	49,200,000	231.91	7.86	337.87

Relevance Measure: TF-IDF



Term Frequency

$$\text{tf}(t, d) = \text{count}(t, d)$$

Inverse Document Frequency

$$\text{idf}(t, D) = \log_2 \left(\frac{|D|}{|\{d \in D : t \in d\}| + 1} \right)$$

$$\text{tf-idf}(t, d) = \text{tf}(t, d) \times \text{idf}(t, D)$$

t	$\text{tf}(t, d)$	$ \{d \in D : t \in d\} $	$\frac{ D +1}{ \{d \in D : t \in d\} +1}$	$\text{idf}(t, d)$	$\text{tf-idf}(t, d)$
movie	16	835,000,000	13.66	3.77	60.36
freedom	7	198,000,000	57.63	5.85	40.94
wallace	43	49,200,000	231.91	7.86	337.87

$$\text{score}(q, d) = \sum_{t \in q} \text{tf-idf}(t, d)$$

$$\text{score}((\text{movie, freedom, wallace}), \text{http://en.wikipedia.org/Braveheart}) \approx 439.17$$

Two Sides to Ranking: Relevance



A screenshot of a Google search interface. The search bar contains the text "obama". Below the search bar, there are tabs for "Web", "Images", "News", "Videos", "More", and "Search tools". The "Web" tab is selected. Below the tabs, it says "About 16,700,000 results (0.23 seconds)". The search results are as follows:

- Broccoli - Wikipedia, the free encyclopedia**
en.wikipedia.org/wiki/Broccoli
Broccoli is an edible green plant in the cabbage family, whose large flowering head is used as a vegetable. The word **broccoli** comes from the Italian plural of ...
Cauliflower - Romanesco broccoli - Broccoli (disambiguation) - Brocolini
- Broccoli - The World's Healthiest Foods**
www.whfoods.com/genpage.php?tname=foodspice&dbid=9
Broccoli can provide you with some special cholesterol-lowering benefits if you will cook it by steaming. The fiber-related components in **broccoli** do a better job ...
- News for broccoli**
- Mistakes We All Make With Spaghetti, Steak And E**
Huffington Post - 2 days ago
But in her new book Brassicas: Cooking the World's Healthiest Vegetables, she says plunking **broccoli**, cauliflower or Brussels sprouts into ...

In the bottom left corner, there is a photograph of Barack Obama smiling. In the bottom right corner, there is a photograph of a head of broccoli. A large red "not equal" symbol (\neq) is overlaid on the search results, positioned between the "News for broccoli" section and the "Mistakes We All Make With Spaghetti, Steak And E" section.

Field-Based Boosting

- Not all text is equal: titles, headers, etc.

```
<!DOCTYPE html>
<html lang="en" dir="ltr" class="client-nojs">
<head>
<meta charset="UTF-8" />
<title>Barack Obama - Wikipedia, the free encyclopedia</title>
```



The screenshot displays the Wikipedia article for Barack Obama. At the top, the HTML source code is visible, with the title tag `<title>Barack Obama - Wikipedia, the free encyclopedia</title>` highlighted in blue. Below the code, the article's main content is shown. The title "Barack Obama" is prominently displayed in a large, bold font, with the text "From Wikipedia, the free encyclopedia" underneath it. The title "Barack Obama" is highlighted with an orange border. To the right of the title, there are icons for a lock, a speaker, and a star. Below the title, a red text box contains the message: "Obama" redirects here. For other uses, see Obama (disambiguation). Below this, a blue text box contains the message: This article is about the 44th president of the United States. For his father, see Barack Obama, Sr. The main body of the article begins with the text: Barack Hussein Obama II (IPA: /bəˈrɑːk huːˈseɪn ouˈbɑːmə/; born August 4, 1961) is the 44th and current President of the United States, and the first African American to hold the office. Born in Honolulu, Hawaii, Obama is a graduate of Columbia University and Harvard Law School, where he served as president of the Harvard Law Review. He was a community organizer in Chicago before earning his law degree. He worked as a civil rights attorney and taught constitutional law at the University of Chicago Law School. On the left side of the page, there is a sidebar with the Wikipedia logo and various navigation links. On the right side, there is a search bar and a "Create account" / "Log in" link.

Anchor Text

- See how the Web views/tags a page

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html>
<head>
  <title>What I watched last night ...</title>
</head>
<body>
<p>Last night I was pretty bored so I made some popcorn and watched
<a href="http://en.wikipedia.org/Braveheart">a movie about William Wallace called Braveheart</a>.
Set in Scotland it has lots of blood and gore.
</p>
</body>
</html>
```

Anchor Text

- See how the Web views/tags a page

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
"http://www.w3.org/TR/
<html>
<head>
  <title>What I watched
</head>
<body>
<p>Last night I was pret
<a href="http://en.wiki
Set in Scotland it has
</p>
</body>
</html>
```

Google da da da dum symphony

Web Videos News Shopping Images More Search tools

About 107,000 results (0.36 seconds)



Beethoven - Symphony No. 5 in C Minor (1) - YouTube
www.youtube.com/watch?v=W2qW6fOtAMY

Lucene uses relevance scoring



```
Tasks Console
SearchWikiIndex [Java Application] C:\Program Files\Java\jre1.8.0_65\bin\javaw.exe (03-05-2017 12:45:22 a. m.)
Opening directory at lucene
Enter a keyword search phrase:
obama
Running query: obama
Parsed query: TITLE:obam^5.0 ABSTRACT:obam
Matching documents: 255
Showing top 10 results
1 http://es.wikipedia.org/wiki/Obama_Republican Obama Republican
2 http://es.wikipedia.org/wiki/Obama_(Fukui) Obama (Fukui)
3 http://es.wikipedia.org/wiki/Republicanos_por_Obama Republicanos por Obama
4 http://es.wikipedia.org/wiki/Engonga_Obame Engonga Obame
5 http://es.wikipedia.org/wiki/Barack_Obama Barack Obama
6 http://es.wikipedia.org/wiki/Michelle_Obama Michelle Obama
7 http://es.wikipedia.org/wiki/Cartel_%22Hope%22_de_Obama Cartel "Hope" de Obama
8 http://es.wikipedia.org/wiki/Transici3n_presidencial_de_Barack_Obama Transici3n presidencial de Barack Obama
9 http://es.wikipedia.org/wiki/Por_qu3_Obama_ganar3_en_2008_y_en_2012 Por qu3 Obama ganar3 en 2008 y en 2012
10 http://es.wikipedia.org/wiki/Ricardo_Mangue_Obama_Nfubea Ricardo Mangue Obama Nfubea
```

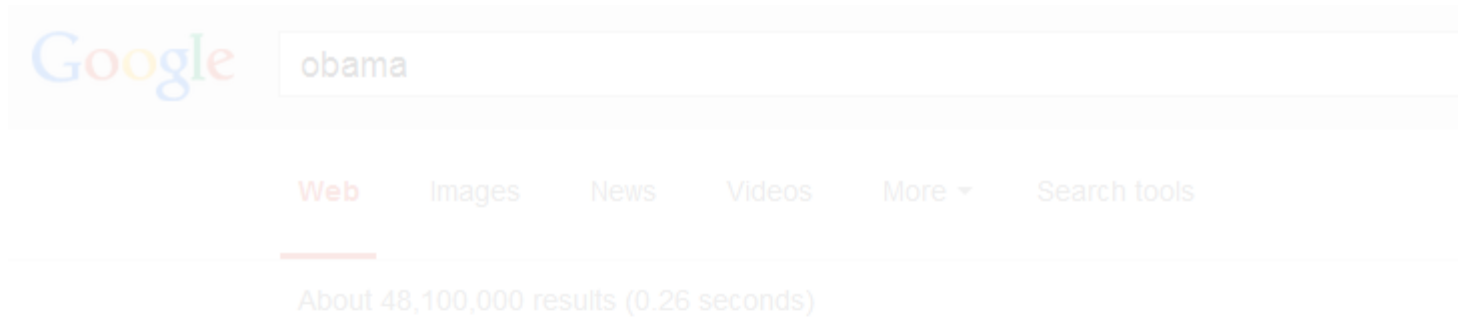


... and Elasticsearch uses Lucene

RANKING:

IMPORTANCE

Two Sides to Ranking: Importance

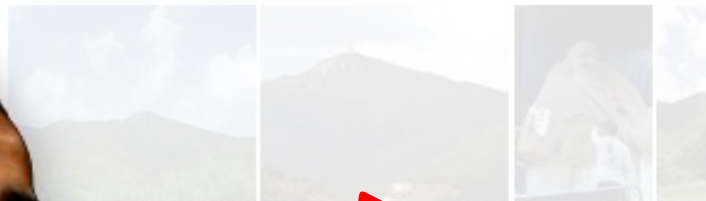


How could we determine that Barack Obama is more important than Mount Obama as a search result for "obama" on the Web?



Images for mount obama

Report images

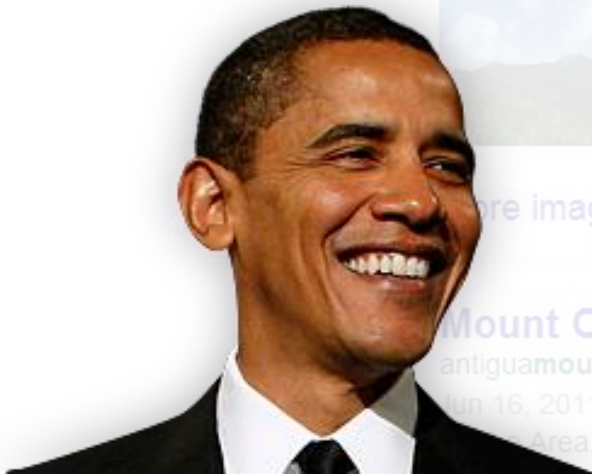
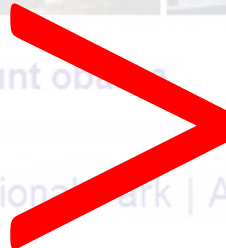


More images for mount obama

Mount Obama National Park | Antigua a
antiguamountobama.com/

Jun 16, 2011 - As the Mount Obama Committee continu

Area, the committee organized a site visit to the C



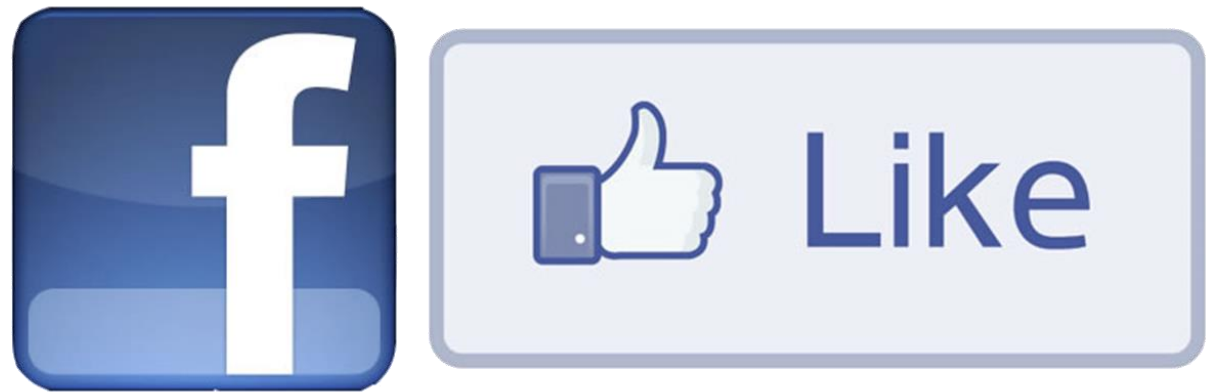
Link Analysis

Which will have more links from other pages?
The Wikipedia article for Mount Obama?
The Wikipedia article for Barack Obama?



Link Analysis

- Consider links as votes of confidence in a page
- A hyperlink is the open Web's version of ...



(... even if the page is linked in a negative way.)

Link Analysis

So if we just count links to a page we can determine its importance and we are done?



Link Spamming



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[deleted] Kala Jadu Specialist +91961



black magic specialist baba ji call now +919610897260



<http://www.blackmagicspecialist.net.in>



java

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Link Importance

So which should count for more?

A link from http://en.wikipedia.org/wiki/Barack_Obama?

Or a link from <http://blackmagicspecialist.net.in>?



PageRank



PageRank: Central Assumption

A page with **lots** of inlinks **from important pages** with **few outlinks** is more important

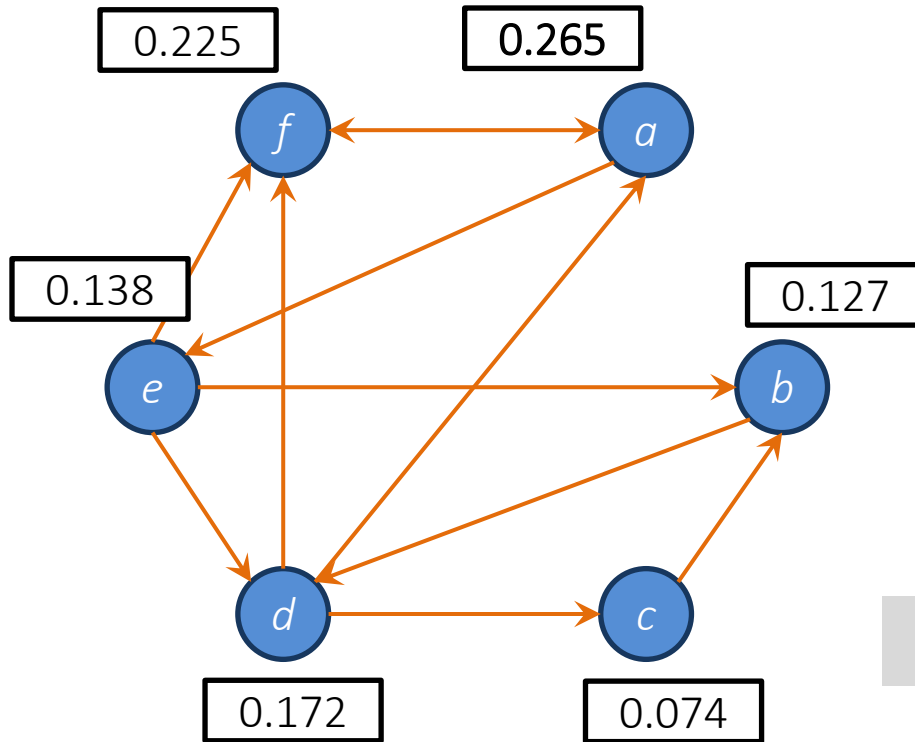
PageRank: Recursive Definition

A page with **lots** of inlinks from important pages with few outlinks is more important



PageRank Model

- The Web: a directed graph



$$G = [V, E]$$

Vertices
(pages)

Edges
(links)

Which vertex is most important?

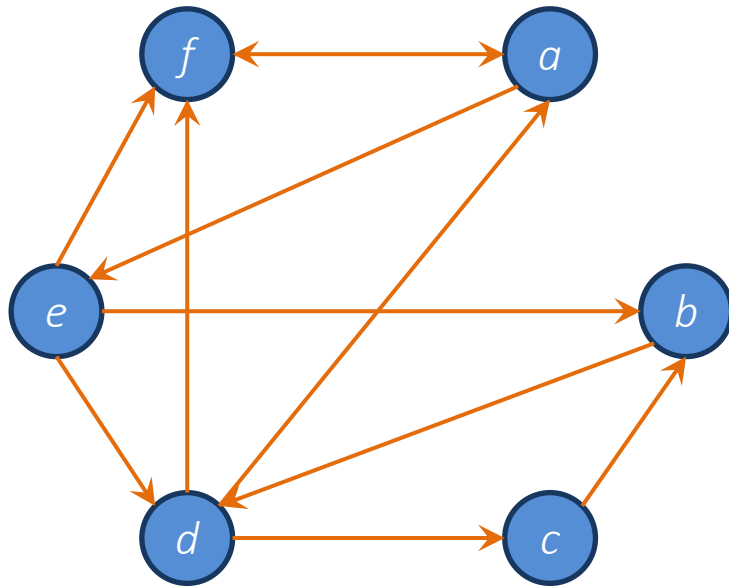


$$V = \{a, b, c, d, e, f\}$$

$$E = \{(a, e), (a, f), (b, d), (c, b), (d, a), (d, c), (d, f), (e, b), (e, d), (e, f), (f, a)\}$$

PageRank Model

- The Web: a directed graph



$$G = \boxed{V} \boxed{E}$$

Vertices
(pages)

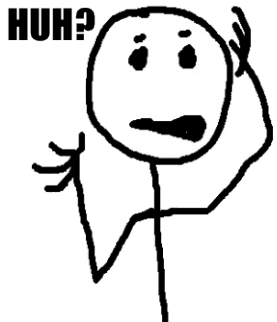
Edges
(links)

$$\text{out}(v) := \{v' \in V \mid (v, v') \in E\}$$

$$\text{in}(v) := \{v' \in V \mid (v', v) \in E\}$$

$$\text{rank}_0(v) := \frac{1}{|V|}$$

$$\text{rank}_i(v) := \sum_{v' \in \text{in}(v)} \frac{\text{rank}_{i-1}(v')}{|\text{out}(v')|}$$



PageRank Model

$$G = [V, E]$$

Vertices
(pages)

Edges
(links)

$$\text{rank}_1(f) = \frac{1}{6} \times \frac{1}{3}$$

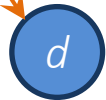
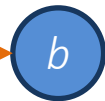


$$\text{rank}_0(e) = \frac{1}{6}$$

$$|\text{out}(e)| = 3$$



$$\text{rank}_1(b) = \frac{1}{6} \times \frac{1}{3}$$



$$\text{rank}_1(d) = \frac{1}{6} \times \frac{1}{3}$$

$$\text{out}(v) := \{v' \in V \mid (v, v') \in E\}$$

$$\text{in}(v) := \{v' \in V \mid (v', v) \in E\}$$

$$\text{rank}_0(v) := \frac{1}{|V|}$$

$$\text{rank}_i(v) := \sum_{v' \in \text{in}(v)} \frac{\text{rank}_{i-1}(v')}{|\text{out}(v')|}$$

PageRank Model

$$G = [V, E]$$

Vertices
(pages)

Edges
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$$\text{rank}_1(f) = \frac{1}{6} \times \frac{1}{3}$$

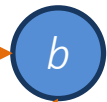


$$\text{rank}_0(e) = \frac{1}{6}$$

$$|\text{out}(e)| = 3$$



$$\text{rank}_1(b) = \frac{1}{6} \times \frac{1}{3} + 1 \times \frac{1}{6}$$



$$\text{rank}_1(d) = \frac{1}{6} \times \frac{1}{3}$$



$$\text{rank}_0(c) = \frac{1}{6}$$

$$|\text{out}(c)| = 1$$

• • •

$$\text{out}(v) := \{v' \in V \mid (v, v') \in E\}$$

$$\text{in}(v) := \{v' \in V \mid (v', v) \in E\}$$

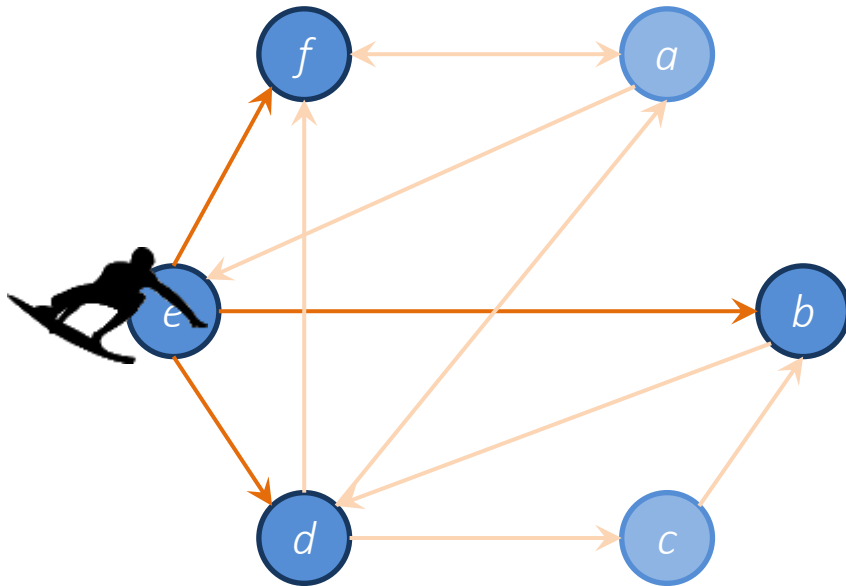
$$\text{rank}_0(v) := \frac{1}{|V|}$$

$$\text{rank}_i(v) := \sum_{v' \in \text{in}(v)} \frac{\text{rank}_{i-1}(v')}{|\text{out}(v')|}$$

PageRank: Random Surfer Model



= someone surfing the web,
clicking links randomly

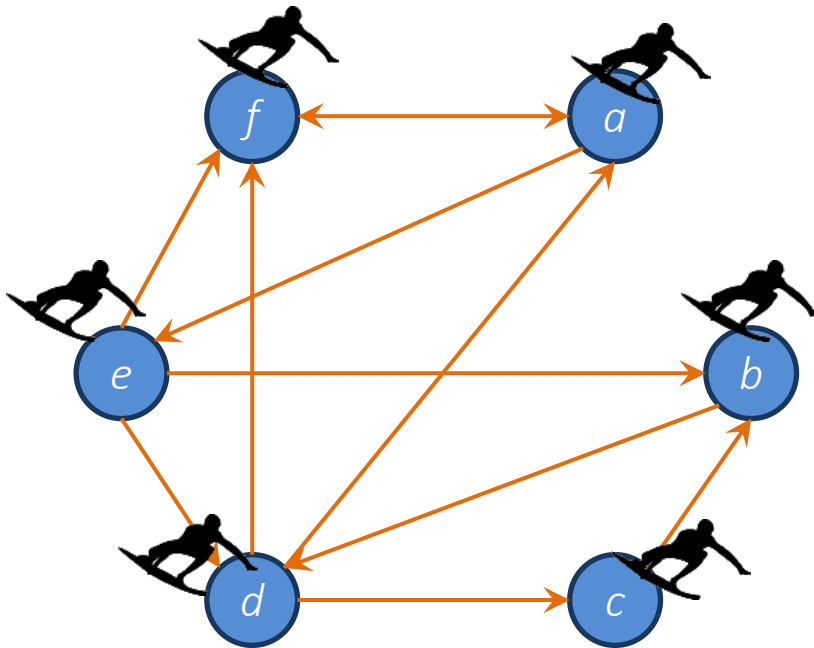


- What is the probability of being at page x after n hops?

PageRank: Random Surfer Model



= someone surfing the web,
clicking links randomly

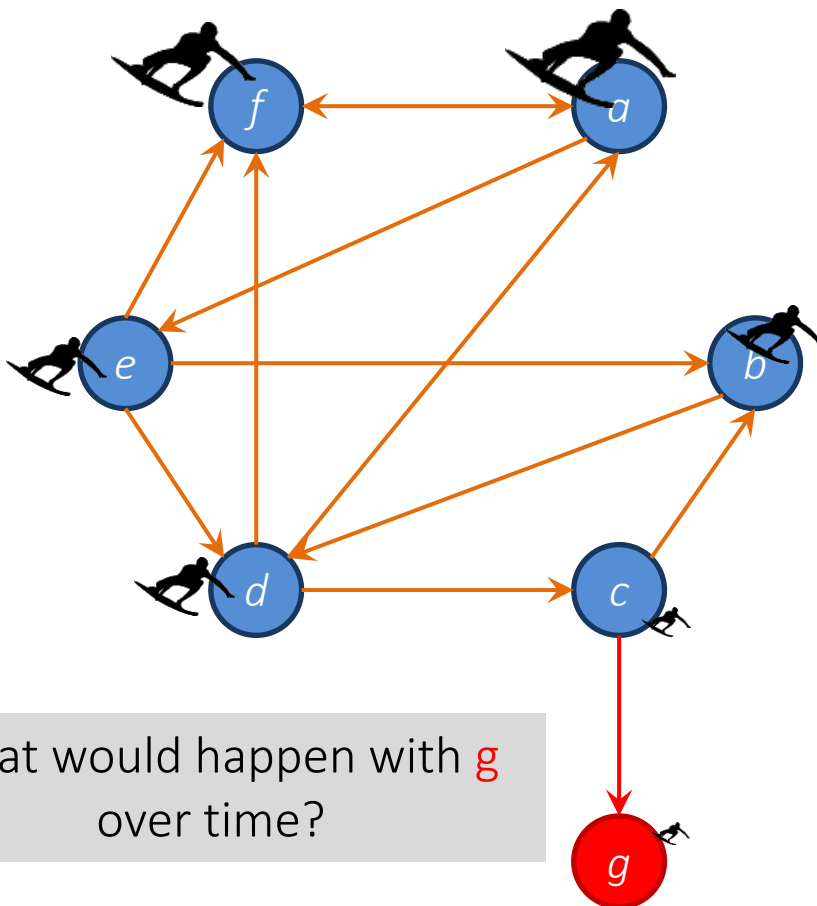


- What is the probability of being at page x after n hops?
- *Initial state*: surfer equally likely to start at any node

PageRank: Random Surfer Model



= someone surfing the web,
clicking links randomly



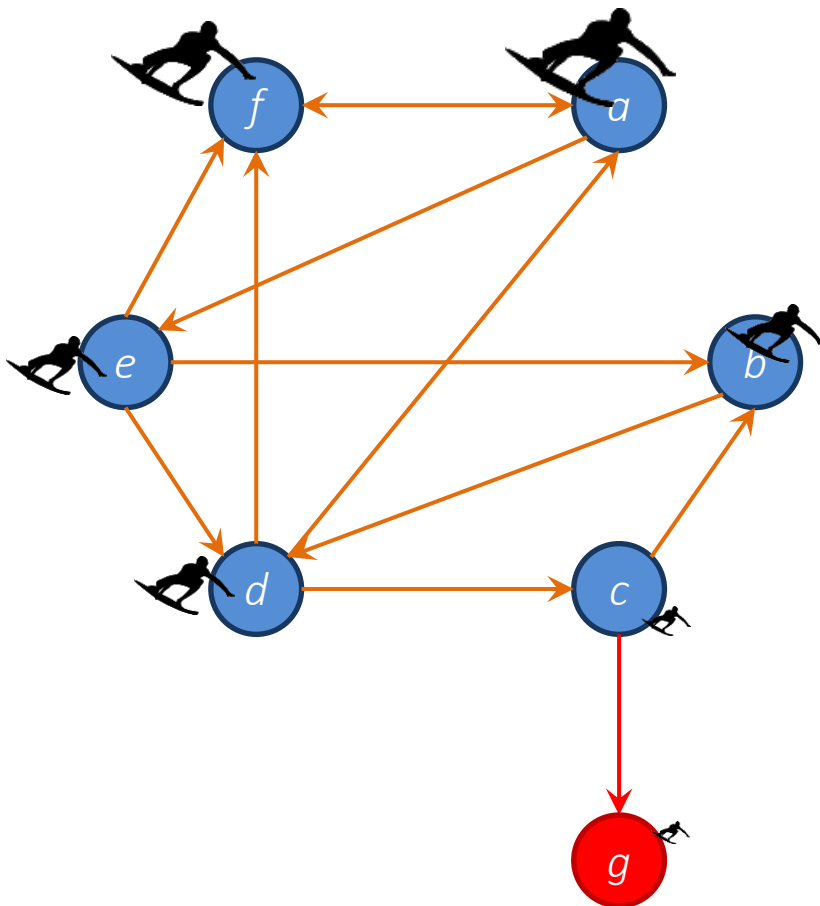
What would happen with **g**
over time?

- What is the probability of being at page x after n hops?
- *Initial state*: surfer equally likely to start at any node
- PageRank applied iteratively for each hop: score indicates probability of being at that page after that many hops

PageRank: Random Surfer Model



= someone surfing the web,
clicking links randomly

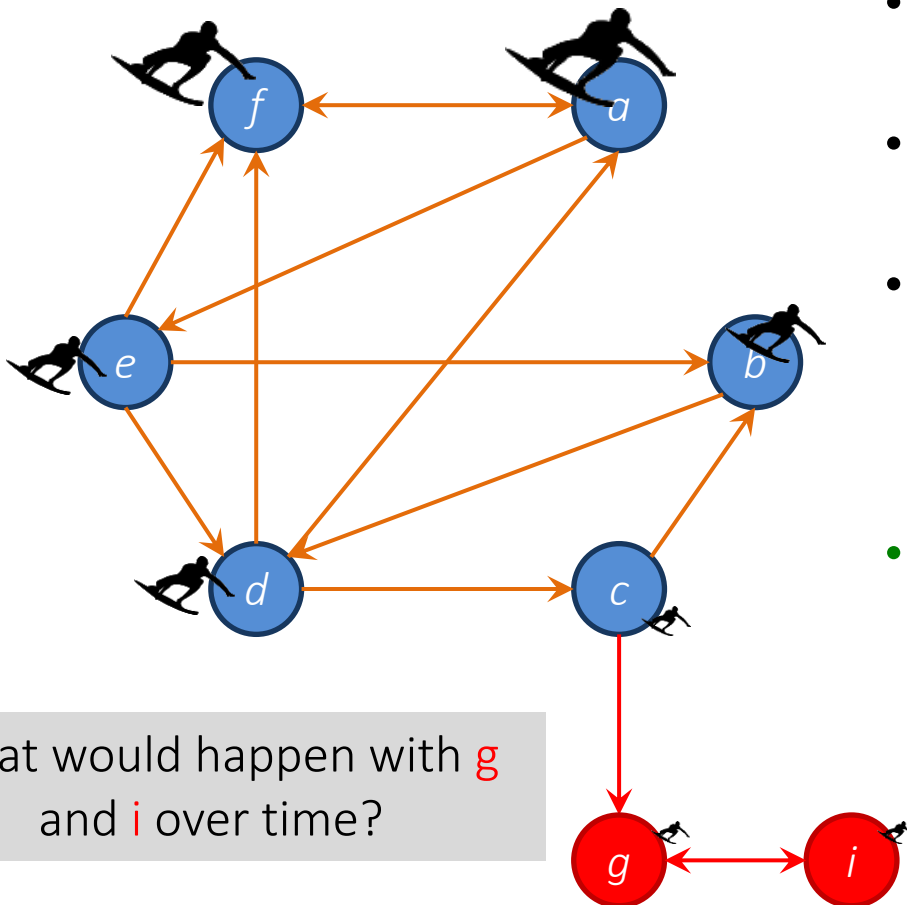


- What is the probability of being at page x after n hops?
- *Initial state*: surfer equally likely to start at any node
- PageRank applied iteratively for each hop: score indicates probability of being at that page after that many hops
- If the surfer reaches a page without links, the surfer randomly jumps to another page

PageRank: Random Surfer Model



= someone surfing the web,
clicking links randomly



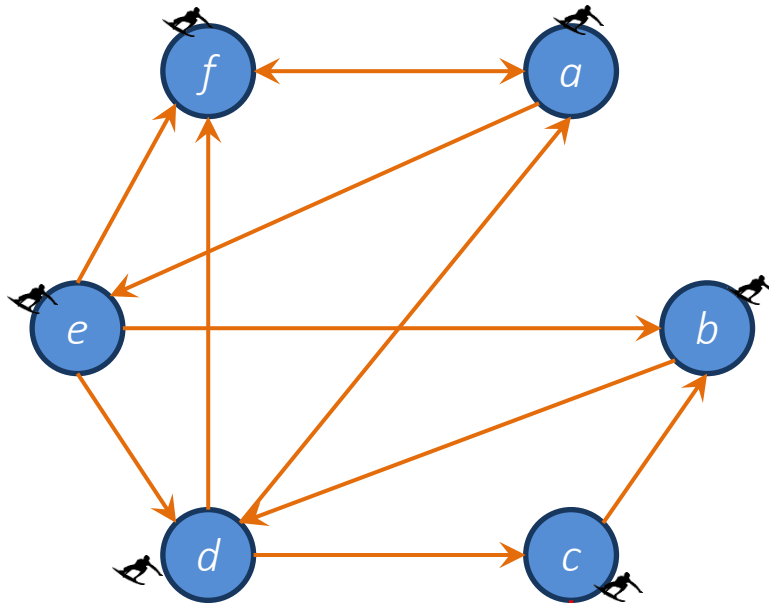
What would happen with **g**
and **i** over time?

- What is the probability of being at page x after n hops?
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PageRank: Random Surfer Model

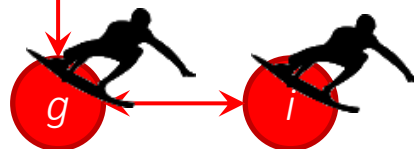


= someone surfing the web,
clicking links randomly



- What is the probability of being at page x after n hops?
- *Initial state*: surfer equally likely to start at any node
- PageRank applied iteratively for each hop: score indicates probability of being at that page after than many hops
- If the surfer reaches a page without out-links, the surfer randomly jumps to another page

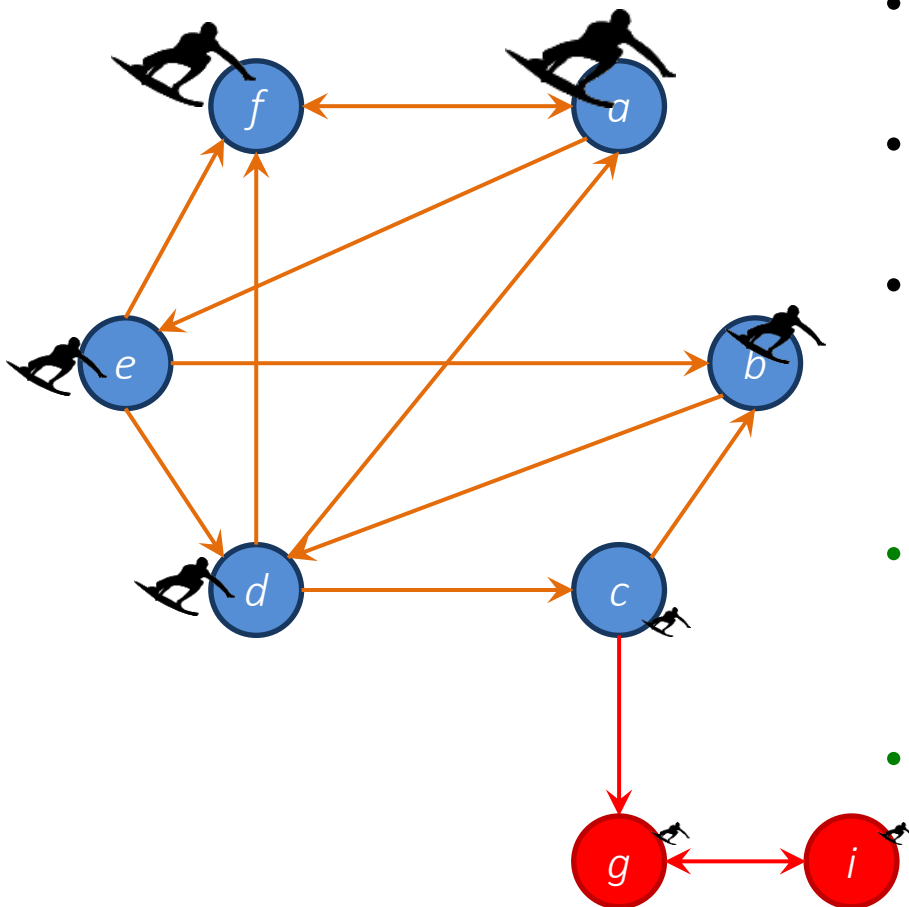
What would happen with g
and i over time?



PageRank: Random Surfer Model



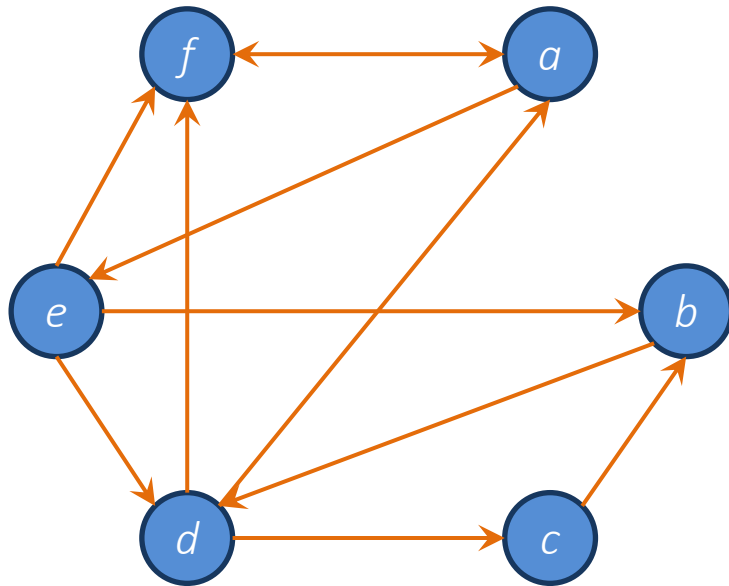
= someone surfing the web,
clicking links randomly



- What is the probability of being at page x after n hops?
- *Initial state*: surfer equally likely to start at any node
- PageRank applied iteratively for each hop: score indicates probability of being at that page after than many hops
- If the surfer reaches a page without out-links, the surfer randomly jumps to another page
- The surfer will jump to a random page at any time with a probability $1 - d$... *this avoids traps and ensures convergence!*

PageRank Model: Final Version

- The Web: a directed graph



$$G = \boxed{V} \boxed{E}$$

Vertices
(pages)

Edges
(links)

$$\text{out}(v) := \{v' \in V \mid (v, v') \in E\}$$

$$\text{in}(v) := \{v' \in V \mid (v', v) \in E\}$$

$$\text{rank}_0(v) := \frac{1}{|V|}$$

$$V' := \{v \in V : |\text{out}(v)| = 0\}$$

$$V'' := \{v \in V : |\text{out}(v)| \neq 0\}$$

d is the follow-a-link probability
typically ($d = 0.85$)

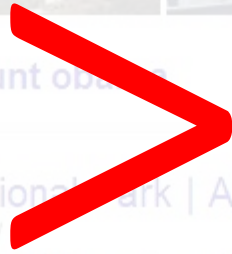
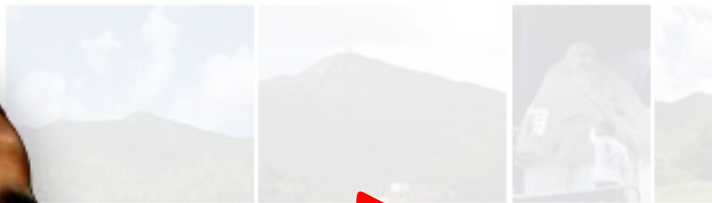
$$\text{rank}_i(v) := d \times \sum_{u \in \text{in}(v)} \frac{\text{rank}_{i-1}(u)}{|\text{out}(u)|} + \sum_{v' \in V'} \frac{\text{rank}_{i-1}(v')}{|V|} + (1-d) \times \sum_{v'' \in V''} \frac{\text{rank}_{i-1}(v'')}{|V|}$$

PageRank: Benefits



- ✓ More robust than a simple link count
- ✓ Fewer ties than link counting
- ✓ Scalable to approximate (for sparse graphs)
- ✓ Convergence guaranteed

Two Sides to Ranking: Importance



Mount Obama National Park | Antigua a
antiguamountobama.com/
Jun 16, 2011 - As the Mount Obama Committee continu
Area, the committee organized a site visit to the C

COMPUTING PAGERANK AT SCALE

Graph Parallel Frameworks: Pregel

Pregel: A System for Large-Scale Graph Processing

Grzegorz Malewicz, Matthew H. Austern, Aart J. C. Bik, James C. Dehnert, Ilan Horn,
Naty Leiser, and Grzegorz Czajkowski
Google, Inc.
{malewicz,austern,ajcbik,dehnert,ilan,naty,gczaj}@google.com

ABSTRACT

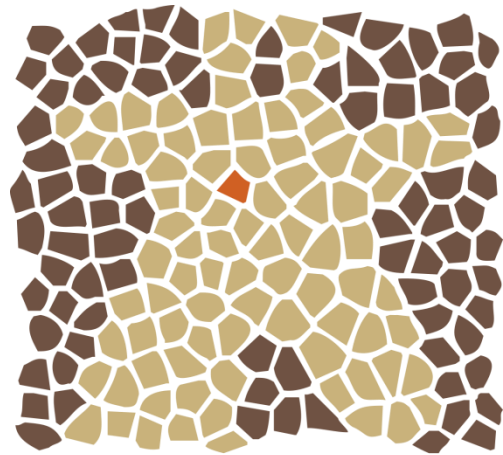
Many practical computing problems concern large graphs. Standard examples include the Web graph and various social networks. The scale of these graphs—in some cases billions of vertices, trillions of edges—poses challenges to their efficient processing. In this paper we present a computational model suitable for this task. Programs are expressed as a sequence of iterations, in each of which a vertex can receive messages sent in the previous iteration, send messages to other vertices, and modify its own state and that of its outgoing edges or mutate graph topology. This vertex-centric approach is flexible enough to express a broad set of algorithms. The model has been designed for efficient, scalable and fault-tolerant implementation on clusters of thousands of commodity computers, and its implied synchronicity makes reasoning about programs easier. Distribution-related details are hidden behind an abstract API. The result is a framework for processing large graphs that is expressive and easy to program.

disease outbreaks, or citation relationships among published scientific work—have been processed for decades. Frequently applied algorithms include shortest paths computations, different flavors of clustering, and variations on the page rank theme. There are many other graph computing problems of practical value, *e.g.*, minimum cut and connected components.

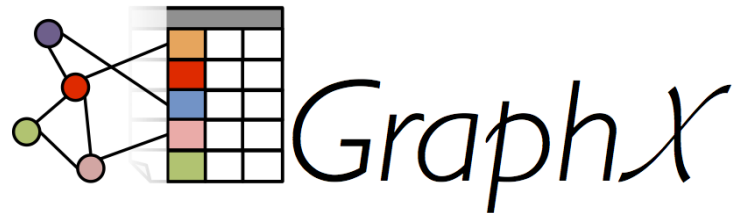
Efficient processing of large graphs is challenging. Graph algorithms often exhibit poor locality of memory access, very little work per vertex, and a changing degree of parallelism over the course of execution [31, 39]. Distribution over many machines exacerbates the locality issue, and increases the probability that a machine will fail during computation. Despite the ubiquity of large graphs and their commercial importance, we know of no scalable general-purpose system for implementing arbitrary graph algorithms over arbitrary graph representations in a large-scale distributed environment.

Implementing an algorithm to process a large graph typically means choosing among the following options:

Graph Parallel Frameworks: Open Source

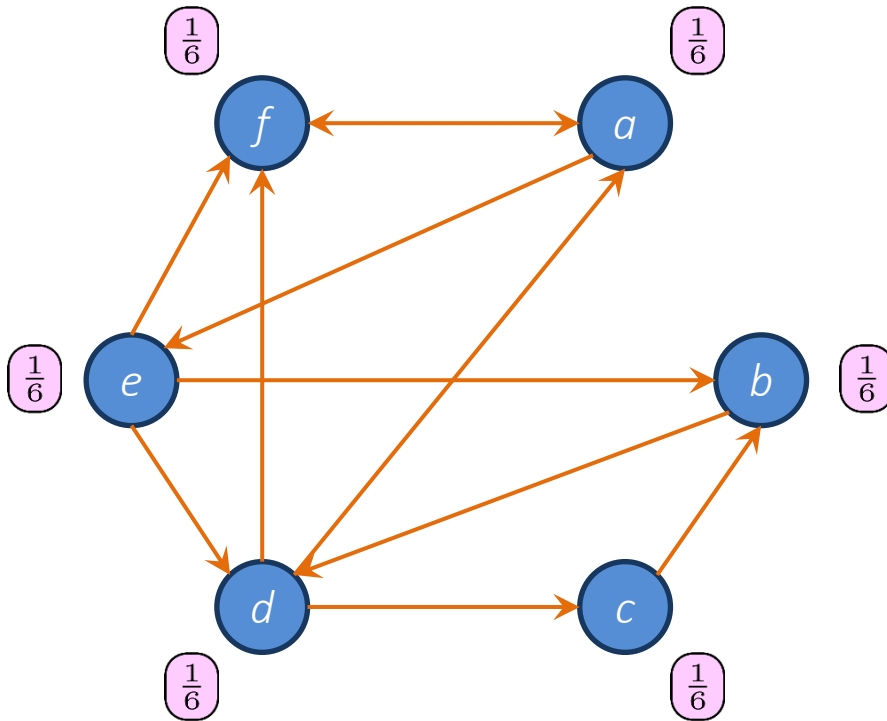


A P A C H E
G I R A P H



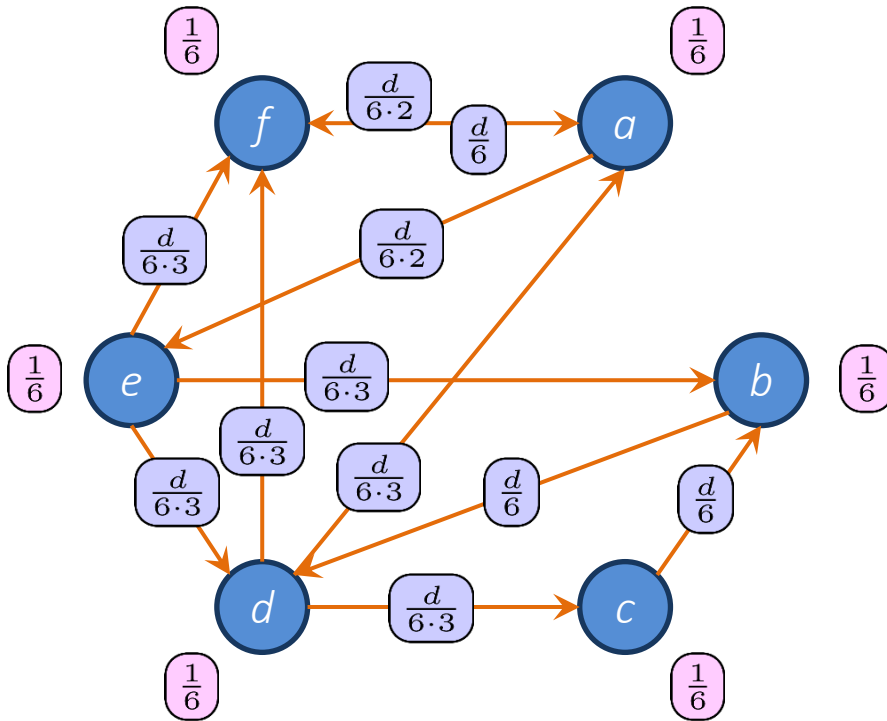
Vertex-Centric Computation

1. Nodes assigned **state**

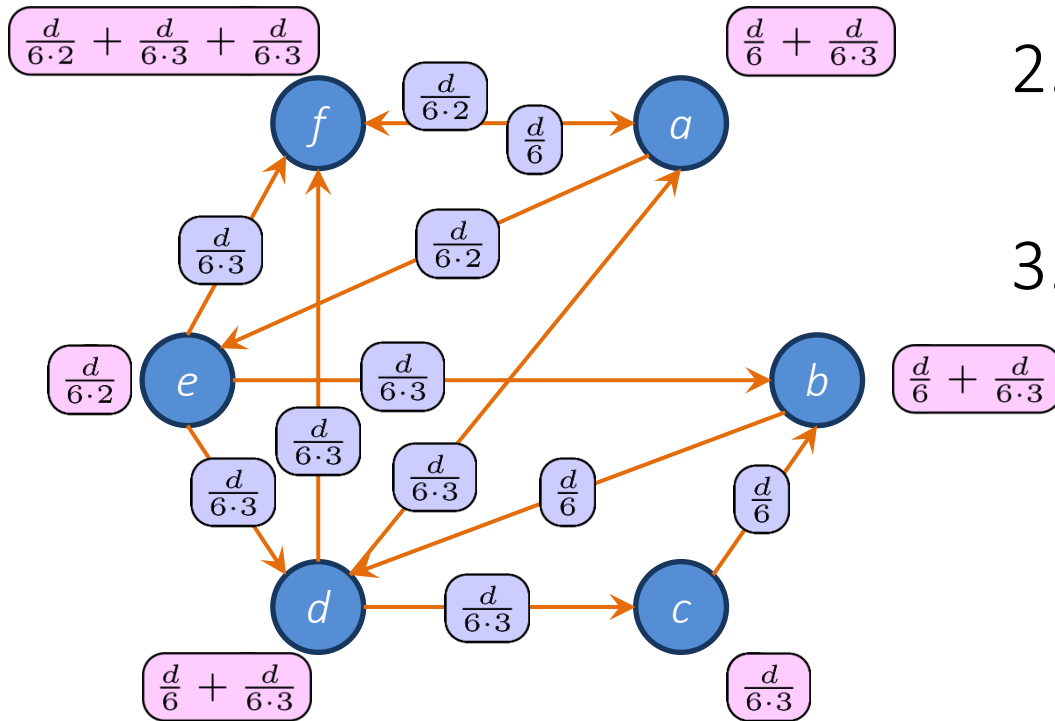


Vertex-Centric Computation

1. Nodes assigned state
2. Nodes pass messages (typically along edges)

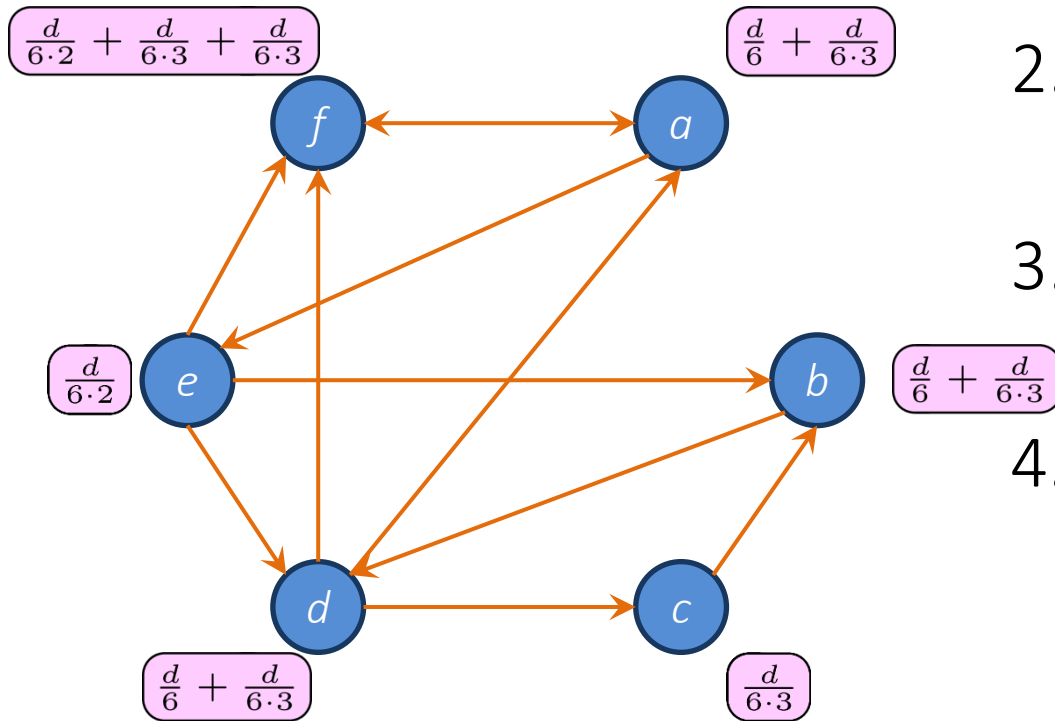


Vertex-Centric Computation



1. Nodes assigned **state**
2. Nodes pass **messages** (typically along **edges**)
3. Nodes aggregate **messages** received

Vertex-Centric Computation



1. Nodes assigned state
2. Nodes pass messages (typically along edges)
3. Nodes aggregate messages received
4. GOTO 2. until some termination criteria are reached

Vertex-Centric Computation: Other Features

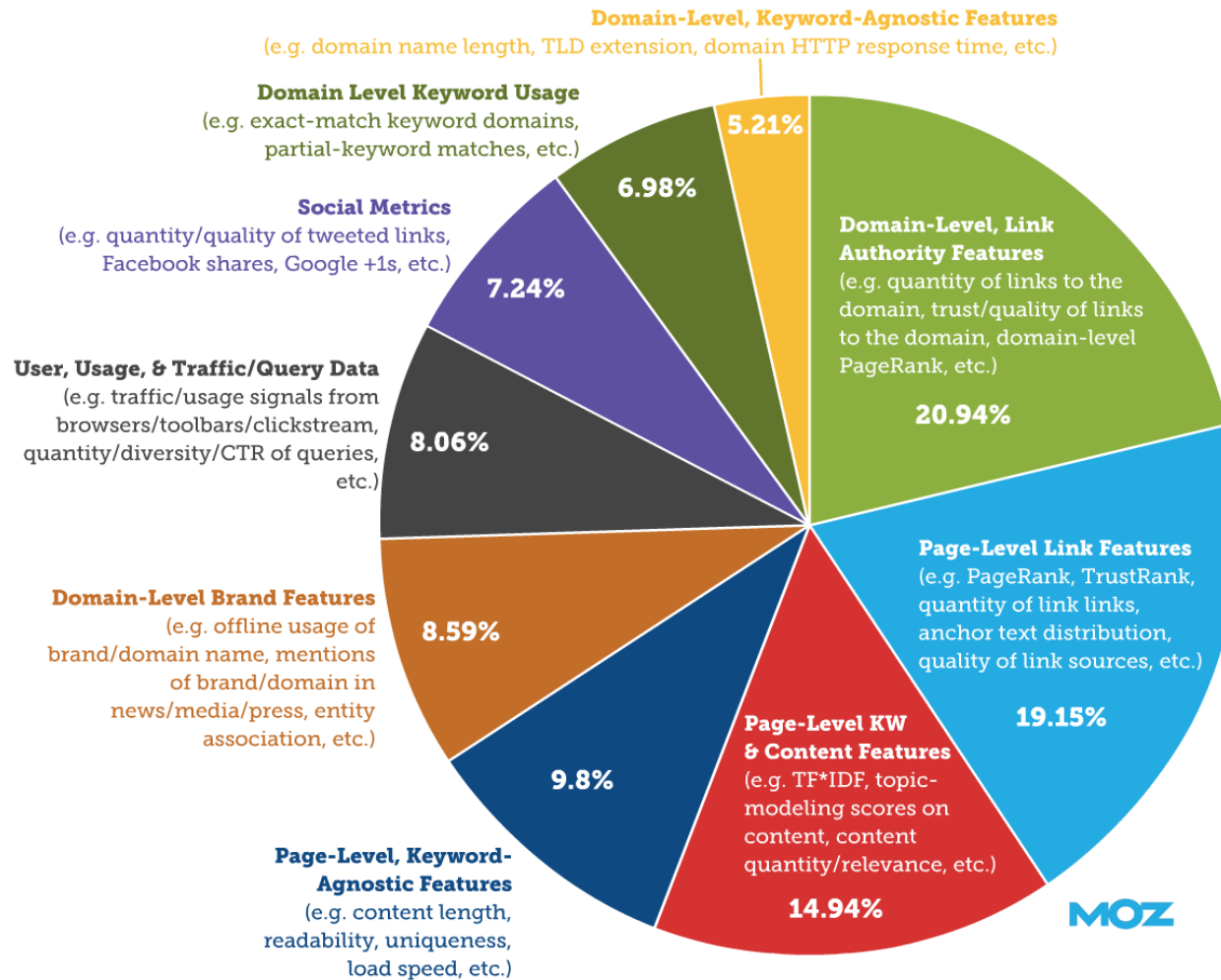
- Message passing and aggregation done in parallel
- Option message passing to non-neighbours
- Optional global “aggregation” phase
- Optional changes to the graph topology

HOW DOES GOOGLE REALLY RANK?
AN EDUCATED GUESS

How Modern Google ranks results (maybe)

Weighting of Thematic Clusters of Ranking Factors in Google

(based on survey responses by 128 SEO professionals in June 2013)



According to survey of SEO experts, not people in Google

How Modern Google ranks results (maybe)

Weighting of Thematic Clusters of Ranking Factors in Google

(based on survey responses by 128 SEO professionals in June 2013)

Domain-Level, Keyword-Agnostic Features
(e.g. domain name length, TLD extension, domain HTTP response time, etc.)

Why so secretive?



partial-keyword matches, etc.)

6.98%

User

Quality

D

b



Page-Level, Keyword-Agnostic Features
(e.g. content length, readability, uniqueness, load speed, etc.)

quantity/relevance, etc.)

14.94%

MOZ

According to survey of SEO experts, not people in Google

Ranking: Science or Art?





Questions?