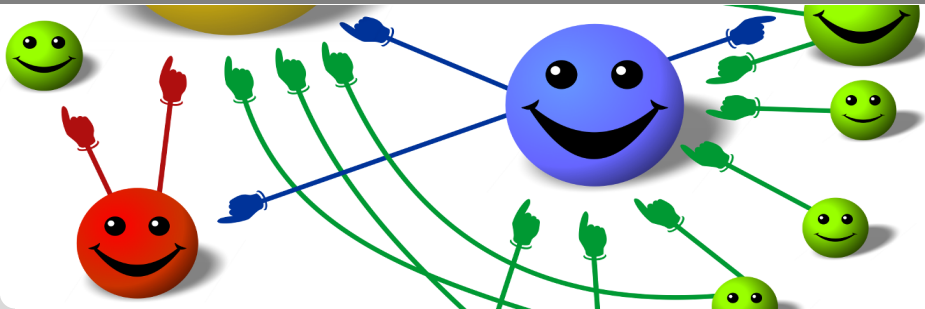


# How Google Searches Work

History of searching and the PageRank algorithm

Martin Thoma, Benjamin Lipp | 7th of February, 2013

SPRACHENZENTRUM




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2 PageRank

3 End

# The Early Days: Web Directories

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- [University of Ulm](#) (1)

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- [Regional: Europe: Germany: States: Baden-Württemberg: Education](#) (1)


This category in other languages:

[German](#) (247)

- "Baden-Württemberg" search on: [AOL](#) - [Ask](#) - [Bing](#) - [Gigablast](#) - [Google](#) - [Lycos](#) - [Yahoo](#) - [Yippy](#)



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- [Regional](#): [Europe](#): [Germany](#): [States](#): [Baden-Württemberg](#): [Localities](#): [Mannheim](#) (2)

This category in other languages:

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---

- [University of Mannheim](#) - Offers undergraduate and graduate programs, includes information on study and research at the university, directorate financial aid.

---

• "University of Mannheim" search on: [AOL](#) - [Ask](#) - [Bing](#) - [Gigablast](#) - [Google](#) - [Lycos](#) - [Yahoo](#) - [Yippy](#)

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1. [World: Français: Régional: Amérique: Etats-Unis: Etat et politique: Ambassades et consulats: Pays représentés](#) (39)
2. [World: Deutsch: Wissen: Bibliotheken: Universitäts- und Hochschulbibliotheken: Deutschland](#) (33)
3. [World: Français: Régional: Amérique: Etats-Unis: Etat et politique: Ambassades et consulats: Représentations à l'étranger](#) (24)
4. [World: Nederlands: Maatschappij: Overheid: Europese Unie](#) (22)
5. [World: Deutsch: Gesundheit: Krankenhäuser und Kliniken: Universitätskliniken: Deutschland](#) (21)

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## Open Directory Sites (1-20 of 15698)

1. [amnesty international Hochschulgruppe Mannheim](#) - Die amnesty-Gruppe an der Uni Mannheim setzt sich unter anderem mit Petitionen, Appellbriefen und stellt aktuelle Aktivitäten vor.  
-- <http://www.amnesty-uni-mannheim.de/> [World: Deutsch: Regional: Europa: Deutschland: Baden-Württemberg: Städte und Gemeinden: M: Mannheim: Gesellschaft](#) (23)
2. [LHG - Liberale Hochschulgruppe Mannheim](#) - Die liberale Studierenden an der Uni Mannheim stellen sich vor.  
-- <http://www.uni-mannheim.de/studorg/b/berale/> [World: Deutsch: Wissen: Bildung: Hochschulen: Europa: Deutschland: Baden-Württemberg: Universität Mannheim](#) (0)
3. [Uni Mannheim](#) - Marktübersicht deutscher Anbieter für Online-Preisvergleiche.  
-- <http://projekt.wifo.uni-mannheim.de/preisvergleich/> [World: Deutsch: Zuhause: Verbraucherinformationen: Preisagenturen: Online-Preisvergleiche](#) (0)
4. [University of Mannheim](#) - Offers undergraduate and graduate programs; includes information on study and research at the university, directories of financial aid.  
-- <http://www.uni-mannheim.de/> [Reference: Education: Colleges and Universities: Europe: Germany: Baden-Württemberg: University of Mannheim](#) (0)



- crawls through the web using hyperlinks
- makes an index of the words contained in a page
- ranks pages for a search query according to number of occurrences of keywords



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We all know that:

- Humans know what is good for them
  - ✗ Machines don't know what's good for humans
  - Humans create Websites
  - Humans will only [link](#) to Websites they like
- ⇒ Hyperlinks are a quality indicator

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# How could we use that?

- Simply count number of links to a Website
- ✗ 10,000 links from only one page
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# A brilliant idea



Sergey Brin



Larry Page



- Decisions of humans are complicated

- A lot of webpages get visited

⇒ modellize clicks on links as random behaviour

- Links are important

- Links of page A get less important, if A has many links

- Links of page A get more important, if many link to A

⇒ if B has a link from A, the rank of B increases by  $\frac{Rank(A)}{Links(A)}$

**if A links to B then**

$$Rank(B) += \frac{Rank(A)}{Links(A)}$$

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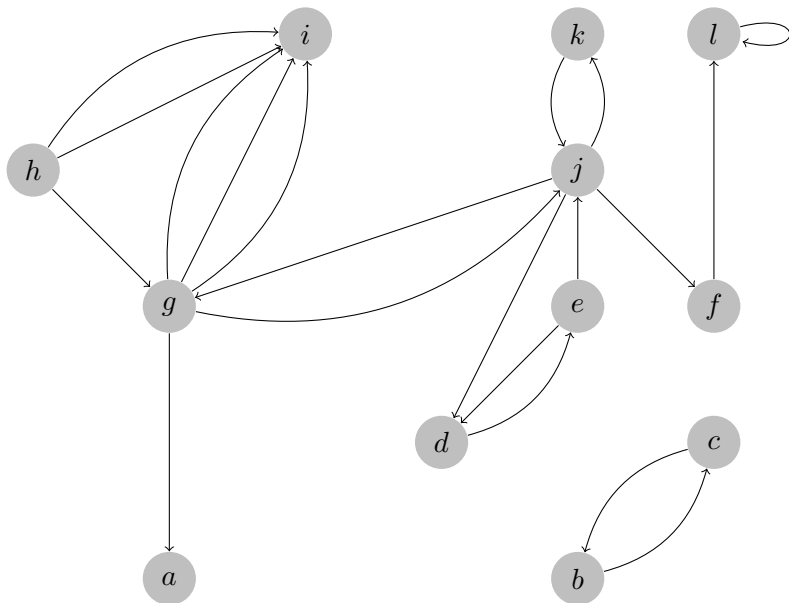
**if A links to B then**

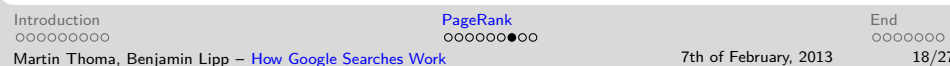
$$Rank(B) += \frac{Rank(A)}{Links(A)}$$

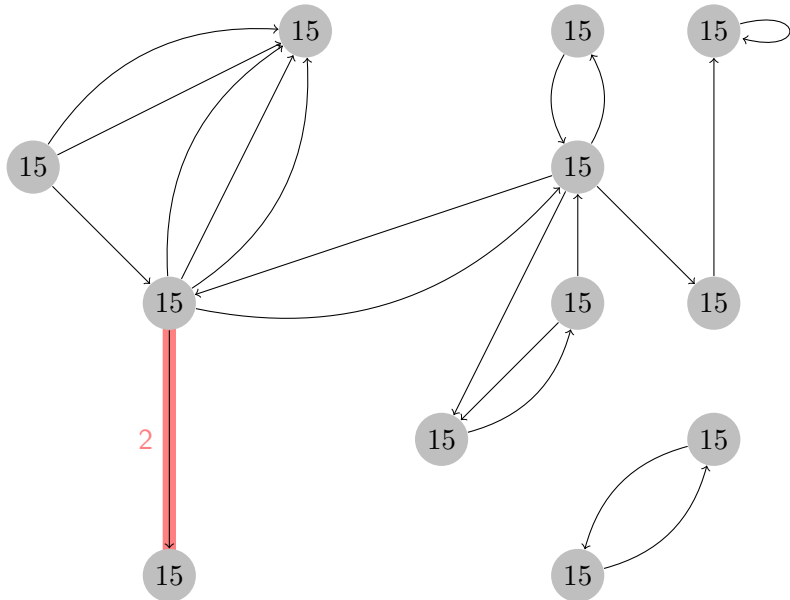


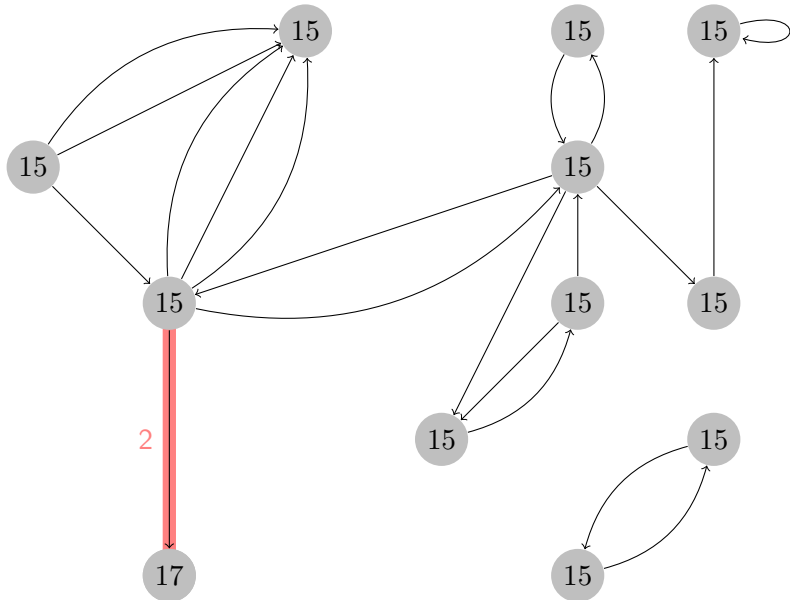
# What is PageRank?

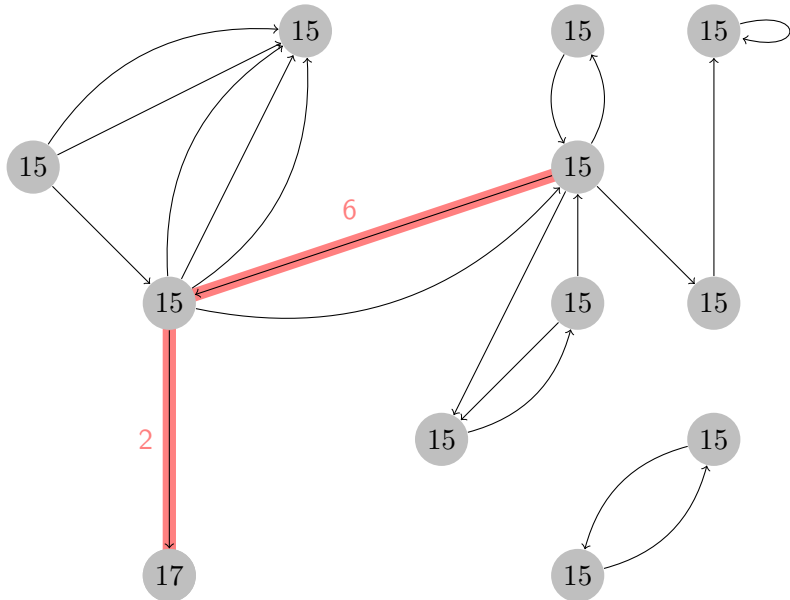
The PageRank algorithm calculates the probability of a randomly clicking user ending up on a given page.

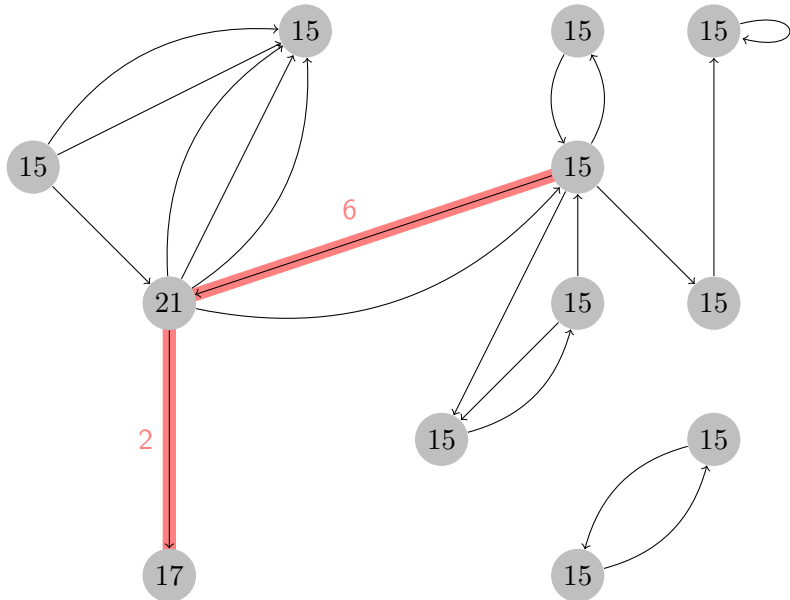


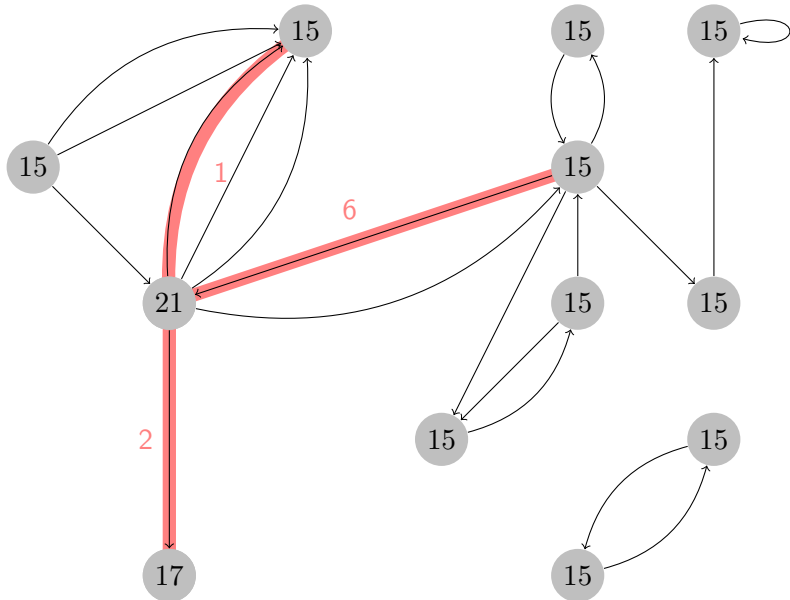




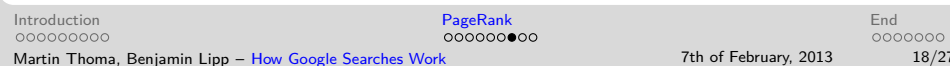


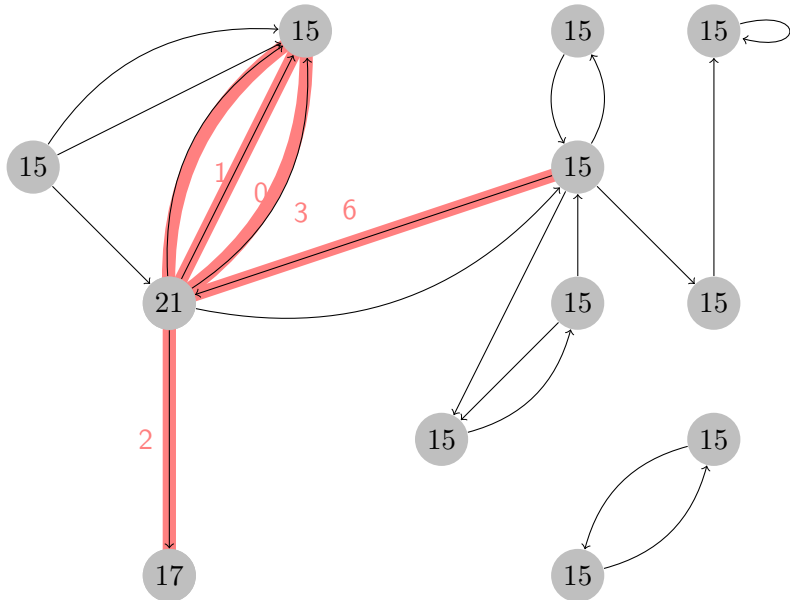


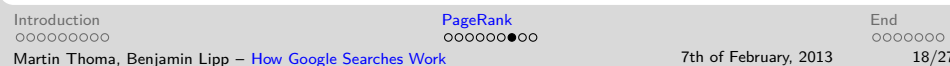












Let  $x$  be a web page. Then

- $L(x)$  is the set of Websites that link to  $x$
- $C(y)$  is the out-degree of page  $y$
- $\alpha$  is probability of random jump
- $N$  is the total number of websites

$$PR(x) := \alpha \left( \frac{1}{N} \right) + (1 - \alpha) \sum_{y \in L(x)} \frac{PR(y)}{C(y)}$$

```
function PAGERANK(Graph web, double  $q = 0.15$ , int iterations)  
  while iterations > 0 do  
    for all page  $\in$  web do                                 $\triangleright$  calculate pageRank of page  
      page.pageRank =  $q$   
      for all  $y \in L(\textit{page})$  do  
        page.pageRank +=  $\frac{y.\textit{pageRank}}{C(y)}$   
      end for  
    end for  
  iterations -= 1
```

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```

- language
- place
- social information

- language
- place
- social information

- language
- place
- social information

# The Filter Bubble

[dontbubble.us](http://dontbubble.us)  
[www.thefilterbubble.com](http://www.thefilterbubble.com)

# The Filter Bubble

## Scott gets Egyptian Protests



The screenshot shows a Google search for "Egypt". The search results are filtered to show only news and travel-related information. The left sidebar shows the "Everything" filter selected. The search results are as follows:

- Crisis in Egypt**  
Voices in Egypt have been muted but will not be silenced. Listen.  
[humanrightsfirst.org/Egypt](http://humanrightsfirst.org/Egypt)
- Egypt - Wikipedia, the free encyclopedia**  
Egypt officially the Arab Republic of Egypt, is a country mainly in North Africa, with the Sinai Peninsula forming a land bridge in Southwest Asia. ...  
[en.wikipedia.org/wiki/Egypt](http://en.wikipedia.org/wiki/Egypt) - Cached - Similar
- Egypt News - The Protests of 2011 - The New York Times**  
World news about Egypt and the protests of 2011. Breaking news and archival information about its people, politics and economy from The New York Times.  
[topics.nytimes.com](http://topics.nytimes.com/topics/countries/territories) - World - Countries and Territories - Cached - Similar
- Egypt Travel, Tours, Vacations, Ancient Egypt from Tour Egypt**  
Information for travelers, resources on history, monuments and activities.  
[www.touregypt.net/](http://www.touregypt.net/) - Cached - Similar
- News for Egypt**  
  
**Why Lara Logan Was Eager to Return to Egypt**  
1 hour ago  
By Charlotte Triggs AP Lara Logan had already had one troubling experience in Egypt before last Friday's "brutal and sustained" sexual assault, ...  
[People Magazine](http://people.com) - 1658 related articles - Shared by 20+
- In Egypt, renewed hope for gender equality**  
USA Today - 24874 related articles - Shared by 5+
- [Realtime updates for Egypt \(390\)](#)

# The Filter Bubble

## Daniel gets Travel Information



Google Egypt

About 321,000,000 results (0.15 seconds)

Everything  
Images  
Videos  
News  
Shopping  
Books  
More

New York, NY  
Change location

Any time  
Latest  
Past 24 hours  
Past week  
Past month  
Past year  
Custom range...

All results  
Sites with images

**Egypt - Wikipedia, the free encyclopedia**  
Egypt officially the Arab Republic of **Egypt**, is a country mainly in North Africa, with the Sinai Peninsula forming a land bridge in Southwest Asia. ...  
Hosni Mubarak - Ancient Egypt - Female genital cutting - History of modern Egypt  
[en.wikipedia.org/wiki/Egypt](http://en.wikipedia.org/wiki/Egypt) - Cached - Similar

**Egypt Travel, Tours, Vacations, Ancient Egypt from Tour Egypt**  
Information for travelers, resources on history, monuments and activities.  
[www.touregypt.net/](http://www.touregypt.net/) - Cached - Similar

**Egypt Daily News, Egypt News**  
Egypt Daily News, covering Egypt News, Arab news, Middle East news and World news.  
Egyptian Guides, egyptian recipes, egyptian food, egyptian airforce. ...  
[www.egyptdailynews.com/](http://www.egyptdailynews.com/) - Cached - Similar

**Images for Egypt** - Report images

**Egypt - CIA - The World Factbook**  
Feb 1, 2011 ... Features a map and brief descriptions of geography, economy, government, and people.  
<https://www.cia.gov/library/publications/the-world.../eg.html> - Cached - Similar



# What You've Learned

- web directories
- web crawler
- graph (nodes, edges)
- random walk (ants)
- PageRank
- read pseudocode
- filter bubble

- [PageRank](#) by Felipe Micaroni Lalli
- screenshots of [www.dmoz.org](http://www.dmoz.org)
- [Hyperlink](#) by Bernard Ladenthin
- screenshots of [dontbubble.us](http://dontbubble.us)
- [Sergey Brin](#) by enlewof
- [Larry Page](#) by aweigend

# Thanks for Your Attention!

Days 1 - 10

Teach yourself variables, constants, arrays, strings, expressions, statements, functions,...



Days 11 - 21

Teach yourself program flow, pointers, references, classes, objects, inheritance, polymorphism, ....



Days 22 - 697

Do a lot of recreational programming. Have fun hacking but remember to learn from your mistakes.



Days 698 - 3648

Interact with other programmers. Work on programming projects together. Learn from them.



Days 3649 - 7781

Teach yourself advanced theoretical physics and formulate a consistent theory of quantum gravity.



Days 7782 - 14611

Teach yourself biochemistry, molecular biology, genetics,...



Day 14611

Use knowledge of biology to make an age-reversing potion.



Day 14611

Use knowledge of physics to build flux capacitor and go back in time to day 21.



Day 21

Replace younger self.



As far as I know, this is the easiest way to "Teach Yourself C++ in 21 Days".