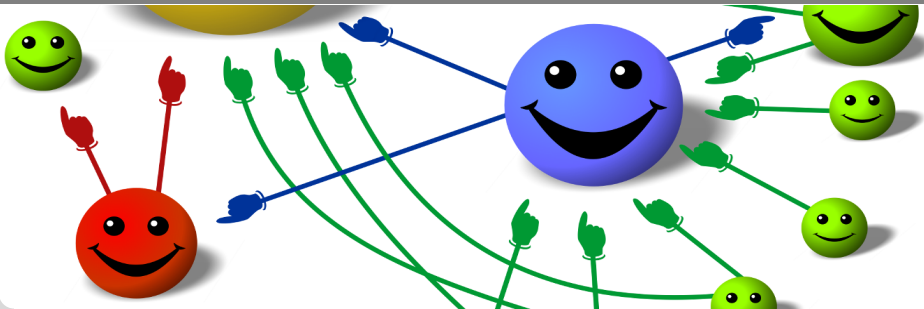


How Google Searches Work

History of searching and the PageRank algorithm

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

SPRACHENZENTRUM




1 Introduction

2 PageRank

3 End

The Early Days: Web Directories

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5,114,083 sites - 96,877 editors - over 1,014,849 categories

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- [Distance Learning](#) (660)
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- [Academic Departments](#) (0)

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| • Belgium (24) | • Malta (14) |
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| • Bulgaria (30) | • Montenegro (1) |
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| • Czech Republic (59) | • Poland (175) |
| • Denmark (11) | • Portugal (6) |
| • Estonia (23) | • Romania (18) |
| • Finland (23) | • Russia (78) |
| • France (19) | • Serbia (6) |
| • Germany (121) | • Slovakia (12) |
| • Greece (22) | • Slovenia (7) |
| • Hungary (16) | • Spain (20) |
| • Iceland (4) | • Sweden (56) |

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- [Berlin](#) (35)
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- [Hesse](#) (7)
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See also:

- [Regional: Europe: Germany](#) (3,998)
- [Regional: Europe: Germany: Education](#) (11)

This category in other languages:

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[German](#) (2,229)

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- [Hochschule Esslingen - University of Applied Sciences](#) (1)
- [Hochschule Furtwangen - University of Applied Sciences](#) (0)
- [Hochschule Heilbronn - Heilbronn University](#) (1)
- [Hochschule Konstanz - University of Applied Sciences](#) (0)
- [International University in Germany](#) (1)
- [Stuttgart Institute of Management and Technology](#) (1)
- [University of Freiburg](#) (1)
- [University of Heidelberg](#) (1)
- [University of Hohenheim](#) (1)
- [University of Konstanz](#) (2)
- [University of Mannheim](#) (1)
- [University of Maryland University College - Mannheim](#)
- [University of Stuttgart](#) (1)
- [University of Ulm](#) (1)

See also:


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

This category in other languages:

[German](#) (247)

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

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See also:

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

This category in other languages:

[German](#) (7)

- [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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Search: **uni mannheim**

Open Directory Categories (1-5 of 100)

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)

[more...](#)

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/liberale/> [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)

The Early Days: Web Crawlers



- 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

The Early Days: Web Crawlers



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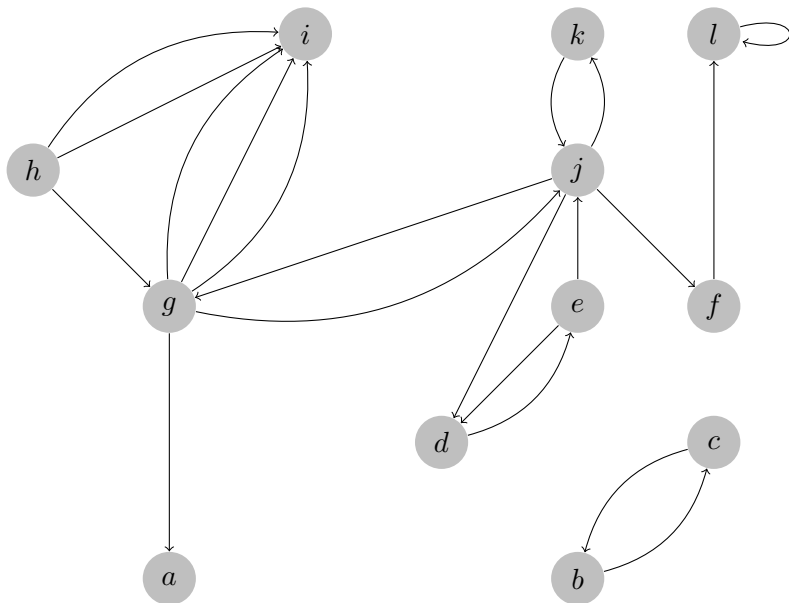
⇒ if B has a link from A, the rank of B increases by $\frac{Rank(A)}{Links(A)}$

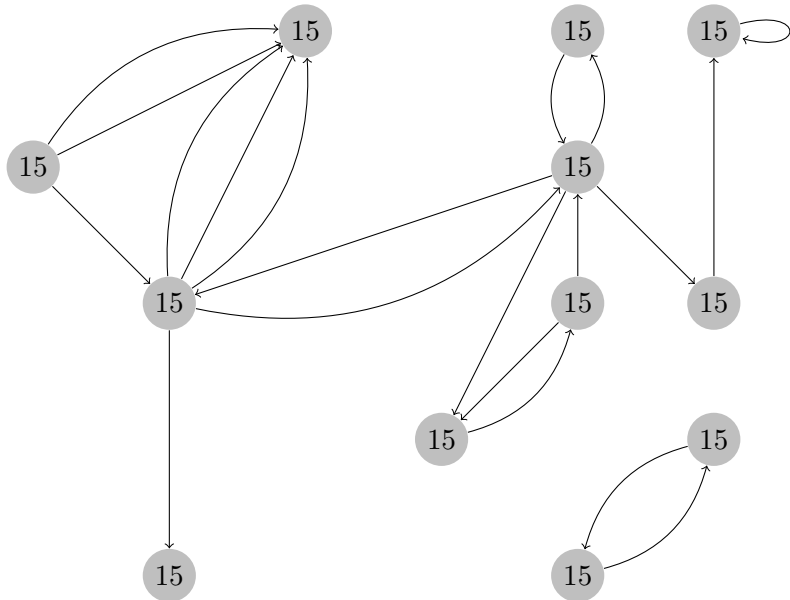
if A links to B then

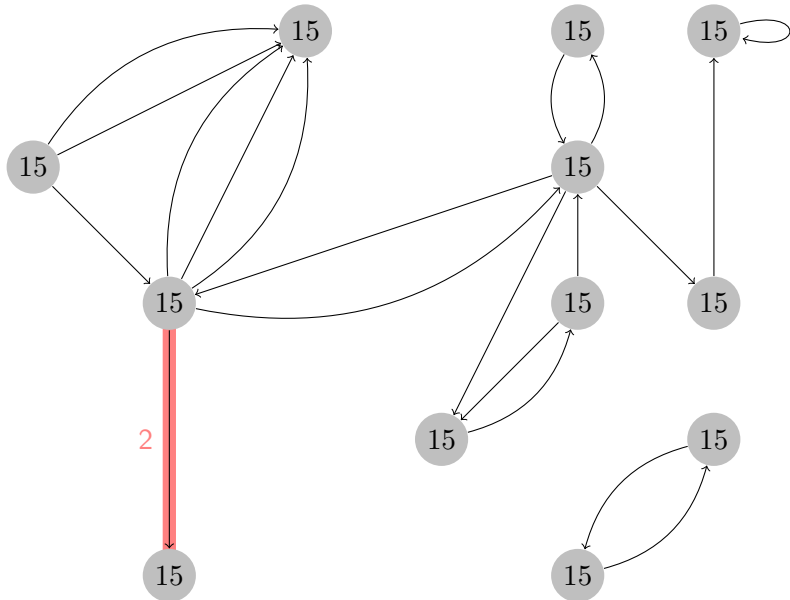
$$Rank(B) += \frac{Rank(A)}{Links(A)}$$

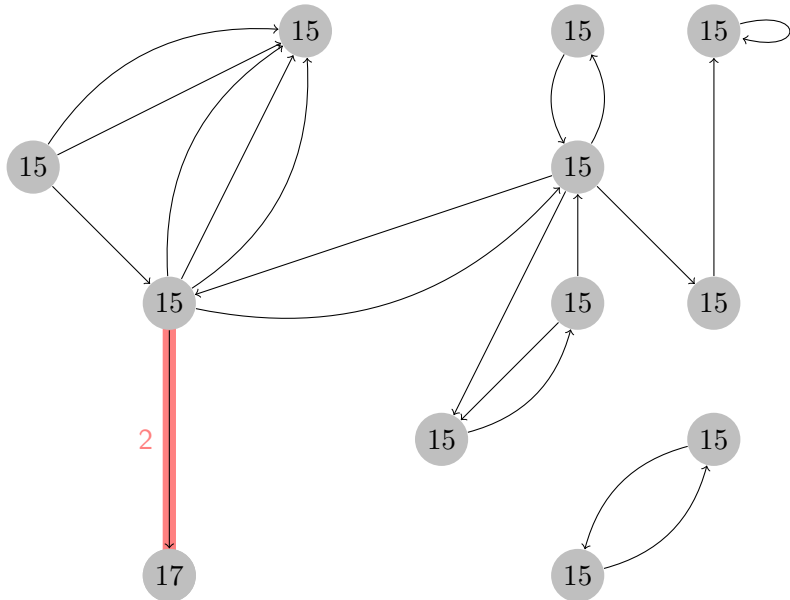
What is PageRank?

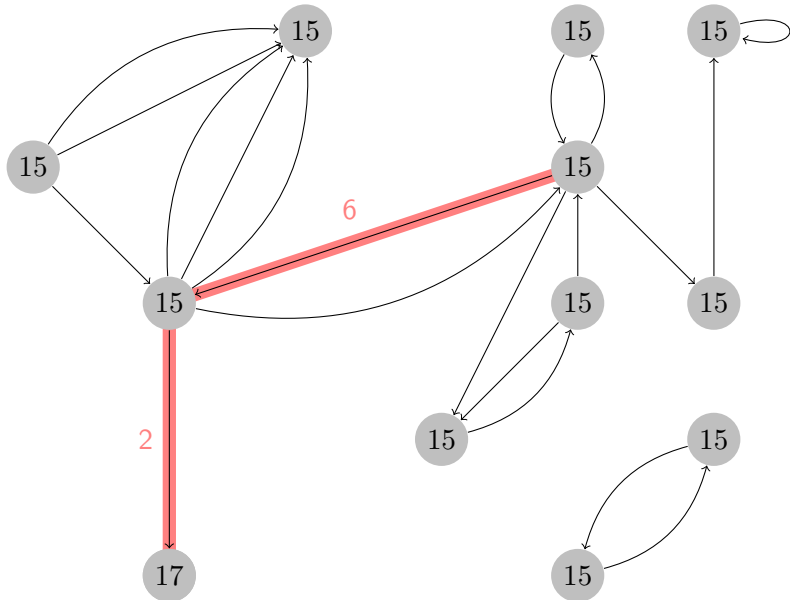
The PageRank algorithm calculates the probability of a randomly clicking user ending up on a given page.

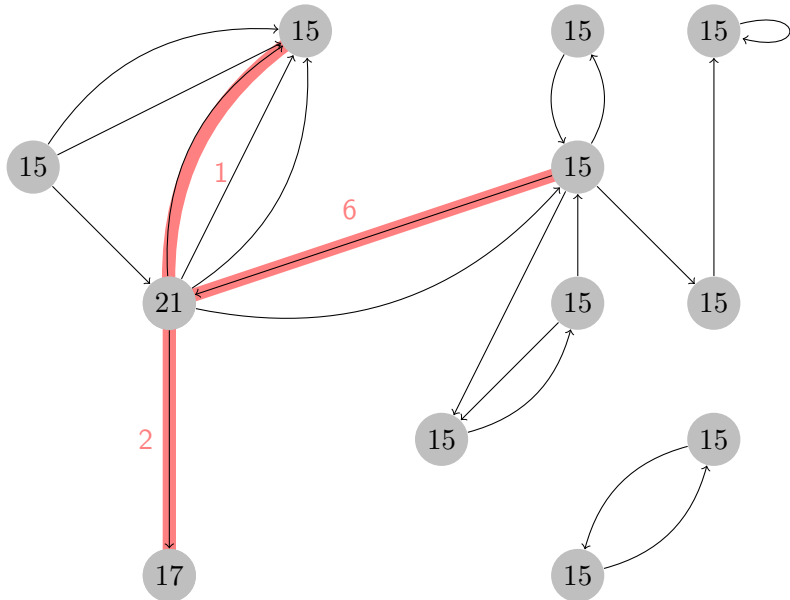


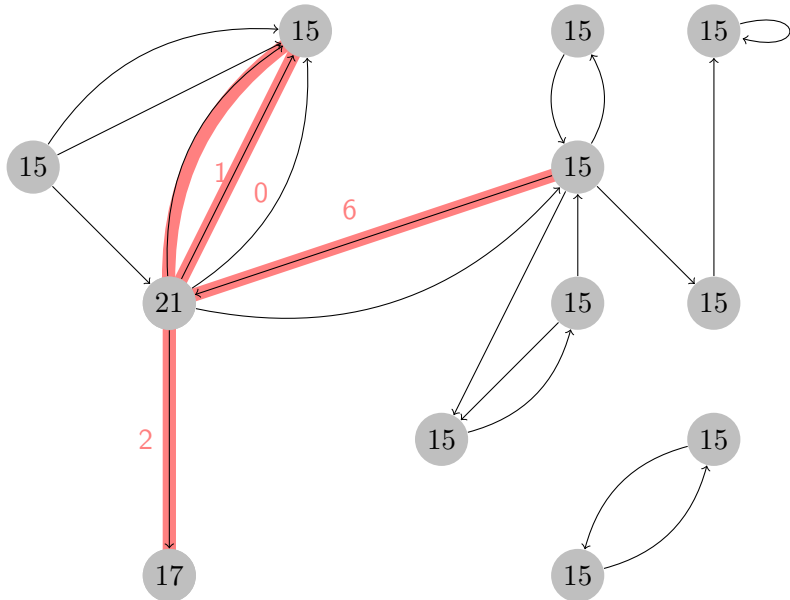


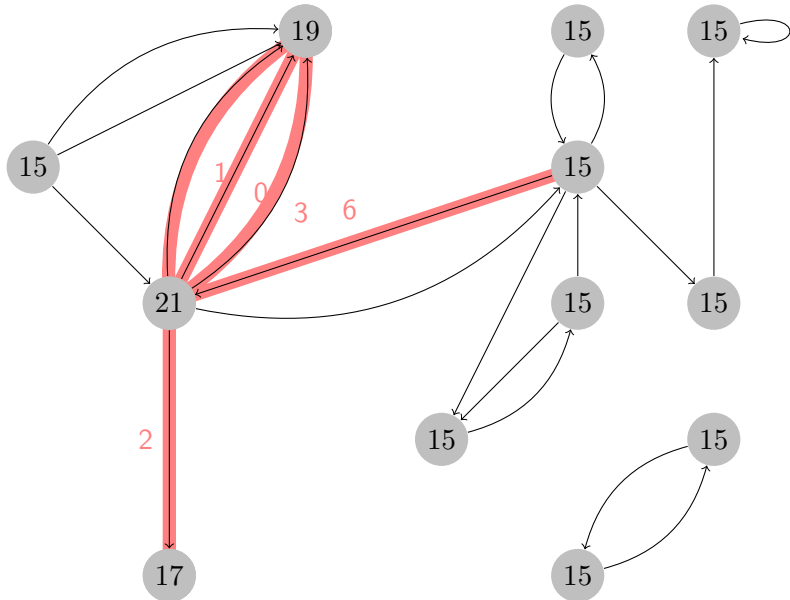












Let x be a web page. Then

- $L(x)$ is the set of websites that link to x
- $C(y)$ is the out-degree of page y
- α 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
- location
- social information: what your friends like

Factors of Influence

- language
- location
- social information: what your friends like

- language
- location
- social information: what your friends like

The Filter Bubble

dontbubble.us
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 content. The left sidebar shows the "Everything" tab 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
- 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 - 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/ - 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 - Cached - Similar

Egypt Travel, Tours, Vacations, Ancient Egypt from Tour Egypt
Information for travelers, resources on history, monuments and activities.
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/ - 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
- [Hyperlink](#) by Bernard Ladenthin
- screenshots of 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".