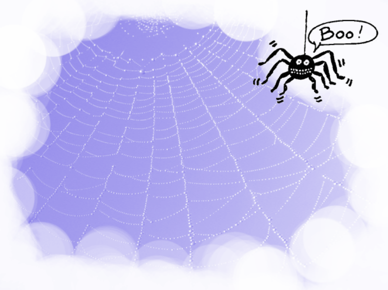
Mining Social and Semantic Network Data on the Web



Markus Schatten, PhD

University of Zagreb
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May 4, 2011

Introduction

Web 2.0, Semantic Web, Web 3.0

Network science

Data collection

- Semistructured data
- XPath
- Regular expressions
- Ajax
- APIs

Data analysis

- Network matrices
- Folksonomy model
- Logic programming

Case study - CROSBI

Outline

Questions

- Why mining social and semantic network data?
- How to collect these data?
- What are the common obstacles and how to solve them?
- How to analyze these data?

Outline

Web 2.0, Semantic Web, Web 3.0

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Why should one bother with these buzzwords?

Why mining (social) web data?

Millions of people,

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Millions of people, on thousands of sites,

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“Social systems are systems of communication”

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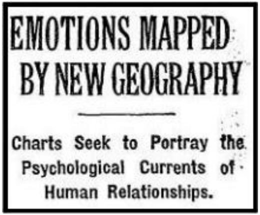
By analyzing the “trails” (the results of social systems structural coupling) we can analyze the social system itself:politics, culture, media, business, technology, science ...

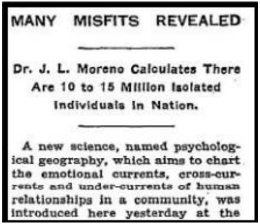
Outline

The “new” science of networks



EMOTIONS MAPPED BY NEW GEOGRAPHY

Charts Seek to Portray the Psychological Currents of Human Relationships.

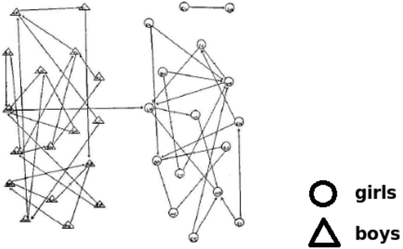


MANY MISFITS REVEALED

Dr. J. L. Moreno Calculates There Are 10 to 15 Million Isolated Individuals in Nation.

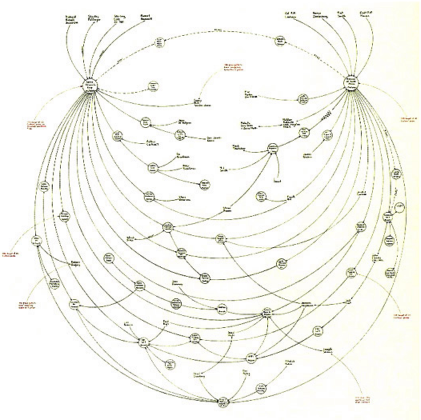
A new science, named psychological geography, which aims to chart the emotional currents, cross-currents and under-currents of human relationships in a community, was introduced here yesterday at the

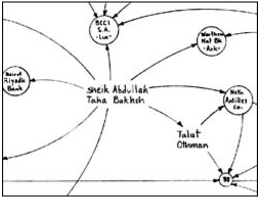
source: The New York Times (April 3rd, 1933., p. 17).



source: An Attraction Network in a Fourth Grade Class (Moreno, Who shall survive?, 1934).

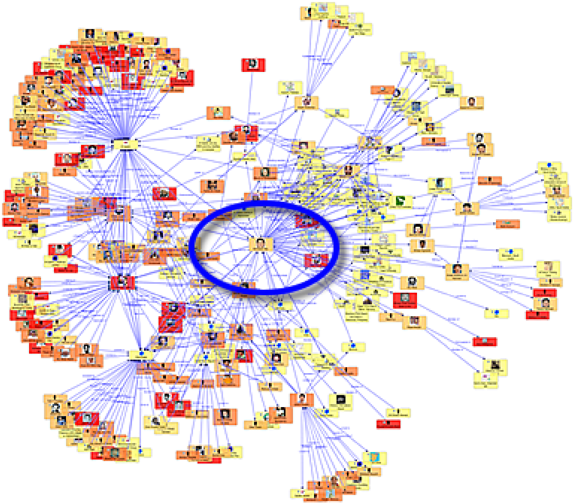
Political and financial networks



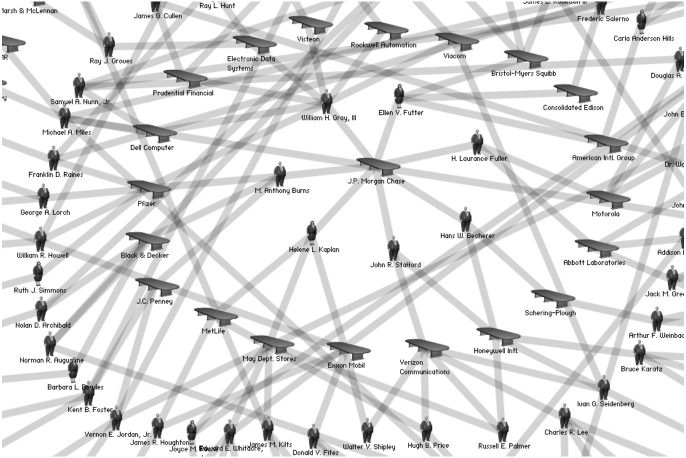


Mark Lombardi (1980s & 1990s)

Terrorist networks

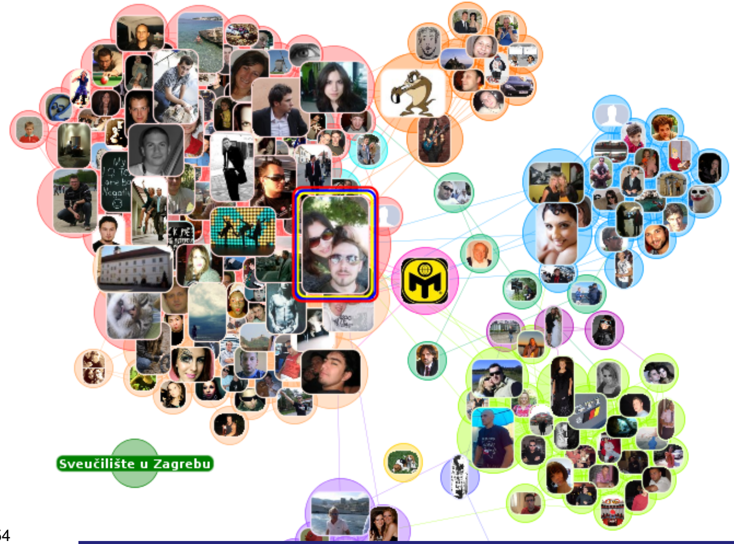


Board of directors membership networks

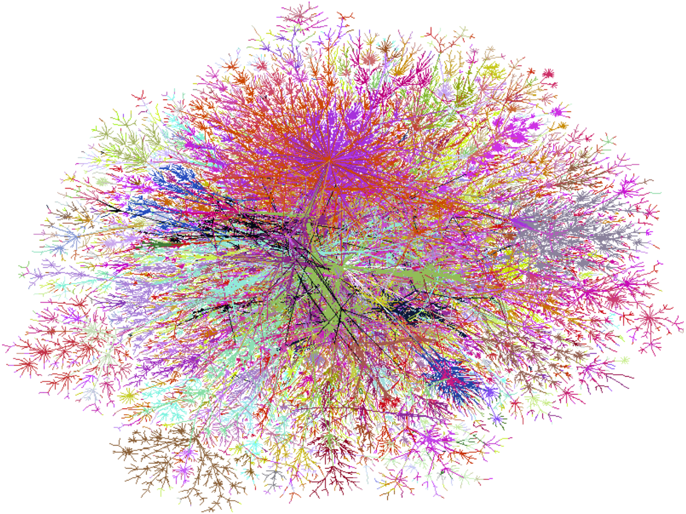


source: `http://theyrule.net`

On-line social networks

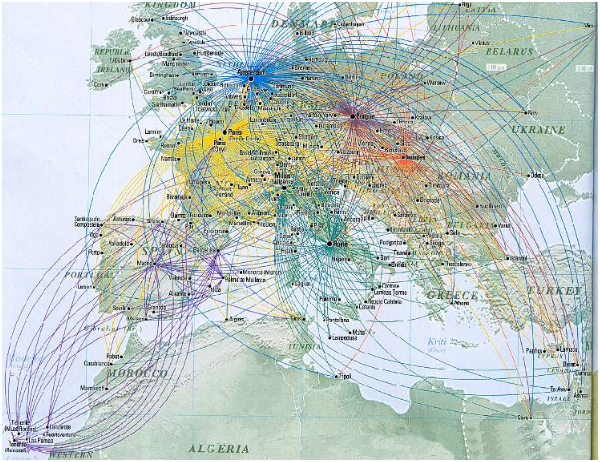


Internet



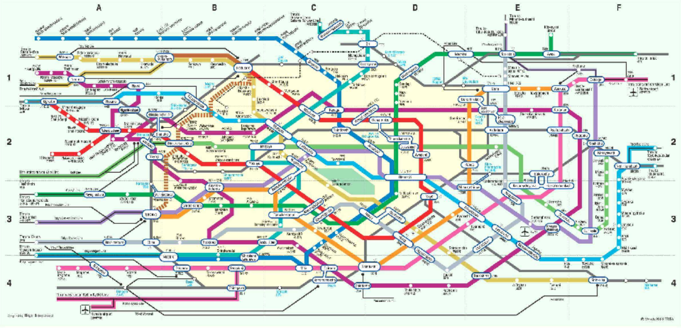
source: Bill Cheswick `http://www.cheswick.com/ches/map/gallery/index.html`

Air traffic networks



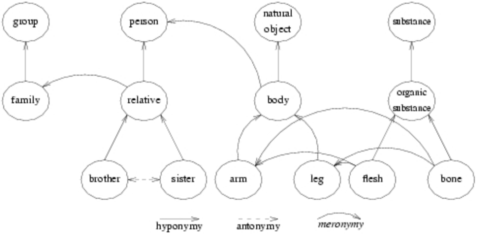
source: Northwest Airlines WorldTraveler Magazine

Railway networks



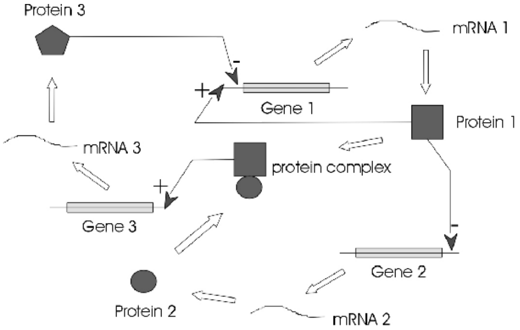
source: TRTA, March 2003 - Tokyo rail map

Semantic networks



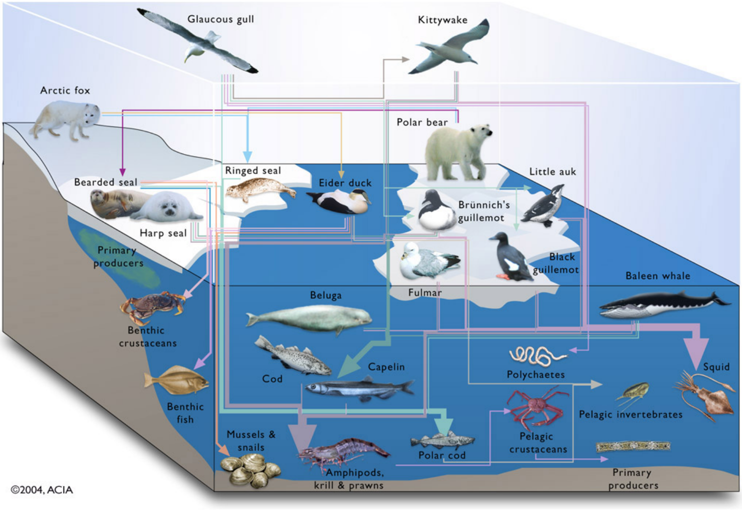
source: `http://wordnet.princeton.edu/man/wnlicens.7WN`

Gene networks



source: `http://www.zaik.uni-koeln.de/bioinformatik/regulatorynets.html.en`

Food chain networks



On-line social and semantic networks

Where can we find networks?

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A semantic network can be found in any specification where concepts are meaningfully connected.

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Data analysis

Case study - CROSBI

Common obstacles in data collection

- Semi-structured data (HTML, XHTML, XML, RDF, OWL ...)

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<div id="menu">
        <div id="menuitem">

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                <font color="red"></font><br />
                <strong>User Name:</strong><br />
                <input maxlength="30" name="login_user_name" size="10" tabindex="1" type="text" /><br /><br />
                <strong>Password:</strong><br />
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                <input name="submit" tabindex="4" type="submit" value="Login" />
                </form>
                <a href="register.php" title="Register">New user</a><br />
                <a href="lost_pass.php" title="Lost password!">Lost password!</a></div>
                <div id="menuitem"><b>Browse</b><br />
                <div id="menuitem">
                        <a href="project.php?browse=pro">Projects</a>
                </div>
                <div id="menuitem">
                        <a href="project.php?browse=org">Organizations</a>
                </div>
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- The need for pattern matching

TOP Administration (2009-11-26 13:02:10) - **Markus Schatten**
ompare to previous (23339)

TOP Administration (2011-01-30 05:47:00) - **Markus Schatten**
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- Client-side content generation

Aston V. - Stoke City

(archive pre-match odds)

Saturday, 23 Apr 2011, 16:00

Final result 1:1 (1:1,0:0)

→ Show all "Premier League" matches

Hidden bookmakers (register or log in to add any of them to comparison):

after a few seconds

Aston V. - Stoke City

(archive pre-match odds)

Saturday, 23 Apr 2011, 16:00

Final result 1:1 (1:1,0:0)

1X2 | AH | O/U | DNB | DC | CS | HT/FT | O/E

Full Time | 1st Half | 2nd Half

Bookmakers	1	X	2	Payout
10Bet	2.10	3.19	3.78	94.9%
12BET	2.20	3.06	3.72	95.2%
188bet	2.21	3.15	3.85	97.1%
5Dimes	2.21	3.23	3.92	98.3%
AllYouBet	2.10	3.19	3.78	94.9%
bet-at-home	2.05	3.10	3.70	92.5%

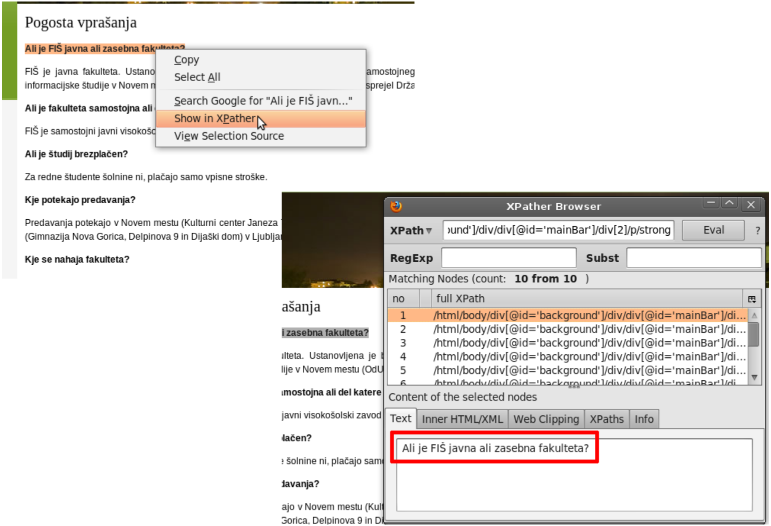
Semistructured data and XPath

- query language for semistructured data
- part of the W3C standard
- uses path expressions to navigate through documents
- has a standard library with over 100 useful functions

Example:

```
/html/body/div[@id='background']/div/div[@id='mainBar']/div/p[last()-1]/
```

XPather (Firefox add-on)



Regular expressions

- Useful for extracting various formatted data and searching for keywords

Example (date matching)

```
27-9-2001    [0-9]{1,2}[0-9]{1,2}[1-2][0-9]{3}
```

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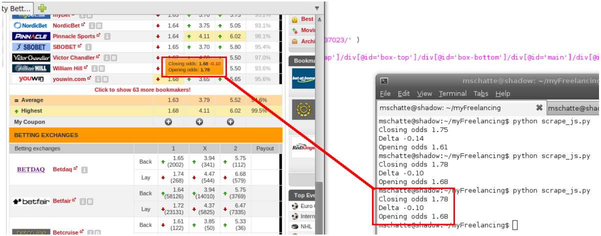

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  - Limited access rights (e.g. Facebook)
  - Limited queries per time interval (e.g. Twitter) etc.

Outline

Networks are most often analyzed using graph theory:

Definition

A graph $\mathcal{G}$ is the pair $(\mathcal{N}, \mathcal{E})$ whereby $\mathcal{N}$ represents the set of verticles or nodes, and $\mathcal{E} \subseteq \mathcal{N} \times \mathcal{N}$ the set of edges connecting pairs from $\mathcal{N}$.

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Definition

A directed graph or digraph $\mathcal{G}$ is the pair $(\mathcal{N}, \mathcal{A})$, whereby $\mathcal{N}$ represents the set of nodes, and $\mathcal{A} \subseteq \mathcal{N} \times \mathcal{N}$ the set of ordered pairs of elements from $\mathcal{N}$ that represent the set of graph arcs.

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Definition

A valued or weighted graph $\mathcal{G}_{\mathcal{V}}$ is the triple $(\mathcal{N}, \mathcal{A}, \mathcal{V})$ whereby $\mathcal{N}$ represents the set of nodes or verticles, $\mathcal{A} \subseteq \mathcal{N} \times \mathcal{N}$ the set of pairs of elements from $\mathcal{N}$ that represent the set of graph arcs, and $\mathcal{V} : \mathcal{N} \to \mathbb{R}$ a function that attaches values or weights to nodes.

Definition

A bipartite graph $\mathcal{G} = (\mathcal{N}, \mathcal{E})$ *is a graph for which set of nodes there exists an partition* $\mathcal{N} = \{X, Y\}$*, such that every arc has one end in* X*, a and the other in* Y*.*

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Definition

A multigraph $\mathcal{G} = (\mathcal{N}, \mathcal{E})$ is a graph in which $\mathcal{E}$ is a multiset, e.g. there can exist multiple edges between two nodes.

Matrix representation

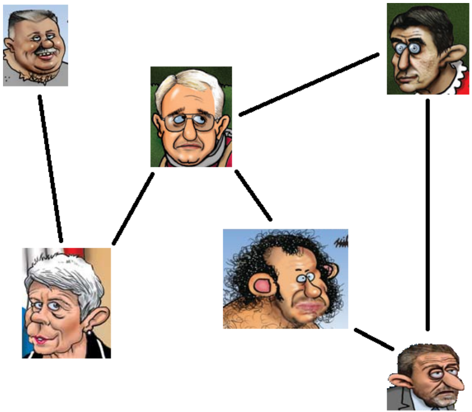
Definition

Let $\mathcal{G}$ be a graph defined with the set of nodes $\{n_1, n_2, ..., n_m\}$ and edges $\{e_1, e_2, ..., e_l\}$. For every i, j ($1 \leqslant i \leqslant m$ and $1 \leqslant j \leqslant m$) we define

$$a_{ij} = \begin{cases} 1, & \text{if there is an edge between nodes } n_i \text{ and } n_j \\ 0, & \text{otherwise} \end{cases}$$

Matrix $A = [a_{ij}]$ is then the adjacency matrix of graph $\mathcal{G}$. The matrix i symmetric since if there is an edge between nodes n_i and n_j then clearly there is also an edge between n_j and n_i. Thus $A = [a_{ij}] = [a_{ji}]$.

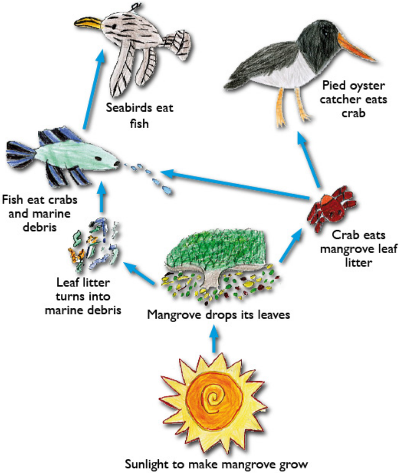
Simple graph



	0	1	0	0	0	1
	1	0	0	1	1	0
	0	0	0	1	0	0
	0	1	1	0	0	0
	0	1	0	0	0	1
	1	0	0	0	1	0

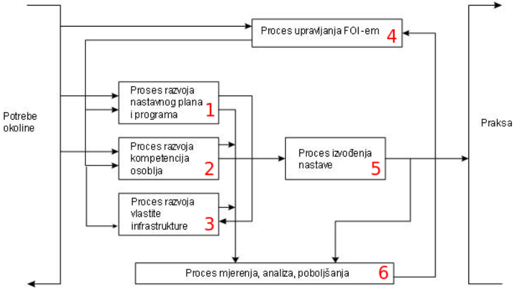
Slike by

Digraph



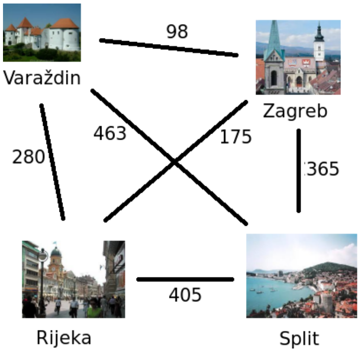
							
	0	0	0	0	0	0	0
	1	0	0	0	1	0	0
	0	0	0	0	0	0	0
	0	1	0	0	0	1	0
	0	0	1	0	0	0	0
	0	0	0	0	1	0	0
	0	0	0	1	0	0	0

Digraph



$$
\begin{array}{c|cccccc}
 & 1 & 2 & 3 & 4 & 5 & 6 \\
\hline
1 & 0 & 0 & 1 & 0 & 0 & 1 \\
2 & 0 & 0 & 0 & 0 & 1 & 1 \\
3 & 0 & 0 & 0 & 0 & 0 & 1 \\
4 & 1 & 1 & 1 & 0 & 0 & 0 \\
5 & 0 & 0 & 0 & 0 & 0 & 1 \\
6 & 0 & 0 & 0 & 1 & 0 & 0
\end{array}
$$

Weighted graph

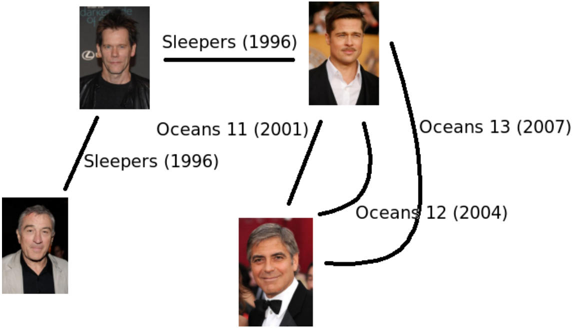


	Varaždin	Zagreb	Rijeka	Split
Varaždin	**0**	**98**	**280**	**463**
Zagreb	**98**	**0**	**175**	**365**
Rijeka	**280**	**175**	**0**	**405**
Split	**463**	**365**	**405**	**0**

Bipartite graph

Captain	1	1	0	0	0	0
Commander	0	1	1	0	0	0
Lt. Junior Grade	0	0	0	1	1	0
Lieutenant	0	0	0	1	1	0
Lt. Commander	0	0	0	1	1	1

Multigraph



0	1	0	3
1	0	1	0
0	1	0	0
3	0	0	0

Matrix algebra and interpretation

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$\mathbb{O}$ - process responsibility matrix ($p \times z$)

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- *A* - actors

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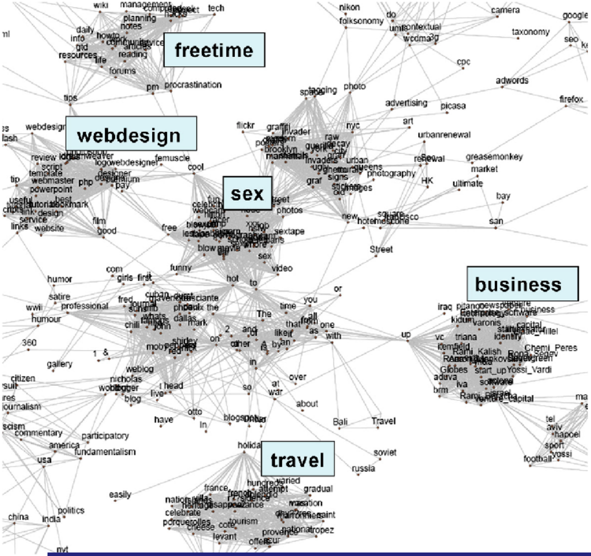
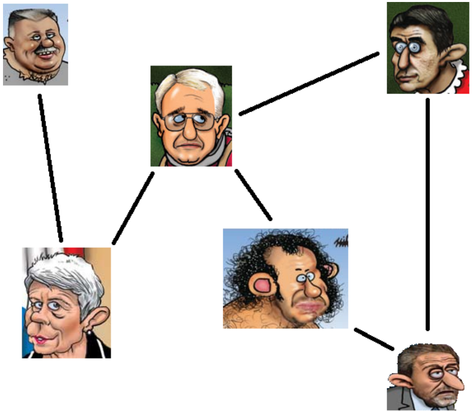
Delicious - analysis



delicious

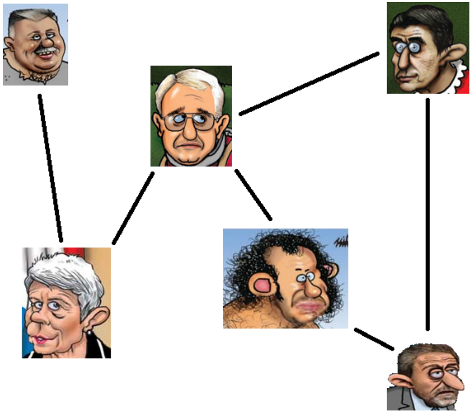
Problems with matrix representation



	0	1	0	0	0	1
	1	0	0	1	1	0
	0	0	0	1	0	0
	0	1	1	0	0	0
	0	1	0	0	0	1
	1	0	0	0	1	0

Slike by

Problems with matrix representation



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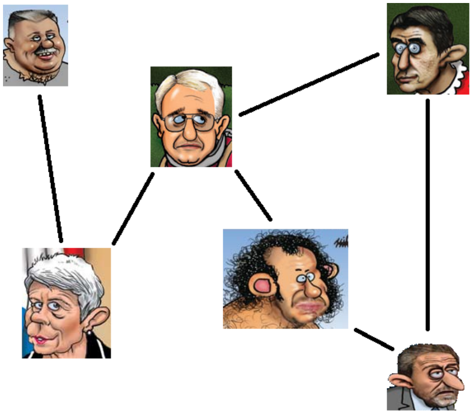
Slike by

- Only the “1”-s contain information

Sparse matrix



Slike by

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- Advantages:
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- Disadvantages:
  - Combinatoric explosion (use heuristics and predicate tabling)

Examples

If *A* is connected to *B*, then *B* is connected to *A*

```
link( A, B ) :- link( B, A ).
```

Examples

Friend of a friend

```
ff( A, B ) :- link( A, C ), link( C, B ).
```

Examples

Is there a path from node *A* to node *B*?

```
path( A, B ) :- link( A, B ).
path( A, B ) :- link( A, C ), path( C, B ).
```

Examples

Which path is that?

```
whichpath( X, Y, [ X, Y ] ) :- link( X, Y ).
whichpath( X, Y, [ X, Z | T ] ) :-
      link( X, Z ),
      whichpath( Z, Y, [ Z | T ] ).
```

Outline

Project outline

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  2. analyze how various scientific fields are conceptually and socially interrelated (do scientists do interdisciplinary research together if they have conceptually connected fields?)

Methodology

- Social systems are represented by their “trails”: CROSBI as the Croatian scientific community, Croatian Wikipedia as the Croatian public
- One system can interpret concepts from another if the concept exists within its conceptual network (e.g. keyword or wiki page)

Data collection

- CROSBI data has been collected using Scrapy in November 2010 (a total of 285,234 entries has been collected)
- Wikipedia data has been collected using the Wikipedia API + Scrapy for parsing

Results

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