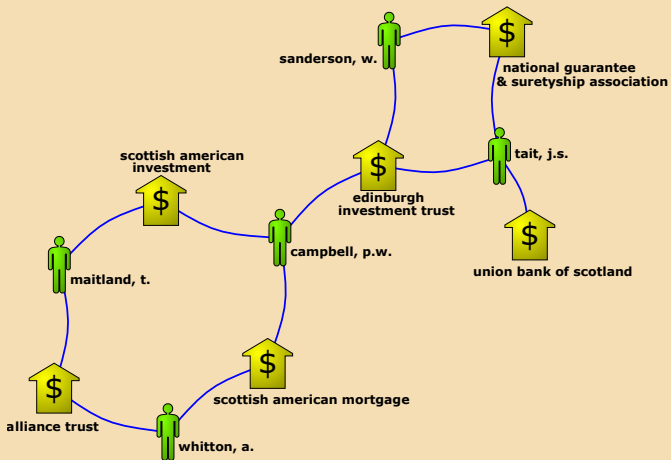


Types of Networks



Andrej Mrvar



Pajek Project File

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

All types of Pajek objects can be combined into a single file – **Pajek Project File** (*.paj). Pajek project file can be constructed in the following way:

- read all data files in Pajek,
- compute some additional data,
- delete (dispose) some data that is not needed,
- save all as a project file with:
File / Pajek Project File / Save
- next time we can restore everything using
File / Pajek Project File / Read



Pajek Session Files

Types of
Networks

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Text → Networks

Every time you run Pajek all steps / operations are stored in a session (log) file. It is stored in the same folder as **Pajek.exe** and has extension ***.log**. File names are **log1.log, log2.log...**

To repeat any session, select **Macro / Repeat Session** and select one of files **log*.***

Note that the log file with the latest number is the log file of the current Pajek session, and one before is the last finished Pajek session.

In this way we can also restore the previous session if it was (accidentally) finished / interrupted.

We can also record a **macro** to perform sequence of commands without running commands one by one.



Pajek

Unicode...

Using Unicode for labels

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

For storing non-latin labels (e.g. labels including č, š, ž, Chinese, Greek letters. . .) Pajek supports **Unicode**. **UTF-8** encoding is used. Pajek requires **BOM (Byte Order Mark)** to recognize UTF-8 files.

Pajek stores files in UTF-8 files with BOM if:

Save Files as Unicode UTF-8 and with BOM

are checked in **Options / Read - Write**.

If not, files are stored as ASCII files where non latin characters are stored using Unicode codes (e.g. Ž for Ž).

When č, š, ž are entered in cp1250, Windows10 automatically transformed them to Unicode.





Pajek

...Unicode

Using Unicode symbols for visualizing partitions

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

We can display Unicode symbols in the middle of vertices to visualize some property defined by a partition (e.g. gender).

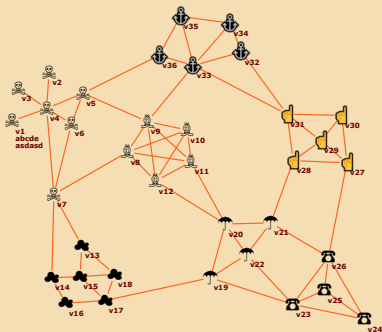
First select which Unicode symbol should present each cluster:

Draw / Options / Symbols for Partition Clusters

then select some partition as the *Second Partition*, and finally check:

Options / Mark Vertices Using / Cluster Symbols of Second Partition

More on using symbols: <http://mrvar.fdv.uni-lj.si/pajek/Symbols/symbols-examples.htm>





Excel2Pajek, Txt2Pajek

Types of Networks

Pajek Project File

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Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Links among vertices can be provided with pairs of vertices, which are not sequential numbers $1..n$, but any numbers or even labels which describe vertices.

We enter labels defining initial and terminal vertices in two columns of Excel file and use program **Excel2Pajek** to transform Excel file to Pajek file.

If we use text file instead of Excel file, we must use tabulator as delimiter among labels and then use program **Txt2Pajek**.



Multiple relations networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text→Networks

Networks containing multiple relations on the same set of vertices (*inviting to a party, borrowing teaching material, discussion about personal matters...*), Several relations can be stored in a single file. This can be done in two ways:

- add to a keyword for description of links:
`*arcs, *edges, *arcslist, *edgeslist, *matrix`
the number of relation followed by its name: e.g.
`*arcslist :3 "inviting to a party"`
All links controlled by this keyword belong to the specified relation (example: `sampsonmul.net 'Testdata'`).
- Any link controlled by `*arcs` or `*edges`, can be assigned to selected relation by starting its description by the number of this relation, e.g.
`3: 47 14 5`
Explanation: Link with endvertices 47 and 14 and weight 5 belongs to relation 3.



...Multiple relations networks

Types of Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Some Pajek commands:

Network / Multiple Relations Network / Info – number of arcs/edges in each relation.

Network / Multiple Relations Network / Extract Relation(s) into Separate Networks – extracting selected relations from multiple relations network.

Visualization of multiple relations networks:

Options / Colors / Edges / Relation Number and
Options / Colors / Arcs / Relation Number - colors of edges/arcs are determined by relation number

Options / Colors / Relation Colors - color table for relation numbers

Options / Lines / Draw Lines / Relations - showing only lines belonging to selected relations e.g. 1-3,6,10-15



Temporal networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text→Networks

Temporal network is network that is changing over time.

In temporal network vertices and lines are not necessarily present or active in all time points.

Additional parameters are used to define presence of vertices and lines. They are given between signs [and]:

– is used to divide lower and upper limit of interval,

, is used to separate intervals,

* means infinity. Example:

```
*Vertices 3
```

```
1 "a" [5-10,12-14]
```

```
2 "b" [1-3,7]
```

```
3 "c" [4-*
```

```
*Edges
```

```
1 2 1 [7]
```

```
1 3 1 [6-8]
```

Vertex 'a' is active from times 5 to 10, and 12 to 14, vertex 'b' in times 1 to 3 and in time 7, vertex 'c' from time 4 on. Edge from 1 to 2 is active only in time 7, edge from 1 to 3 in times 6 to 8.



Pajek

...Temporal networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Lines and vertices in a temporal network should satisfy the *consistency* condition: a line can be active in time t only if its end-vertices are active too. When generating time slices of a given temporal network only 'consistent' lines are generated. Note that time records should always be written at the end of the row where vertices / lines are defined.

Example 1: **Sampson monastery data** is a temporal network.

Sampson studied relations among 18 monks in the New England monastery. He measured several relations, e.g. *friendship* (*affect*), *esteem*, *influence*, *sanction* in different time points.

Reference: Sampson, S (1969): *Crysis in a cloister*. Unpublished doctoral dissertation. Cornell University



Pajek

...Temporal networks...

Types of
Networks

Pajek Project File

Pajek Session
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Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Example 2: **Lindenstrasse**: temporal network of actors and relations among them in the long-running German soap opera.

For each actor her/his name, gender, birthdate, and several other records are available. Additionally for each actor episode numbers in which the actor played actively are given. For each line in the network its meaning is given: family relation, business relation, unfriendly relationships, . . .

Properties of vertices are represented by different shapes, colors, sizes of vertices: e.g. triangles correspond to men, circles to women; and properties of lines are represented by colors: green line stands for family relation, blue for business relations,

LindenStrasse is **temporal** but also **multirelational** network:

- 1 "family relation" (arcs and edges)
- 2 "unfriendly relationships" (edges)
- 3 "business relations" (edges)
- 4 "friendships" (edges)
- 5 "partner relations" (edges)



...Temporal networks...

Types of Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Network / Temporal Network / Generate in Time

Generate network in specified time points or interval. Input first time, last time and step (integers).

- **All** – Generate all networks in specified time points.
- **Only Different** – Generate network in specified time point only if the new network will differ in at least one vertex or line from the previous network which was generated.
- **Interval** – Generate network with vertices and lines present in selected time interval.



Pajek

...Temporal networks...

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

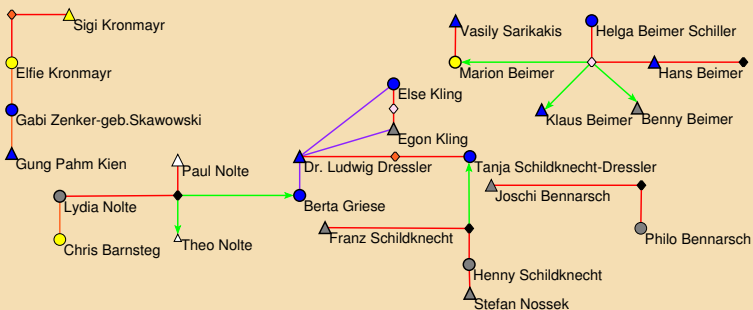
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Episode 5





Pajek

...Temporal networks...

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

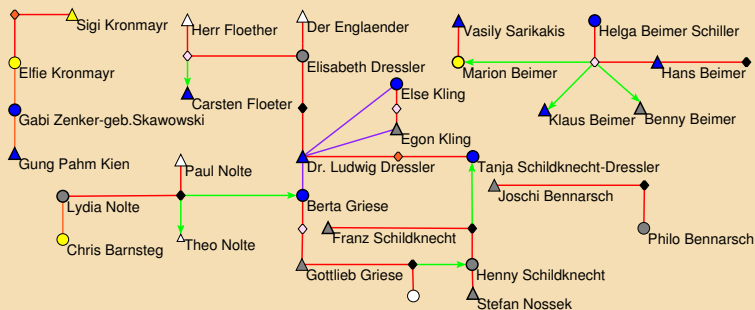
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Episode 6





Pajek

...Temporal networks...

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

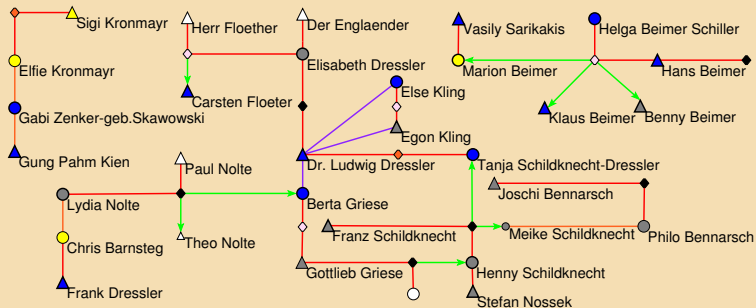
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Episode 7





Pajek

...Temporal networks...

Animations...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Using program **PajekToSVGAnim** we can prepare animations of temporal networks. Some examples of such animations:

- **Sampson monastery:** <http://mrvar.fdv.uni-lj.si/sola/info4/andrej/Anim/Sampson/sampson-anim.htm>
- **Sampson monastery as multirelation network:**
<http://mrvar.fdv.uni-lj.si/sola/info4/andrej/Anim/Sampson/sampson-multi-anim.htm>
- **Lindenstrasse:**
<http://mrvar.fdv.uni-lj.si/sola/info4/andrej/Anim/Linden/linden-anim.htm>



Pajek

...Temporal networks...

...Animations...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

First we have to prepare an input file. We can use program *Pajek* for this task:

- In *Pajek* load temporal network (e.g *Sampson.net*, *Sampson-Multi.net*, or *linden.net*).
- Generate networks in selected time points: **Network / Temporal Network / Generate in Time / Only Different.**
- In *Draw window* select **Export / Append to Pajek Project File / Select File** and select name of generated project file.
- First select the original network and add it to project file: **Export / Append to Pajek Project File / Append - F3**
- Proceed to network in the first time point, make some manual adjustments of vertices (if needed) and add it to project file (**F3**).
- Proceed to network in next time point, make some manual adjustments of vertices (if needed) and add it to project file (**F3**).
- When you add the network in last time point data preparation in Pajek is finished.



Pajek

...Temporal networks

...Animations

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Next, use program **PajekToSVGAnim** to create the animation:

- Select project file created by Pajek (e.g. `Sampson-Anim.paj`, `Sampson-Multi-Anim.paj`, or `Linden-Anim.paj`) using **Browse** in the **Source** field.
- Change some parameters, if needed.
- Run: **SVG / Generate - Firefox / Chrome**.

All files (temporal network, input project file generated by Pajek and animations) are available here:

- Sampson:
`http://mrvar.fdv.uni-lj.si/sola/info4/andrej/Anim/Sampson/Sampson.zip`
- Lindenstrasse:
`http://mrvar.fdv.uni-lj.si/sola/info4/andrej/Anim/Linden/Linden.zip`

Note that some options work only when run from server and not when run locally (e.g. showing / hiding relations).



Pajek

Networks obtained from texts...

Dictionary networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

In a dictionary network vertices are terms described in a dictionary; from term u there is an arc to term v when term v appears in the description of term u .

ODLIS – Online Dictionary of Library and Information Science

library

From the Latin *liber*, meaning "book." In Greek and the Romance languages, the corresponding term is *bibliotheca*. A collection or group of collections of books and/or other print or nonprint materials organized and maintained for use (reading, consultation, study, research, etc.). Institutional libraries, organized to facilitate access by a specific clientele, are staffed by librarians and other personnel trained to provide services to meet user needs. By extension, the room, building, or facility that houses such a collection, usually but not necessarily built for that purpose. Directory information on libraries is available alphabetically by country in *World Guide to Libraries*, a serial published by K.G. Saur. Two comprehensive worldwide online directories of library homepages are *Libdex* and *Libweb*. See also the UNESCO Libraries Portal. Abbreviated *lib*. **See also:** academic library, government library, monastic library, new library, proto-library, public library, special library, and subscription library.

Also, a collective noun used by publishers, particularly during the Victorian period, for certain books published in series (example: *Everyman's Library*).



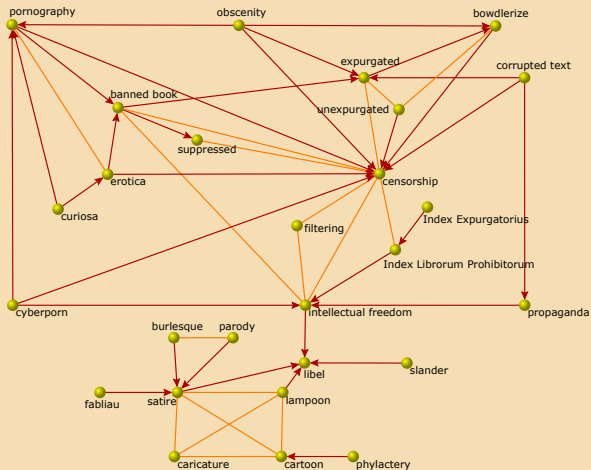
Pajek

...Networks obtained from texts...

...Dictionary networks...

Types of
Networks

ODLIS



Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks



Pajek

...Networks obtained from texts...

...Dictionary networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text→Networks

FOLDOC – Free On-line Dictionary Of Computing

computer

<computer>

A machine that can be programmed to manipulate symbols. Computers can perform complex and repetitive procedures quickly, precisely and reliably and can store and retrieve large amounts of data. Most computers in use today are electronic **digital computers** (as opposed to **analogue computers**).

The physical components from which a computer is constructed are known as **hardware**, which can be of four types: **CPU**, **memory**, **input devices** and **output devices**.



Pajek

...Networks obtained from texts...

...Dictionary networks

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

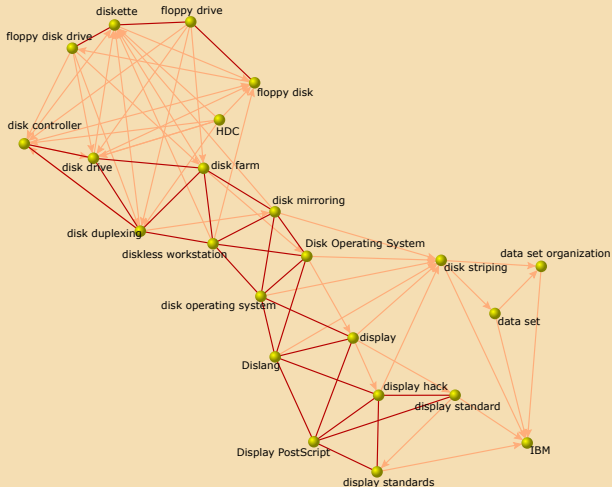
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

FOLDOC





Pajek

...Networks obtained from texts...

Associations

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

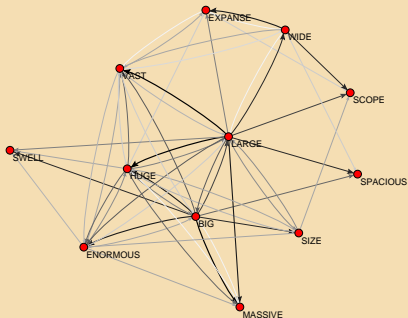
Multiple relations

Temporal network

Text → Networks

Edinburgh Associative Thesaurus - EAT

In this network associations among words collected on student population are provided. Vertices are words. Links $u \rightarrow v$ are determined using the following question: Which word v comes into your mind when you hear word u ? The weight tells us how many times this association was selected.





Pajek

...Networks obtained from texts...

Semantic networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Semantic network

WordNet – A Lexical Database for English

Multirelational network with the following relations:

- 1 hypernym pointers (maple.tree, tree.plant, fire.attack)
- 2 entailment pointers (drive.ride push.press)
- 3 similar pointers (boiling.hot)
- 4 member meronym pointers (Luxemburg.Benelux), (the Netherlands.Benelux)
- 5 substance meronym pointers (pavement.street)
- 6 part meronym pointers (medical-diagnosis.medical-care)
- 7 cause pointers (anesthetize.sleep, pasteurize.condense)
- 8 grouped verb pointers (exit.leave)
- 9 attribute pointers (quality.bad)



Pajek

...Networks obtained from texts...

...Semantic networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

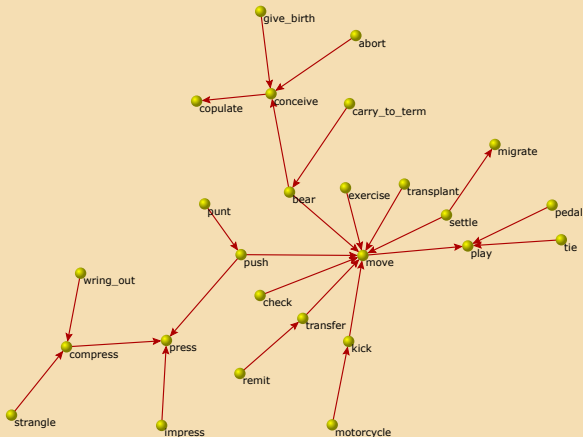
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

WordNet - Entailment pointers





Pajek

...Networks obtained from texts...

...Semantic networks...

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

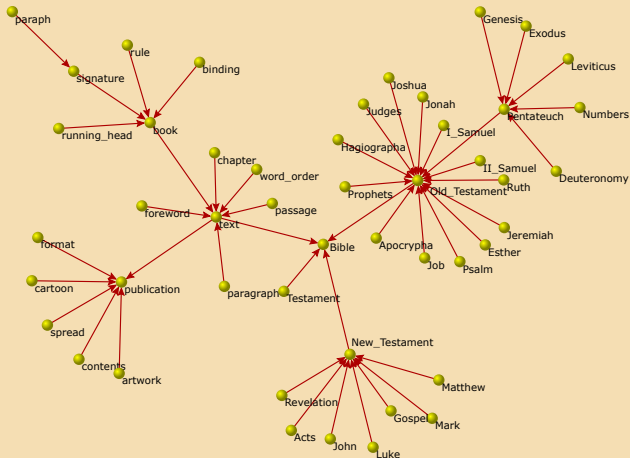
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

WordNet - Part meronymy pointers





Pajek

...Networks obtained from texts...

...Semantic networks...

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

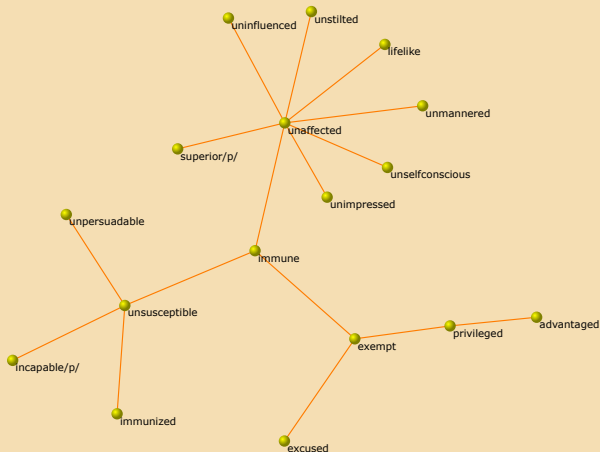
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

WordNet - Similar pointers





Pajek

...Networks obtained from texts...

...Semantic networks

Types of Networks

Pajek Project File

Pajek Session Files

Unicode

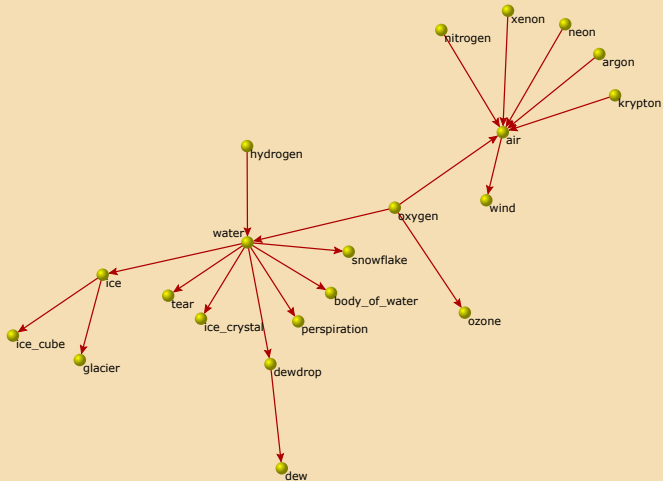
Excel2Pajek

Multiple relations

Temporal network

Text → Networks

WordNet - Substance meronymy pointers





Pajek

...Networks obtained from texts

Changing, deleting, adding letters

Types of
Networks

Pajek Project File

Pajek Session
Files

Unicode

Excel2Pajek

Multiple relations

Temporal network

Text → Networks

Two words are connected by an edge if we can reach one from the other by

- changing a single character (e. g., *work* — *word*)
- adding / removing a single character (e. g., *ever* — *fever*).

Examples: **Dic28**, **SI5**

