NetsJSON

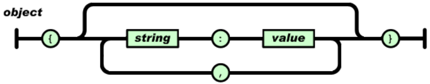
Vladimir Batagelj

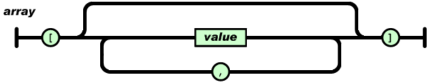
IMFM Ljubljana, IAM UP Koper, and NRU HSE Moscow

UP FAMNIT & IAM Computer science seminar and Mathematical research seminar

Koper, April 6, 2020

Outline

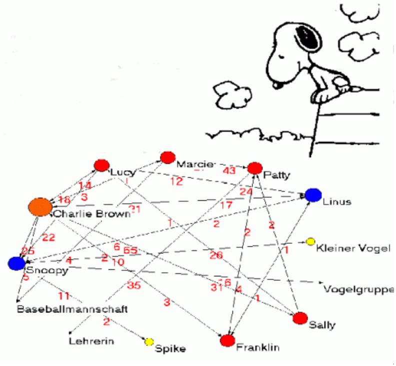




Vladimir Batagelj: vladimir.batagelj@fmf.uni-lj.si

Version (April 6, 2020, 15 : 21): NetsJSON-UP.pdf

Networks



Alexandra Schuler/ Marion Laging-Glaser: Analyse von Snoopy Comics

A *network* is based on two sets – set of *nodes* (vertices), that represent the selected *units*, and set of *links* (lines), that represent *ties* between units. They determine a *graph*. A link can be *directed* – an *arc*, or *undirected* – an *edge*.

Additional data about nodes or links can be known – their *properties* (attributes). For example: name/label, type, value, . . .

Network = Graph + Data

The data can be measured or computed.

Networks / Formally

A *network* $\mathcal{N} = (\mathcal{V}, \mathcal{L}, \mathcal{P}, \mathcal{W})$ consists of:

- a *graph* $\mathcal{G} = (\mathcal{V}, \mathcal{L})$, where $\mathcal{V}$ is the set of nodes, $\mathcal{A}$ is the set of arcs, $\mathcal{E}$ is the set of edges, and $\mathcal{L} = \mathcal{E} \cup \mathcal{A}$ is the set of links.
  $n = |\mathcal{V}|$, $m = |\mathcal{L}|$
- $\mathcal{P}$ *node value functions* / properties: $p : \mathcal{V} \to A$
- $\mathcal{W}$ *link value functions* / weights: $w : \mathcal{L} \to B$

Visual complexity, Icon index, Network Repository

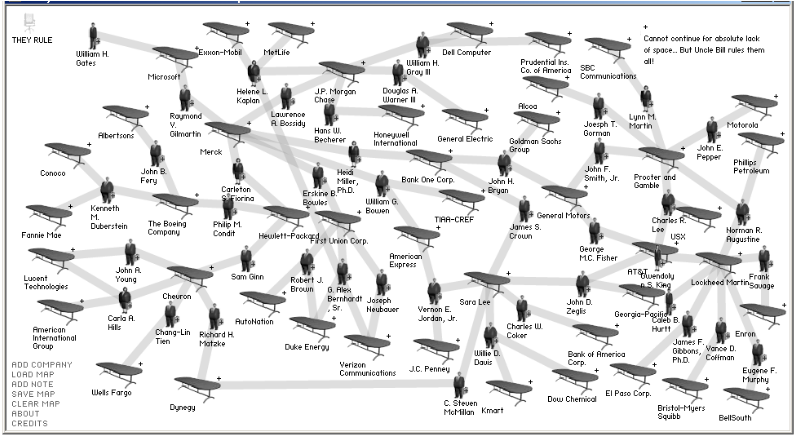
Two-mode networks

In a *two-mode* network $\mathcal{N} = ((\mathcal{U}, \mathcal{V}), \mathcal{L}, \mathcal{P}, \mathcal{W})$ the set of nodes consists of two disjoint sets of nodes $\mathcal{U}$ and $\mathcal{V}$, and all the links from $\mathcal{L}$ have one endnode in $\mathcal{U}$ and the other node in $\mathcal{V}$.

A classical example of two-mode network are the Southern women (Davis 1941).

Names of Participants of Group I	Code Numbers and Dates of Social Events Reported in *Old City Herald*													
	(1) 6/27	(2) 3/2	(3) 4/12	(4) 9/26	(5) 2/25	(6) 5/19	(7) 3/15	(8) 9/16	(9) 4/8	(10) 6/10	(11) 2/23	(12) 4/7	(13) 11/21	(14) 8/3
1. Mrs. Evelyn Jefferson	×	×	×	×	×	×		×	×					
2. Miss Laura Mandeville	×	×	×		×	×	×	×						
3. Miss Theresa Anderson		×	×	×	×	×	×	×	×					
4. Miss Brenda Rogers	×		×	×	×	×	×	×						
5. Miss Charlotte McDowd			×	×	×		×							
6. Miss Frances Anderson			×		×	×		×						
7. Miss Eleanor Nye					×	×	×	×						
8. Miss Pearl Oglethorpe						×		×	×					
9. Miss Ruth DeSand					×		×	×	×					
10. Miss Verne Sanderson							×	×	×			×		
11. Miss Myra Liddell								×	×	×		×		
12. Miss Katherine Rogers								×	×	×		×	×	×
13. Mrs. Sylvia Avondale							×	×	×	×		×	×	×
14. Mrs. Nora Fayette						×	×		×	×	×	×	×	×
15. Mrs. Helen Lloyd							×	×		×	×	×		
16. Mrs. Dorothy Murchison								×	×					
17. Mrs. Olivia Carleton									×		×			
18. Mrs. Flora Price									×		×			

They Rule


THEY RULE
William H. Gates
Microsoft
Exxon-Mobil
MetLife
Helene L. Kaplan
Raymond V. Gilmartin
Lawrence A. Bossidy
J.P. Morgan Chase
William H. Gray III
Douglas A. Warner III
Dell Computer
Prudential Ins. Co. of America
SBC Communications
Cannot continue for absolute lack of space... But Uncle Bill rules them all!
Albertsons
Merck
Hans W. Becherer
Honeywell International
General Electric
Alcoa
Goldman Sachs Group
Joesph T. Gorman
Lynn M. Martin
Motorola
John E. Pepper
Phillips Petroleum
Conoco
John B. Fery
Carleton S. Fiorina
Heidi Miller, Ph.D.
Erskine B. Bowles
William G. Bowen
Bank One Corp.
John H. Bryan
John F. Smith, Jr.
Procter and Gamble
Fannie Mae
Kenneth M. Duberstein
The Boeing Company
Philip M. Condit
Hewlett-Packard
First Union Corp.
TIAA-CREF
James S. Crown
General Motors
Charles R. Lee
USX
Norman R. Augustine
American Express
George M.C. Fisher
Lucent Technologies
John A. Young
Chevron
Sam Ginn
Robert J. Brown
G. Alex Bernhardt, Sr.
Joseph Neubauer
Vernon E. Jordan, Jr.
Sara Lee
John D. Zeglis
AT&T
Gwendolyn S. King
Lockheed Martin
Frank Savage
American International Group
Carla A. Hills
Chang-Lin Tien
Richard H. Matzke
AutoNation
Duke Energy
Charles W. Coker
Georgia-Pacific
Caleb B. Hurtt
Enron
Willie D. Davis
Bank of America Corp.
James F. Gibbons, Ph.D.
Vance D. Coffman
Eugene F. Murphy
ADD COMPANY
LOAD MAP
ADD NOTE
SAVE MAP
CLEAR MAP
ABOUT
CREDITS
Wells Fargo
Dynegy
Verizon Communications
J.C. Penney
C. Steven McMillan
Kmart
Dow Chemical
El Paso Corp.
Bristol-Myers Squibb
BellSouth

Temporal network

A *temporal network*

$$\mathcal{N}_T = (\mathcal{V}, \mathcal{L}, \mathcal{P}, \mathcal{W}, T)$$

is obtained if the *time* T is attached to an ordinary network. T is a set of *time points* $t \in T$.

In temporal network nodes $v \in \mathcal{V}$ and links $l \in \mathcal{L}$ are not necessarily present or active in all time points. If a link $l(u, v)$ is active in time point t then also its endnodes u and v should be active in time t.

Also the properties of nodes and links can change through time. To describe the changes we introduce the temporal quantities (TQ) [5, 2].

We denote the network consisting of links and nodes active in time $t \in T$ by $\mathcal{N}(t)$ and call it a *time slice* in time point t.

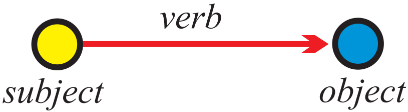
Multirelational networks

In a *multirelational* network

$$\mathcal{N} = (\mathcal{V}, (\mathcal{L}_1, \mathcal{L}_2, \ldots, \mathcal{L}_k), \mathcal{P}, \mathcal{W})$$

the set of links $\mathcal{L}$ is partitioned into subsets (*relations*) $\mathcal{L}_i$.

Important for encoding textual data according to the S-V-O (*Subject-Verb-Object*) model or its improvements.



Examples: Roberto Franzosi; *KEDS*, *Tabari*, KEDS / Gulf.
This coding can be directly considered as network with *Subjects* ∪ *Objects* as nodes and links (arcs) labeled with *Verbs*.

See also RDF triples in semantic web, SPARQL.

```
% Recoded by WEISmonths, Sun Nov 28 21:57:00 2004
% from http://www.ku.edu/~keds/data.dir/balk.html
*vertices 325
1 "AFG" [1-*]
2 "AFR" [1-*]
3 "ALB" [1-*]
4 "ALBMED" [1-*]
5 "ALG" [1-*]
 ...
318 "YUGGOV" [1-*]
319 "YUGMAC" [1-*]
320 "YUGMED" [1-*]
321 "YUGMTN" [1-*]
322 "YUGSER" [1-*]
323 "ZAI" [1-*]
324 "ZAM" [1-*]
325 "ZIM" [1-*]
*arcs :0 "*** ABANDONED"
*arcs :10 "YIELD"
*arcs :11 "SURRENDER"
*arcs :12 "RETREAT"
 ...
*arcs :223 "MIL ENGAGEMENT"
*arcs :224 "RIOT"
*arcs :225 "ASSASSINATE TORTURE"
*arcs
224: 314 153 1 [4]          890402  YUG     KSV     224  (RIOT)  RIOT-TORN
212: 314 83 1 [4]           890404  YUG     ETHALB  212  (ARREST PERSON) ALB ETHNIC JAILED
224: 3 83 1 [4]             890407  ALB     ETHALB  224  (RIOT)  RIOTS
123: 83 153 1 [4]           890408  ETHALB  KSV     123  (INVESTIGATE)   PROBING
 ...
42: 105 63 1 [175]          030731  GER     CYP     042  (ENDORSE)       GAVE SUPPORT
212: 295 35 1 [175]         030731  UNWCT   BOSSER  212  (ARREST PERSON) SENTENCED TO PRIS
43: 306 87 1 [175]          030731  VAT     EUR     043  (RALLY) RALLIED
13: 295 35 1 [175]          030731  UNWCT   BOSSER  013  (RETRACT)       CLEARED
121: 295 22 1 [175]         030731  UNWCT   BAL     121  (CRITICIZE)     CHARGES
122: 246 295 1 [175]        030731  SER     UNWCT   122  (DENIGRATE)     TESTIFIED
121: 35 295 1 [175]         030731  BOSSER  UNWCT   121  (CRITICIZE)     ACCUSED
```

Kansas Event Data System *KEDS*

Linked networks

In a *linked* or *multimodal* network

$$\mathcal{N} = ((\mathcal{V}_1, \mathcal{V}_2, \ldots, \mathcal{V}_j), (\mathcal{L}_1, \mathcal{L}_2, \ldots, \mathcal{L}_k), \mathcal{P}, \mathcal{W})$$

the set of nodes $\mathcal{V}$ is partitioned into subsets (*modes*) $\mathcal{V}_i$, $\mathcal{L}_s \subseteq \mathcal{V}_p \times \mathcal{V}_q$, and properties and weights are usually partial functions.

Description of networks using a spreadsheet

How to describe a network $\mathcal{N}$? In principle the answer is simple – we list its components $\mathcal{V}$, $\mathcal{L}$, $\mathcal{P}$, and $\mathcal{W}$.

The simplest way is to describe a network $\mathcal{N}$ by providing $(\mathcal{V}, \mathcal{P})$ and $(\mathcal{L}, \mathcal{W})$ in a form of two tables.

As an example, let us describe a part of network determined by the following works:
Generalized blockmodeling, Clustering with relational constraint, Partitioning signed social networks, The Strength of Weak Ties

There are nodes of different types (modes): persons, papers, books, series, journals, publishers; and different relations among them: author_of, editor_of, contained_in, cites, published_by.

Both tables are often maintained in Excel. They can be exported as text in CSV (Comma Separated Values) format.

bibNodes.csv

```
name;mode;country;sex;year;vol;num;fPage;lPage;x;y
"Batagelj, Vladimir";person;SI;m;;;;;;809.1;653.7
"Doreian, Patrick";person;US;m;;;;;;358.5;679.1
"Ferligoj, Anuška";person;SI;f;;;;;;619.5;680.7
"Granovetter, Mark";person;US;m;;;;;;145.6;660.5
"Moustaki, Irini";person;UK;f;;;;;;783.0;228.0
"Mrvar, Andrej";person;SI;m;;;;;;478.0;630.1
"Clustering with relational constraint";paper;;;1982;47;;413;426;684.1;3
"The Strength of Weak Ties";paper;;;1973;78;6;1360;1380;111.3;329.4
"Partitioning signed social networks";paper;;;2009;31;1;1;11;408.0;337.8
"Generalized Blockmodeling";book;;;2005;24;;1;385;533.0;445.9
"Psychometrika";journal;;;;;;;;741.8;086.1
"Social Networks";journal;;;;;;;;321.4;236.5
"The American Journal of Sociology";journal;;;;;;;;111.3;168.9
"Structural Analysis in the Social Sciences";series;;;;;;;;310.4;082.8
"Cambridge University Press";publisher;UK;;;;;;;534.3;238.2
"Springer";publisher;US;;;;;;;884.6;174.0
```

bibNodes.csv

In large networks, to avoid the empty cells, we split a network to some subnetworks – a collection.

bibLinks.csv


```
from;relation;to
"Batagelj, Vladimir";authorOf;"Generalized Blockmodeling"
"Doreian, Patrick";authorOf;"Generalized Blockmodeling"
"Ferligoj, Anuška";authorOf;"Generalized Blockmodeling"
"Batagelj, Vladimir";authorOf;"Clustering with relational constraint"
"Ferligoj, Anuška";authorOf;"Clustering with relational constraint"
"Granovetter, Mark";authorOf;"The Strength of Weak Ties"
"Granovetter, Mark";editorOf;"Structural Analysis in the Social Sciences
"Doreian, Patrick";authorOf;"Partitioning signed social networks"
"Mrvar, Andrej";authorOf;"Partitioning signed social networks"
"Moustaki, Irini";editorOf;"Psychometrika"
"Doreian, Patrick";editorOf;"Social Networks"
"Generalized Blockmodeling";containedIn;"Structural Analysis in the Soci
"Clustering with relational constraint";containedIn;"Psychometrika"
"The Strength of Weak Ties";containedIn;"The American Journal of Sociolo
"Partitioning signed social networks";containedIn;"Social Networks"
"Partitioning signed social networks";cites;"Generalized Blockmodeling"
"Generalized Blockmodeling";cites;"Clustering with relational constraint
"Structural Analysis in the Social Sciences";publishedBy;"Cambridge Univ
"Psychometrika";publishedBy;"Springer"
```

bibLinks.csv

Factorization and description of large networks

To save space and improve the computing efficiency we often replace values of categorical variables with integers. In R this encoding is called a *factorization*.

We enumerate all possible values of a given categorical variable (coding table) and afterwards replace each its value by the corresponding index in the coding table.

This approach is used in most programs dealing with large networks. Unfortunately the coding table is often a kind of meta-data.

CSV2Pajek.R

```
# transforming CSV file to Pajek files
# by Vladimir Batagelj, June 2016
# setwd("C:/Users/batagelj/work/Python/graph/SVG/EUSN")
# colC <- c(rep("character",4),rep("numeric",7)); nas=c("","NA","NaN")
colC <- c(rep("character",4),rep("numeric",5)); nas=c("","NA","NaN")
nodes <- read.csv2("bibNodes.csv",encoding='UTF-8',colClasses=colC,na.strings=nas)
n <- nrow(nodes); M <- factor(nodes$mode); S <- factor(nodes$sex)
mod <- levels(M); sx <- levels(S); S <- as.numeric(S); S[is.na(S)] <- 0
links <- read.csv2("bibLinks.csv",encoding='UTF-8',colClasses="character")
F <- factor(links$from,levels=nodes$name,ordered=TRUE)
T <- factor(links$to,levels=nodes$name,ordered=TRUE)
R <- factor(links$relation); rel <- levels(R)
net <- file("bib.net","w"); cat('*vertices ',n,'\n',file=net)
clu <- file("bibMode.clu","w"); sex <- file("bibSex.clu","w")
cat('%',file=clu); cat('%',file=sex)
for(i in 1:length(mod)) cat(' ',i,mod[i],file=clu)
cat('\n*vertices ',n,'\n',file=clu)
for(i in 1:length(sx)) cat(' ',i,sx[i],file=sex)
cat('\n*vertices ',n,'\n',file=sex)
for(v in 1:n) {
  cat(v,' "',nodes$name[v],'"\n',sep='',file=net);
  cat(M[v],'\n',file=clu); cat(S[v],'\n',file=sex)
}
for(r in 1:length(rel)) cat('*arcs :',r,' "',rel[r],'"\n',sep='',file=net)
cat('*arcs\n',file=net)
for(a in 1:nrow(links))
  cat(R[a],': ',F[a],' ',T[a],' 1 l "',rel[R[a]],'"\n',sep='',file=net)
close(net); close(clu); close(sex)
```

CSV2Pajek.R

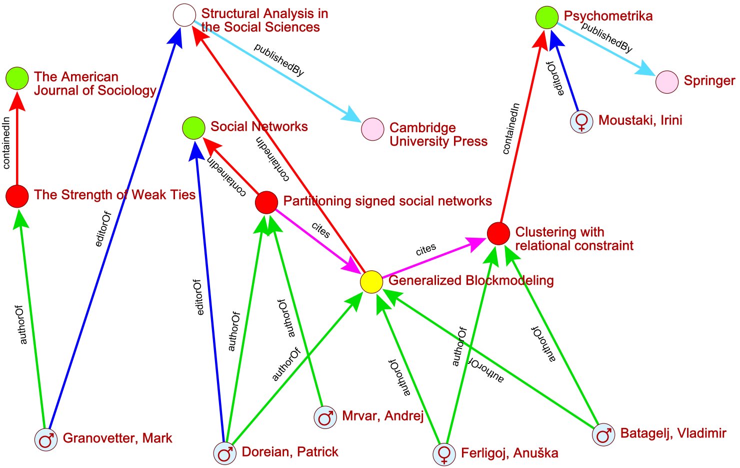
bib.net

```
*vertices  16
1 "Batagelj, Vladimir"
2 "Doreian, Patrick"
3 "Ferligoj, Anuška"
4 "Granovetter, Mark"
5 "Moustaki, Irini"
6 "Mrvar, Andrej"
7 "Clustering with relational constraint"
8 "The Strength of Weak Ties"
9 "Partitioning signed social networks"
10 "Generalized Blockmodeling"
11 "Psychometrika"
12 "Social Networks"
13 "The American Journal of Sociology"
14 "Structural Analysis in the Social Sciences"
15 "Cambridge University Press"
16 "Springer"
*arcs :1 "authorOf"
*arcs :2 "cites"
*arcs :3 "containedIn"
*arcs :4 "editorOf"
*arcs :5 "publishedBy"
```

```
*arcs
1: 1 10 1 l "authorOf"
1: 2 10 1 l "authorOf"
1: 3 10 1 l "authorOf"
1: 1 7 1 l "authorOf"
1: 3 7 1 l "authorOf"
1: 4 8 1 l "authorOf"
4: 4 14 1 l "editorOf"
1: 2 9 1 l "authorOf"
1: 6 9 1 l "authorOf"
4: 5 11 1 l "editorOf"
4: 2 12 1 l "editorOf"
3: 10 14 1 l "containedIn"
3: 7 11 1 l "containedIn"
3: 8 13 1 l "containedIn"
3: 9 12 1 l "containedIn"
2: 9 10 1 l "cites"
2: 10 7 1 l "cites"
5: 14 15 1 l "publishedBy"
5: 11 16 1 l "publishedBy"
```

bib.net, bibMode.clu, bibSex.clu; bib.paj, bib.ini.

Bibliographic network – picture / Pajek



Nets and NetsJSON

For dealing with networks with properties with structured values (for example, temporal quantities) we are developing a Python package Nets [3].

For describing temporal networks we initially, extending Pajek format, defined and used the Ianus format.

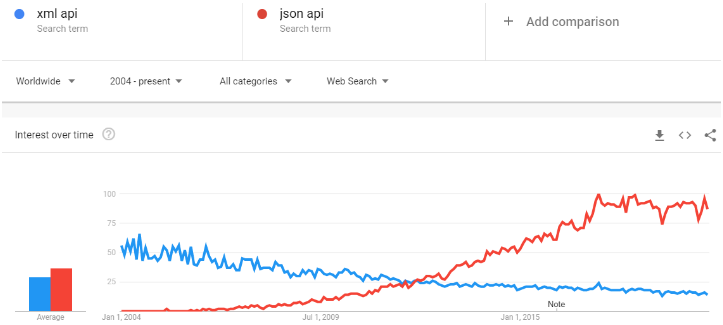
In 2015 we started to develop a new format based on JSON – we named it netJSON. On February 26, 2019 the format was renamed to NetsJSON because of the collision with http://netjson.org/rfc.html.

NetsJSON has two formats: a *basic* and a *general* format. Current implementation of the Nets / TQ library supports only the basic format.

Besides for a *description* of networks with structured values, NetsJSON should *envelope* (most of) existing network description formats [6] (archiving, conversion) and provide input data for D3.js *visualization*s.

XML api – JSON api

In near past, for description of structured data the XML (Extensible Markup Language) was mostly used. In last years a JSON format started to replace it. Google trends (March 2020)



JSON

JSON (JavaScript Object Notation) is a text data format that preserves the structure of data objects. It is "compatible" with basic data structures in modern programming languages.

The initial version of JSON was developed by Douglas Crockford (around 2002). He based it on the Javascript notation. The principal idea is: if we apply on a string (sequence of characters) containing a description of a data object, the Javascript function `eval` we get as its result the corresponding data object. JSON is a programming language independent, open code standard for exchange of data among programs.

Two JSON standards exist:

- The JSON Data Interchange Format. Standard ECMA-404, October 2013.
- The JavaScript Object Notation (JSON) Data Interchange Format Request for Comments: 7159, March 2014.

JSON


```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```


Wikipedia

JSON

XML is appropriate for describing the structure of textual data, JSON is becoming the first choice for describing structured data.

JSON has much simpler grammar, is more readable and compatible with basic data structures in modern programming languages.

All keys (names of fields) are in double quotes.

JSON files are by default based on the encoding Unicode (UTF-8).

The MIME type for JSON files is `application/json`, the recommended file extension is `.json`.

For work with JSON there exists supporting libraries for all important programming languages http://www.json.org/.

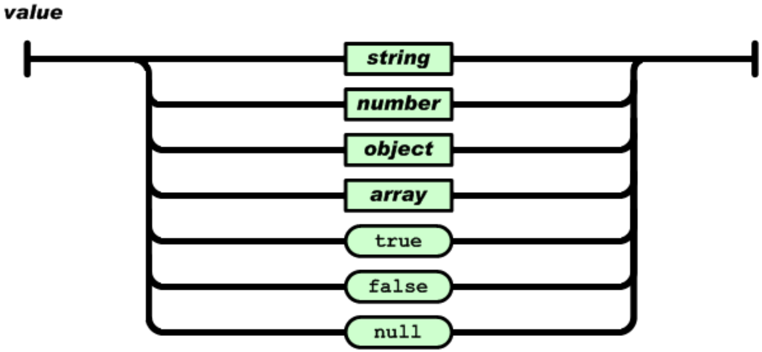
JSON grammar

```
value
    object
    array
    string
    number
    true
    false
    null
object
    { }
    { members }
members
    pair
    pair , members
pair
    string : value
array
    [ ]
    [ elements ]
elements
    value
    value , elements
```

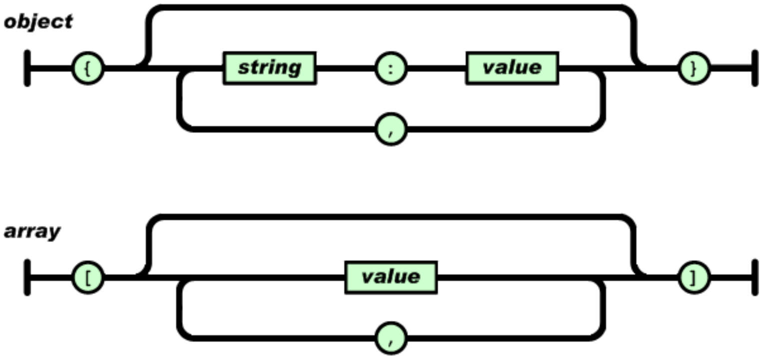
```
string
    ""
    " chars "
chars
    char
    char chars
char
    any-Unicode-character-except-
      "-or-\-or-control-character
    \"
    \\
    \/
    \b
    \f
    \n
    \r
    \t
    \u four-hex-digits
number
    int
    int frac
    int exp
    int frac exp
```

```
int
    digit
    digit1-9 digits
    - digit
    - digit1-9 digits
frac
    . digits
exp
    e digits
digits
    digit
    digit digits
e
    e
    e+
    e-
    E
    E+
    E-
```

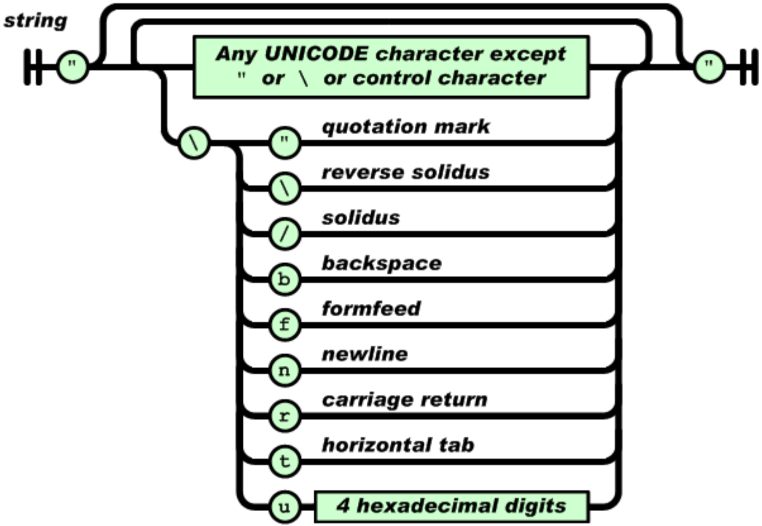
JSON grammar



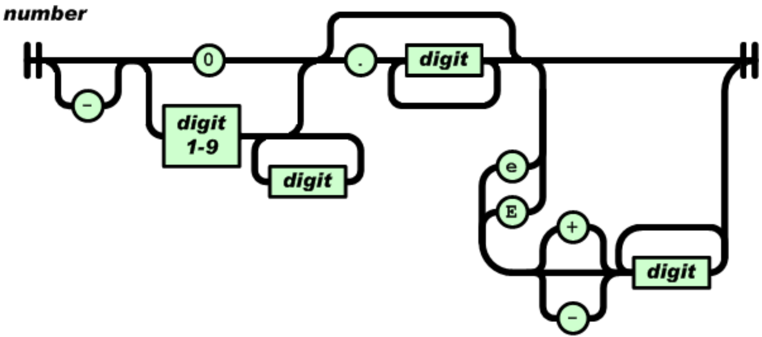
JSON grammar



JSON grammar



JSON grammar



Well formed and valid JSON files

A JSON file is *well formed* iff it respects JSON's grammar. Is my file well formed? service. JSONlint - another checker. We can inspect it using a web browser!!!

JSON editor

Similar to XML's DTD files or schema, we can impose additional restrictions to the structure of JSON files describing special types of data using JSON schema – the JSON files respecting these additional restrictions are called *valid*.

Github, validation, JSON Schema Lint, JSON Schema validator.
R packages jsonlite, rjson and RJSONIO. jsonlite Quick start

JSON in R - jsonlite

```
> library(jsonlite)
> J <- fromJSON(readLines("john.json"))
> J
$firstName
[1] "John"

$lastName
[1] "Smith"

...
$phoneNumbers
    type        number
1   home  212 555-1234
2 office  646 555-4567

$children
list()

$spouse
NULL

> john <- toJSON(J)
> john
{"firstName":["John"],"lastName":["Smith"],"isAlive":[true],"age":[25],"
"city":["New York"],"state":["NY"],"postalCode":["10021-3100"]},"phoneNu
{"type":"office","number":"646 555-4567"}],"children":[],"spouse":{}}
> js <- file("john2.json",encoding="UTF-8")
> write(john,file=js)
```

Informal description of the basic NetsJSON format

```
{
"NetsJSON": "basic",
"info": {
   "org":1, "nNodes":n, "nArcs":mA, "nEdges":mE,
   "simple":TF, "directed":TF, "multirel":TF, "mode":m,
   "network":fName, "title":title,
   "time": { "Tmin":tm, "Tmax":tM, "Tlabs": {labs} },
   "meta": [events], ...
   },
"nodes": [
   { "id":nodeId, "lab":label, "x":x, "y":y, ... },
   ***
   ]
"links": [
   { "type":arc/edge, "n1":nodeID1, "n2":nodeID2, "rel":r, ... }
   ***
   ]
}
```

where ... are user defined properties and *** is a sequence of such elements.

Basic NetsJSON format

An event description can contain fields:

```
{  "date": date,
   "title": short description,
   "author": name,
   "desc": long description,
   "url": URL,
   "cite": reference,
   "copy": copyright
}
```

for describing temporal networks a node element and a link element has an additional required property `tq`

Example 1, Franzosi's violence network / UTF-8 no sig

CSV2JSON.R

```
# transforming CSV files to JSON file
# by Vladimir Batagelj, June 2016
setwd("C:/Users/batagelj/work/Python/graph/SVG/EUSN")
library(rjson)
colC <- c(rep("character",4),rep("numeric",5)); nas <- c("","NA","NaN")
nodes <- read.csv2("bibNodesXY.csv",encoding='UTF-8',colClasses=colC,na.strings=nas)
M <- factor(nodes$mode); mod <- levels(M); M <- as.numeric(M)
S <- factor(nodes$sex); sx <- levels(S); S <- as.numeric(S); S[is.na(S)] <- 0
links <- read.csv2("bibLinks.csv",encoding='UTF-8',colClasses="character")
F <- as.numeric(factor(links$from,levels=nodes$name,ordered=TRUE))
T <- as.numeric(factor(links$to,levels=nodes$name,ordered=TRUE))
R <- factor(links$relation); rel <-levels(R); R <- as.numeric(R)
n <- nrow(nodes); nods <- vector('list',n)
for(i in 1:n) nods[[i]] <- list(id=i,name=nodes$name[i],mode=M[i],
   sex=S[i],x=as.numeric(nodes$x[i])/1000,y=as.numeric(nodes$y[i])/1000)
m <- nrow(links); lnks <- vector('list',m)
for(i in 1:m) lnks[[i]] <- list(type="arc",source=F[i],target=T[i],
   rel=R[i],weight=1)
meta <- list(date="June 11,2016",author="Vladimir Batagelj")
leg <- list(mode=mod,sex=sx,rel=rel)
inf <- list(network="bib",org=1,nNodes=n,nArcs=m,
  title="Example for EUSN'16",legend=leg,meta=meta)
data <- list(NetsJSON="basic",info=inf,nodes=nods,links=lnks)
json <- file("bib.json","w"); cat(toJSON(data),file=json); close(json)
```

bib.json

```
{"NetsJSON":"basic",
 "info":{"network":"bib","org":1,"nNodes":16,"nArcs":19,"title":"Example for EUSN'16",
  "legend":{
   "mode":["book","journal","paper","person","publisher","series"],
   "sex":["f","m"],
   "rel":["authorOf","cites","containedIn","editorOf","publishedBy"]},
  "meta":{"date":"June 11,2016","author":"Vladimir Batagelj"}},
 "nodes":[
  {"id":1,"name":"Batagelj, Vladimir","mode":4,"sex":2,"x":0.8091,"y":0.6537},
  {"id":2,"name":"Doreian, Patrick","mode":4,"sex":2,"x":0.3585,"y":0.6791},
  {"id":3,"name":"Ferligoj, Anu\u0161ka","mode":4,"sex":1,"x":0.6195,"y":0.6807},
  {"id":4,"name":"Granovetter, Mark","mode":4,"sex":2,"x":0.1456,"y":0.6605},
  {"id":5,"name":"Moustaki, Irini","mode":4,"sex":1,"x":0.783,"y":0.228},
  {"id":6,"name":"Mrvar, Andrej","mode":4,"sex":2,"x":0.478,"y":0.6301},
  {"id":7,"name":"Clustering with relational constraint","mode":3,"sex":0,"x":0.6841,"y":0.3801}
...
  {"id":15,"name":"Cambridge University Press","mode":5,"sex":0,"x":0.5343,"y":0.2382},
  {"id":16,"name":"Springer","mode":5,"sex":0,"x":0.8846,"y":0.174}],
 "links":[
  {"type":"arc","source":1,"target":10,"rel":1,"weight":1},
  {"type":"arc","source":2,"target":10,"rel":1,"weight":1},
  {"type":"arc","source":3,"target":10,"rel":1,"weight":1},
  {"type":"arc","source":1,"target":7,"rel":1,"weight":1},
  {"type":"arc","source":3,"target":7,"rel":1,"weight":1},
  {"type":"arc","source":4,"target":8,"rel":1,"weight":1},
  {"type":"arc","source":4,"target":14,"rel":4,"weight":1},
...
  {"type":"arc","source":10,"target":7,"rel":2,"weight":1},
  {"type":"arc","source":14,"target":15,"rel":5,"weight":1},
  {"type":"arc","source":11,"target":16,"rel":5,"weight":1}
]}
```

bib.json, picture: bib

D3.js

There exists an excellent library D3.js for interactive data visualization on the web (and locally) in SVG format. Most of the network data for D3.js are prepared in the JSON format. Many nice D3.js based network visualization solutions were developed:

- Force: Force-Directed Graph, Force Layout & Matrix Market Format, 3D Force Layout; An A to Z of extra features for the d3 force layout
- Directed: Directed Graph Editor, Directed Edges (Curves and Arrow Markers), Mobile Patent Suits
- Other: Co-occurrence Matrix, Hive Plots, Chord Diagram, Hierarchical Edge Bundling
- Applications: Linked JAZZ, Ontology Visualization, Visualizing Package Dependencies, Connectome explorer for the "brain" of C. elegans, Gene functional interaction networks
- More: D3 gallery, The Big List of D3.js Examples - Christophe Viau, Over 2000 D3.js Examples and Demos

bib.json

References I

- Batagelj, V.: Python Packages for Networks. Encyclopedia of Social Network Analysis and Mining. Reda Alhajj, Jon Rokne (Eds.), 2nd Ed, Springer, 2017
- Batagelj, V., Maltseva, D.: Temporal bibliographic networks. Journal of Informetrics, 14(2020)1, 101006. PDF
- Batagelj, V.: Nets. https://github.com/bavla/Nets
- Batagelj, V.: NetsJSON. https://github.com/bavla/netsJSON
- Batagelj, V., Praprotnik, S.: An algebraic approach to temporal network analysis based on temporal quantities. Social Network Analysis and Mining, 6(2016)1, 1-22. PDF
- Bodlaj, J., Cerinšek, M.: Network Data File Formats. Encyclopedia of Social Network Analysis and Mining. Reda Alhajj, Jon Rokne (Eds.), 2nd Ed, Springer, 2018