Graph

Vladimir Batagelj

Inštitut za matematiko, fiziko in mehaniko
Oddelek za teoretično računalništvo

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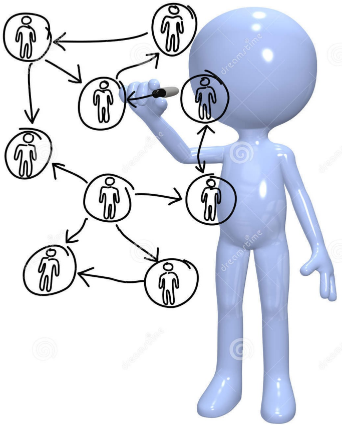
Outline



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

Networks

A **graph** $\mathcal{G} = (\mathcal{V}, \mathcal{L})$ consists of the set of nodes $\mathcal{V}$ and the set of links $\mathcal{L}$. A link is either directed, an arc, or undirected, an edge – $\mathcal{L} = \mathcal{A} \cup \mathcal{E}$, $\mathcal{A} \cup \mathcal{E} = \emptyset$ where $\mathcal{A}$ is the set of arcs and $\mathcal{E}$ is the set of edges.

A **network** $\mathcal{N} = (\mathcal{V}, \mathcal{L}, \mathcal{P}, \mathcal{W})$ – is a graph with node properties $\mathcal{P}$ an link properties or weights $\mathcal{W}$.

In a **two-mode network** $\mathcal{N} = ((\mathcal{V}_1, \mathcal{V}_2), \mathcal{L}, \mathcal{P}, \mathcal{W})$ – the set of nodes is split into two disjoint subsets. Each link has an end-node in each subset.

In a **multirelational network** $\mathcal{N} = (\mathcal{V}, (\mathcal{L}_i, i \in I), \mathcal{P}, \mathcal{W})$ – the set of links is partitioned to several subsets – relations
(Subject Verb Object).

In a **temporal network** $\mathcal{N} = (\mathcal{V}, \mathcal{L}, \mathcal{P}, \mathcal{W}, \mathcal{T})$ – the time component $\mathcal{T}$ is added. To each node and link its activity set (of time points) is assigned. Also properties of nodes and links can change through time – temporal quantities.

A **collection** of networks – networks with common subsets of nodes.

The types can be combined. For example: two-mode multirelational temporal network.

Data structure

Every node/link has an id. For links, if not provided by the user, it is assigned by the package.
The data structure `graph` is composed from 3 dictionaries:

- `graph` – keys: properties of the network. Some properties are fixed: `network`, `title`, `simple`, `directed`, `multirel`, `mode`, `temporal`, `meta`. The user can add other properties – for example: `nNodes`, `nArcs`, `nWeak`, `time: (Tmin,Tmax)`, `planar`, etc.
- `nodes` – keys are node ids. The value is a list of four dictionaries:
  [edgeStar, inArcStar, outArcStar, nodeProperties]
  Each star has node ids as keys with a list of link ids as value.
- `links` – keys are link ids. The value is a list
  [nodeId1, nodeId2, directed, relId, linkProperties]
  where linkProperties is again a dictionary.

Functions

Work in progress !!!

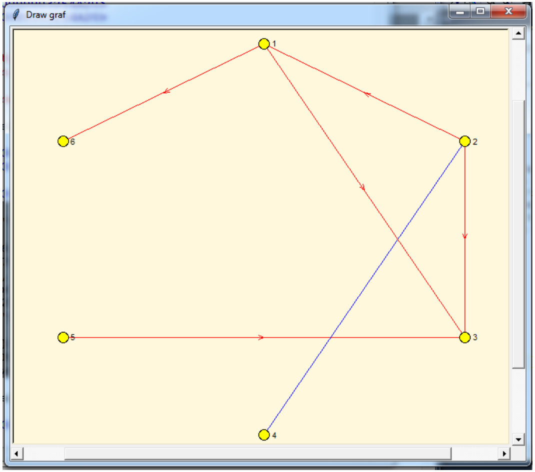
See the code.

In the version `GraphNew.py` a new implementation of multiple links between a pair of nodes was done. Not all other functions were tested yet.

Test of graph constructors

```
from GraphNew import Graph
def TestAdd():
    G = Graph()
    G.addNode(2); G.addNode(1); G.addNode(3); G.addNode(4)
    G.addEdge(2,4,{'w':3}); G.addArc(2,1,{'w':5});
    G.addArc(1,3,{'w':4}); G.addArc(2,3,{'w':6})
    G.addNode(5); G.addNode(6)
    i=G.addArc(5,3,{'w':5}); j=G.addEdge(2,4,{'w':7});
    G.addArc(1,6,{'w':8});G.addArc(1,3,{'w':5})
    G.onCircle()
    print(G)
    G.draw(800,800,"Cornsilk")
    G.savePajek('test.net')
    G.delLink(j); G.delLink(i)
    print(G)
    return G
```

Network picture



Network data

```
>>> G._graph
{'mode': 1, 'multirel': False, 'temporal': False, 'simple': False}
>>> G._nodes
{
1: [{}, {2: [2]}, {3: [3, 8], 6: [7]}, {'x': 0.5, 'y': 0.95}],
2: [{4: [1]}, {}, {1: [2], 3: [4]}, {'x': 0.88971, 'y': 0.725}],
3: [{}, {1: [3, 8], 2: [4], 5: []}, {}, {'x': 0.88971, 'y': 0.275}],
4: [{2: [1]}, {}, {}, {'x': 0.5, 'y': 0.045}],
5: [{}, {}, {3: []}, {'x': 0.11029, 'y': 0.275}],
6: [{}, {1: [7]}, {}, {'x': 0.11029, 'y': 0.725}]
}
>>> G._links
{
1: [2, 4, False, None, {'w': 3}],
2: [2, 1, True, None, {'w': 5}],
3: [1, 3, True, None, {'w': 4}],
4: [2, 3, True, None, {'w': 6}],
7: [1, 6, True, None, {'w': 8}],
8: [1, 3, True, None, {'w': 5}]
}
```

netJSON format

```
{
"netJSON": "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, ... }
   ***
   ]
}
```

... user defined properties
*** sequence of such elements

Transforming Pajek files into netJSON

```
gdir = 'c:/users/batagelj/work/python/graph/graph'
wdir = 'c:/users/batagelj/work/python/graph/JSON'
# indent = None
indent = 3
import sys, os, datetime, json
sys.path = [gdir]+sys.path; os.chdir(wdir)
import GraphNew as Graph
file='violenceM.net'
P = Graph.Graph.loadPajek(file)
# info
n=len(P); mE = len(list(P.edges())); mA = len(list(P.arcs()))
ctime=datetime.datetime.now().ctime()
title="Franzosi's violence network"
meta=[{"date":ctime, "author": "Pajek2JSON"}]
meta.append(P.getGraph('meta'))
info = {"network": "violenceM", "org": 1, "nNodes": n,
  "nArcs": mA, "nEdges": mE, "title": title, "meta": meta}
# nodes
nodes = []
for node in P.nodes():
  Node = {"id": node, "lab": P.getNode(node,"lab"),
    "tq": P.getNode(node,"tq")}
  nodes.append(Node)
```

. . . Transforming Pajek files into netJSON

```
# links
links = []
for e in P.links():
  link = P.link(e); ltype = "arc" if link[2] else "edge"
  Link = {"type": ltype, "n1": link[0], "n2": link[1],
    "rel": link[3], "tq": P.getLink(e,'tq')}
  links.append(Link)
# JSON
net = {"netJSON": "basic", "info": info, "nodes": nodes, "links": links}
js = open(info['network']+'.json','w')
json.dump(net, js, ensure_ascii=False, indent=indent)
js.close()
```

Transforming Ianus TEN files into netJSON

On September 15, 2016 the function
`Ianus2netJSON(N,file="test.json")`
was added to the library TQ. N is a TQ network.

```
>>> gdir = 'c:/users/batagelj/work/python/graph/graph'
>>> wdir = 'c:/users/batagelj/work/python/graph/JSON'
>>> import sys, os, datetime, json
>>> sys.path = [gdir]+sys.path; os.chdir(wdir)
>>> import TQ
>>> B = TQ.TQ.Ianus2Mat('exampleB.ten')
>>> TQ.TQ.Ianus2netJSON(B)
>>> B = TQ.TQ.Ianus2Mat('simpleViolence.ten')
>>> TQ.TQ.Ianus2netJSON(B)
```

We get the corresponding netJSON files `exampleB.json` and `simpleViolence.json`.

Loading netJSON files into Graph

On September 15, 2016 the function

`loadNetJSON(file)`

was added to the library Graph. `file` is a netJSON file.

```
>>> gdir = 'c:/users/batagelj/work/python/graph/graph'
>>> wdir = 'c:/users/batagelj/work/python/graph/JSON'
>>> import sys, os, datetime, json
>>> sys.path = [gdir]+sys.path; os.chdir(wdir)
>>> import GraphNew as Graph
>>> G = Graph.Graph.loadNetJSON('classE.json')
>>> G.draw(800,800,"#ffa0ff")
>>> B = Graph.Graph.loadNetJSON('exampleB.json')
>>> T = Graph.Graph.loadNetJSON('simpleViolence.json')
>>> B._nodes
{1: [{}, {5: [7]}, {2: [1]}, {'lab': '1', 'tq': [[1, 10, 1]]}],
2: [{}, {1: [1], 3: [4]}, {3: [2], 6: [3]}, {'lab': '2', 'tq': [[1, 10,
3: [{}, {2: [2], 6: [9]}, {2: [4], 4: [5]}, {'lab': '3', 'tq': [[1, 10,
4: [{}, {3: [5], 6: [10]}, {5: [6]}, {'lab': '4', 'tq': [[1, 10, 1]]}],
5: [{}, {4: [6]}, {1: [7], 6: [8]}, {'lab': '5', 'tq': [[1, 10, 1]]}],
6: [{}, {2: [3], 5: [8]}, {3: [9], 4: [10]}, {'lab': '6', 'tq': [[1, 10,
>>> T._links[5]
[1, 7, True, None, {'tq': [[25, 28, 1], [28, 29, 5], [29, 30, 3],
[30, 31, 5], [31, 32, 2], [32, 33, 1], [38, 40, 2], [41, 42, 4],
[43, 44, 1], [45, 46, 10], [48, 49, 2]]}]
>>> n = len(T._nodes); [ T.getNode(v+1,'lab') for v in range(n)]
```

Loading netJSON files into Graph

On September 16, 2016 the function `TQnetBin(self)` was added to the library Graph. It sets all values in tq in links to 1.

```
>>> G = Graph.Graph.loadNetJSON('exampleB.json')
>>> B = G.TQnetBin()
>>> G._links
{1: [1, 2, True, None, {'tq': [[1, 8, 2], [9, 10, 4]]}],
 2: [2, 3, True, None, {'tq': [[2, 7, 7], [8, 10, 3]]}],
 3: [2, 6, True, None, {'tq': [[4, 6, 4], [8, 10, 5]]}],
 4: [3, 2, True, None, {'tq': [[4, 9, 5]]}],
 5: [3, 4, True, None, {'tq': [[1, 5, 5], [5, 9, 7]]}],
 6: [4, 5, True, None, {'tq': [[1, 3, 4], [3, 10, 2]]}],
 7: [5, 1, True, None, {'tq': [[3, 8, 1], [8, 9, 5]]}],
 8: [5, 6, True, None, {'tq': [[1, 5, 6], [5, 7, 3], [9, 10, 5]]}],
 9: [6, 3, True, None, {'tq': [[4, 8, 1], [8, 9, 5]]}],
10: [6, 4, True, None, {'tq': [[3, 7, 9], [8, 10, 8]]}]}
>>> B._links
{1: [1, 2, True, None, {'tq': [(1, 8, 1), (9, 10, 1)]}],
 2: [2, 3, True, None, {'tq': [(2, 7, 1), (8, 10, 1)]}],
 3: [2, 6, True, None, {'tq': [(4, 6, 1), (8, 10, 1)]}],
 4: [3, 2, True, None, {'tq': [(4, 9, 1)]}],
 5: [3, 4, True, None, {'tq': [(1, 9, 1)]}],
 6: [4, 5, True, None, {'tq': [(1, 10, 1)]}],
 7: [5, 1, True, None, {'tq': [(3, 9, 1)]}],
 8: [5, 6, True, None, {'tq': [(1, 7, 1), (9, 10, 1)]}],
 9: [6, 3, True, None, {'tq': [(4, 9, 1)]}],
10: [6, 4, True, None, {'tq': [(3, 7, 1), (8, 10, 1)]}]}
```

Loading netJSON files into Graph

On September 16, 2016 the function

```
    def TQnetDeg(self,u):
        deg = TQ.TQ.setConst(self._nodes[u][3]['tq'],0)
        for p in self.star(u):
            deg = TQ.TQ.sum(deg,TQ.TQ.binary(self._links[p][4]['tq']))
        return deg
```

and TQnetInDeg and TQnetOutDeg were added to the library Graph.

```
>>> G = Graph.Graph.loadNetJSON('ExampleB.json')
>>> for u in G._nodes: print(G.TQnetDeg(u))
[(1, 3, 1), (3, 8, 2), (8, 10, 1)]
[(1, 2, 1), (2, 4, 2), (4, 6, 4), (6, 7, 3), (7, 8, 2), (8, 10, 3)]
[(1, 2, 1), (2, 4, 2), (4, 7, 4), (7, 8, 3), (8, 9, 4), (9, 10, 1)]
[(1, 3, 2), (3, 7, 3), (7, 8, 2), (8, 9, 3), (9, 10, 2)]
[(1, 3, 2), (3, 7, 3), (7, 10, 2)]
[(1, 3, 1), (3, 4, 2), (4, 6, 4), (6, 7, 3), (7, 8, 1), (8, 10, 3)]
```