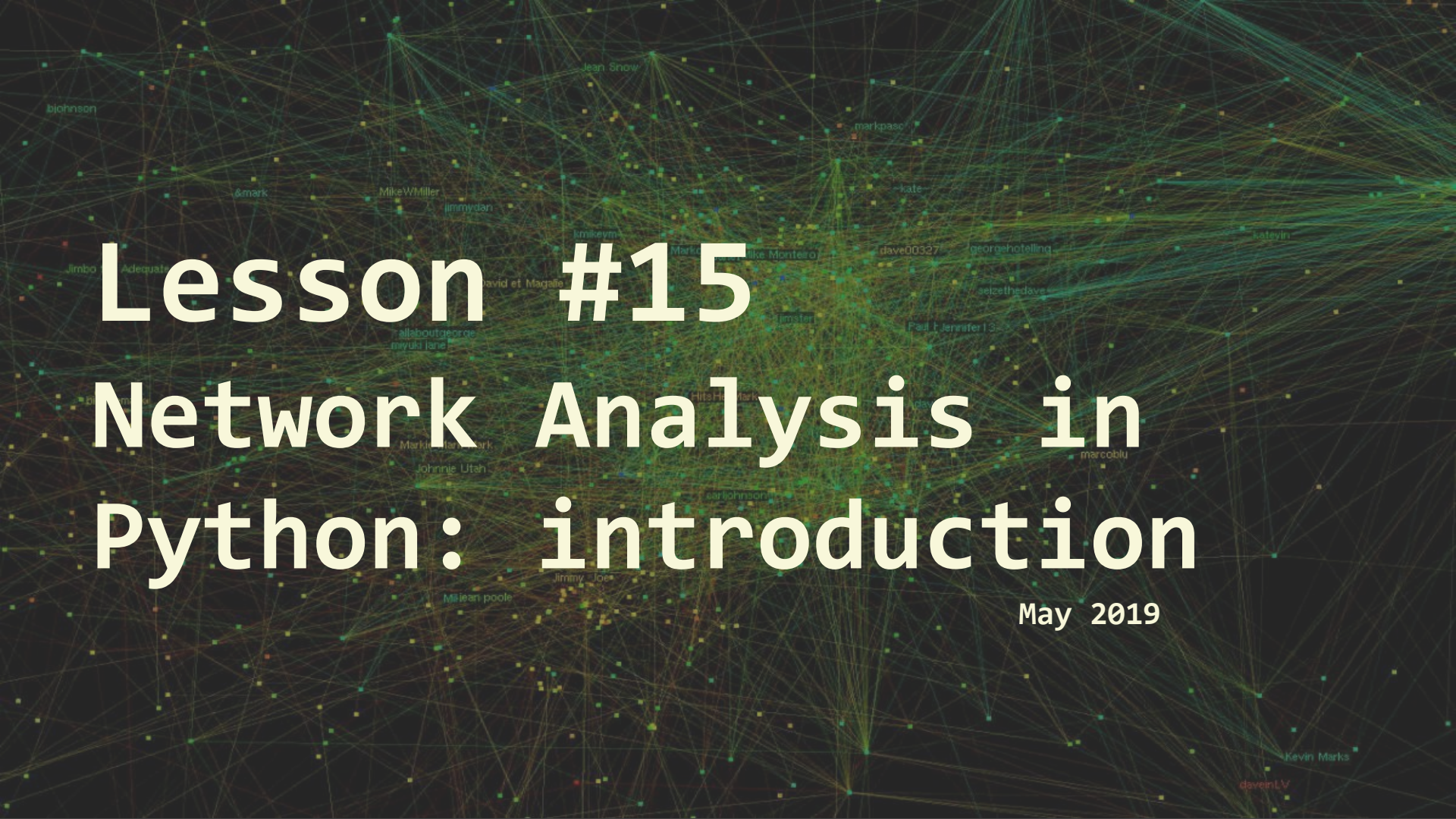
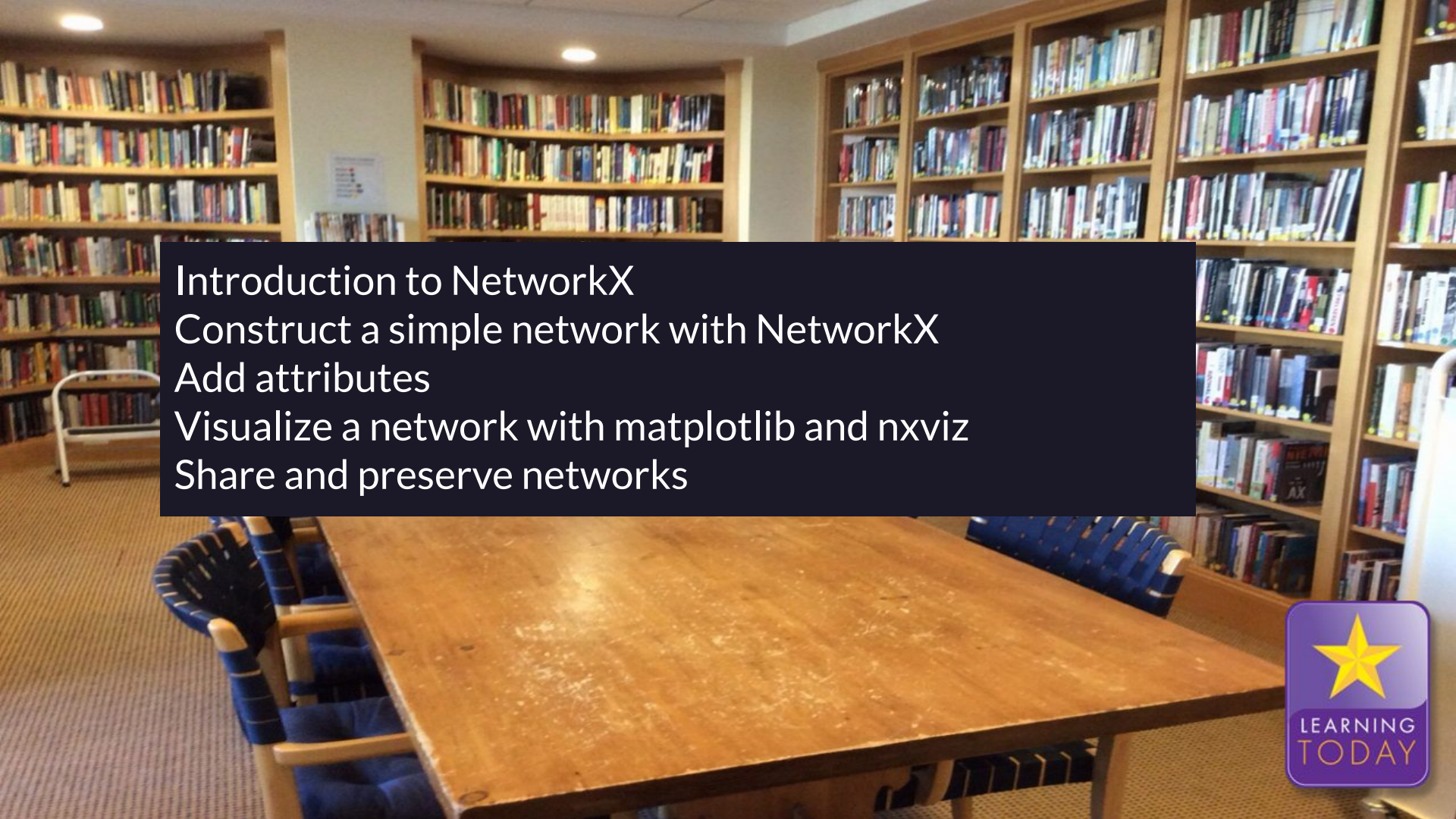


Lesson #15 Network Analysis in Python: introduction

May 2019


Introduction to NetworkX
Construct a simple network with NetworkX
Add attributes
Visualize a network with matplotlib and nxviz
Share and preserve networks
LEARNING
TODAY

Update from repository

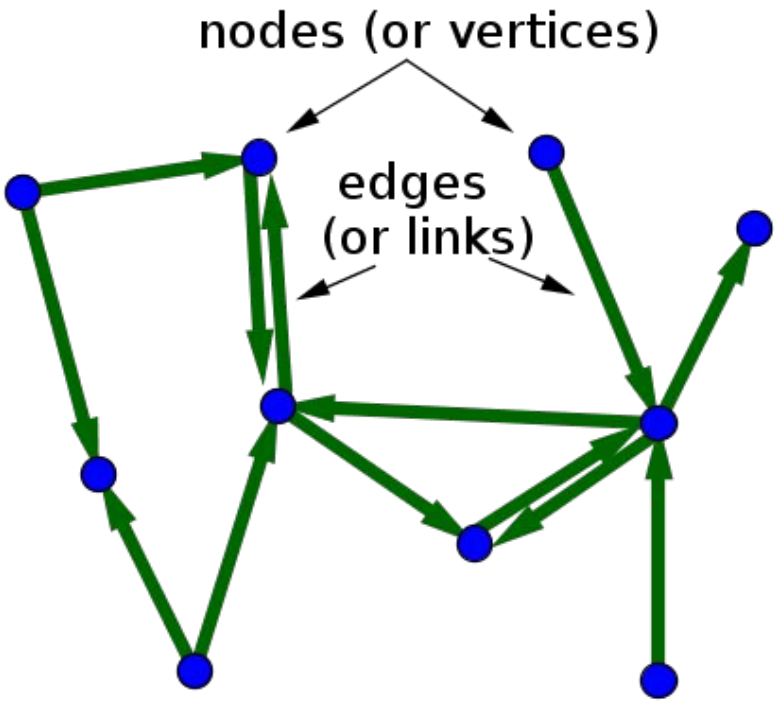
```
git clone https://github.com/ivanovitchm/datascience_one_2019_1
```

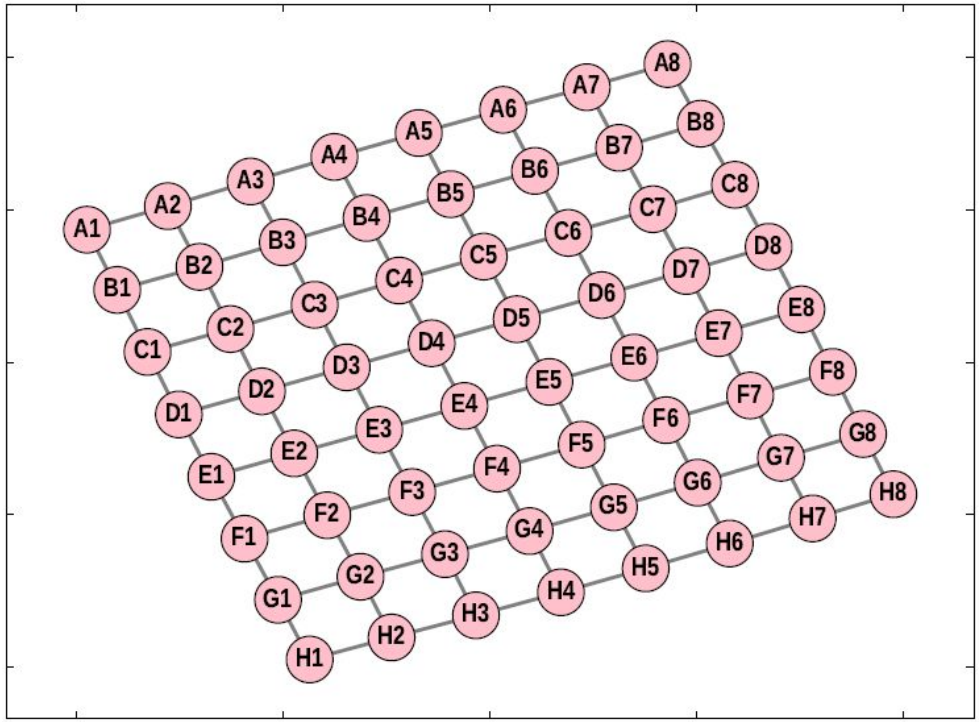
Or ....

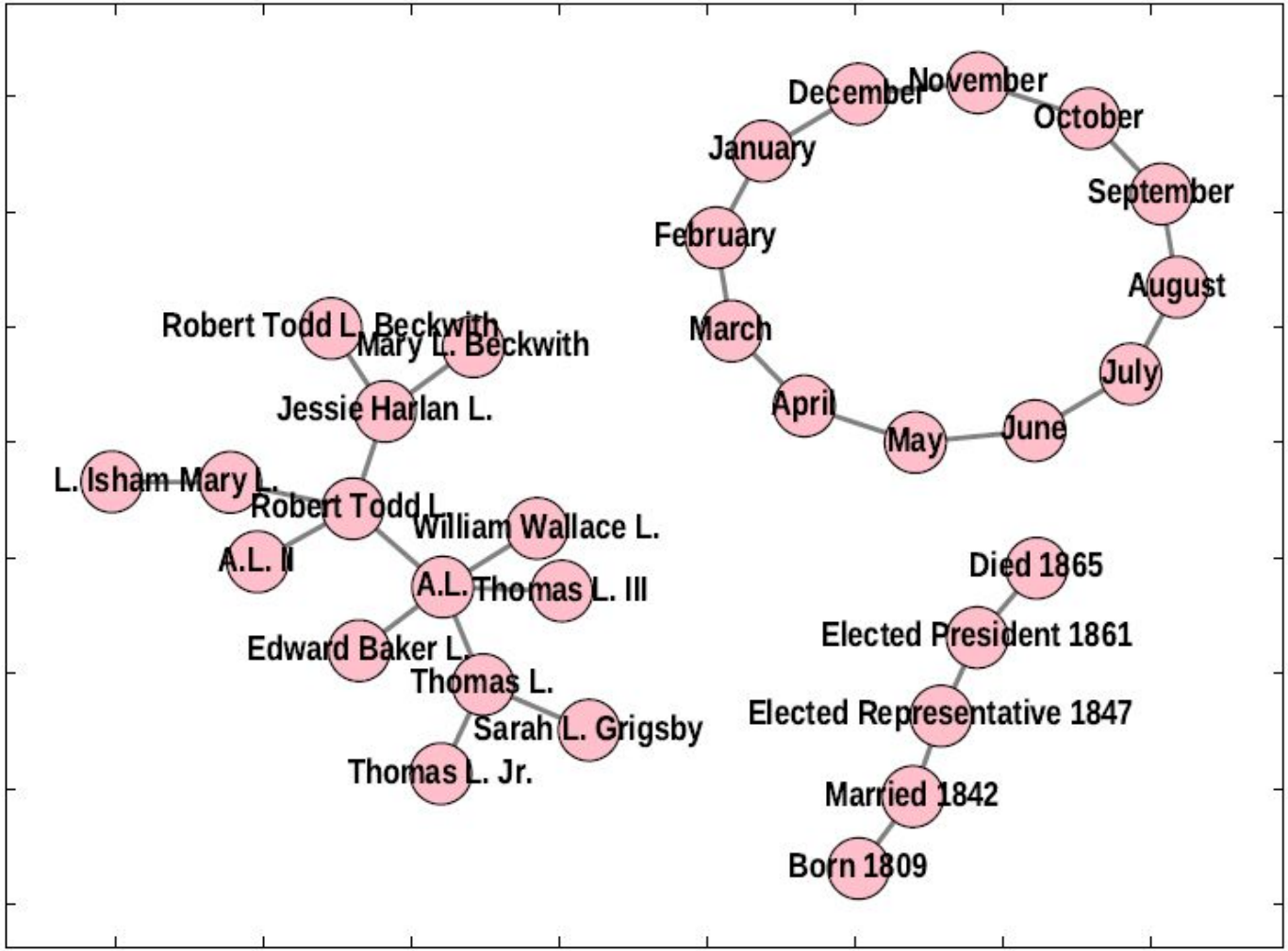
```
git pull
```

What is a network?

Know your networks



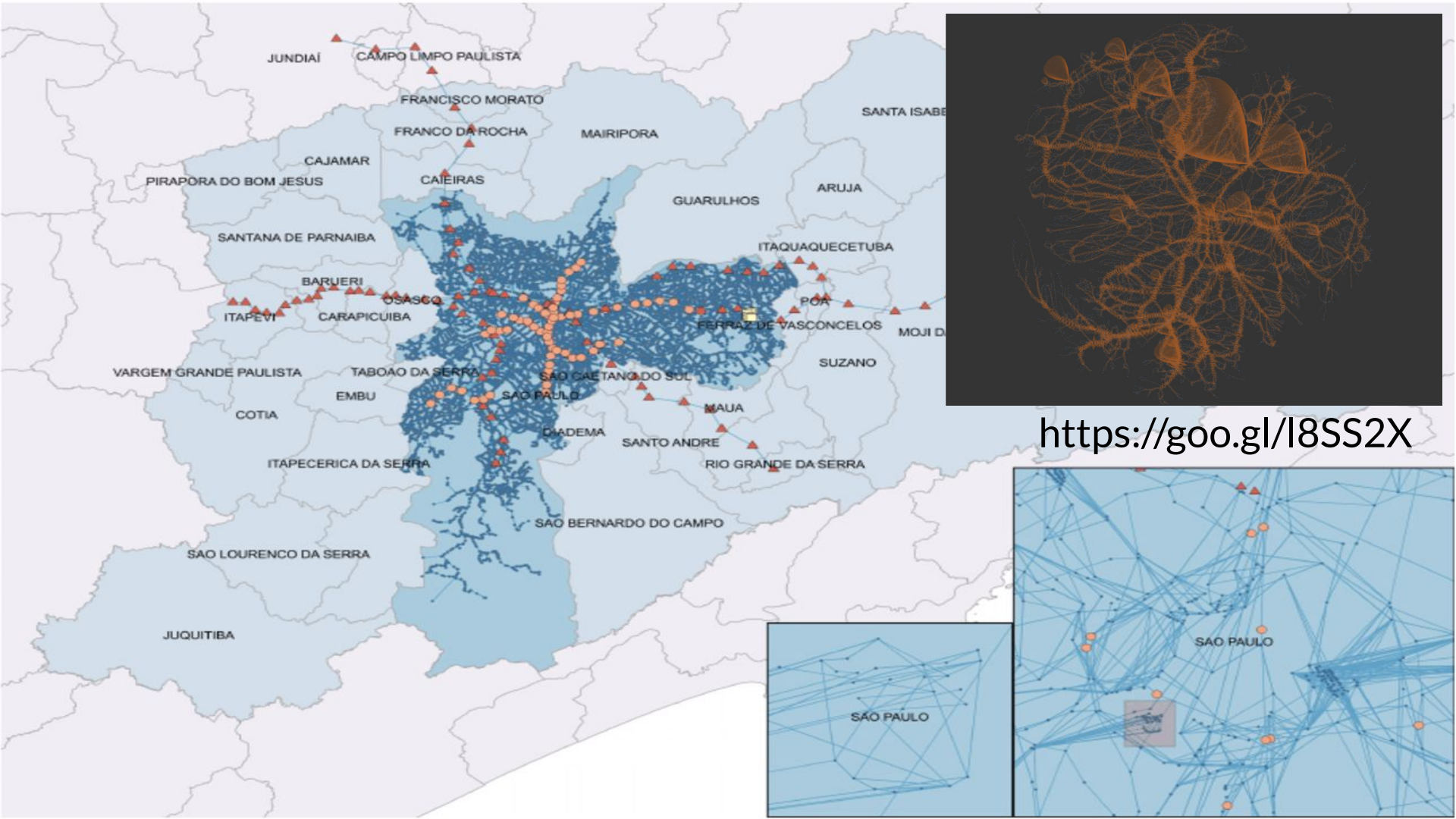



December
November
October
January
September
February
August
March
July
April
June
May
Robert Todd L. Beckwith
Mary L. Beckwith
Jessie Harlan L.
L. Isham Mary L.
Robert Todd L
William Wallace L.
A.L. II
A.L.
Thomas L. III
Edward Baker L.
Thomas L.
Sarah L. Grigsby
Thomas L. Jr.
Died 1865
Elected President 1861
Elected Representative 1847
Married 1842
Born 1809

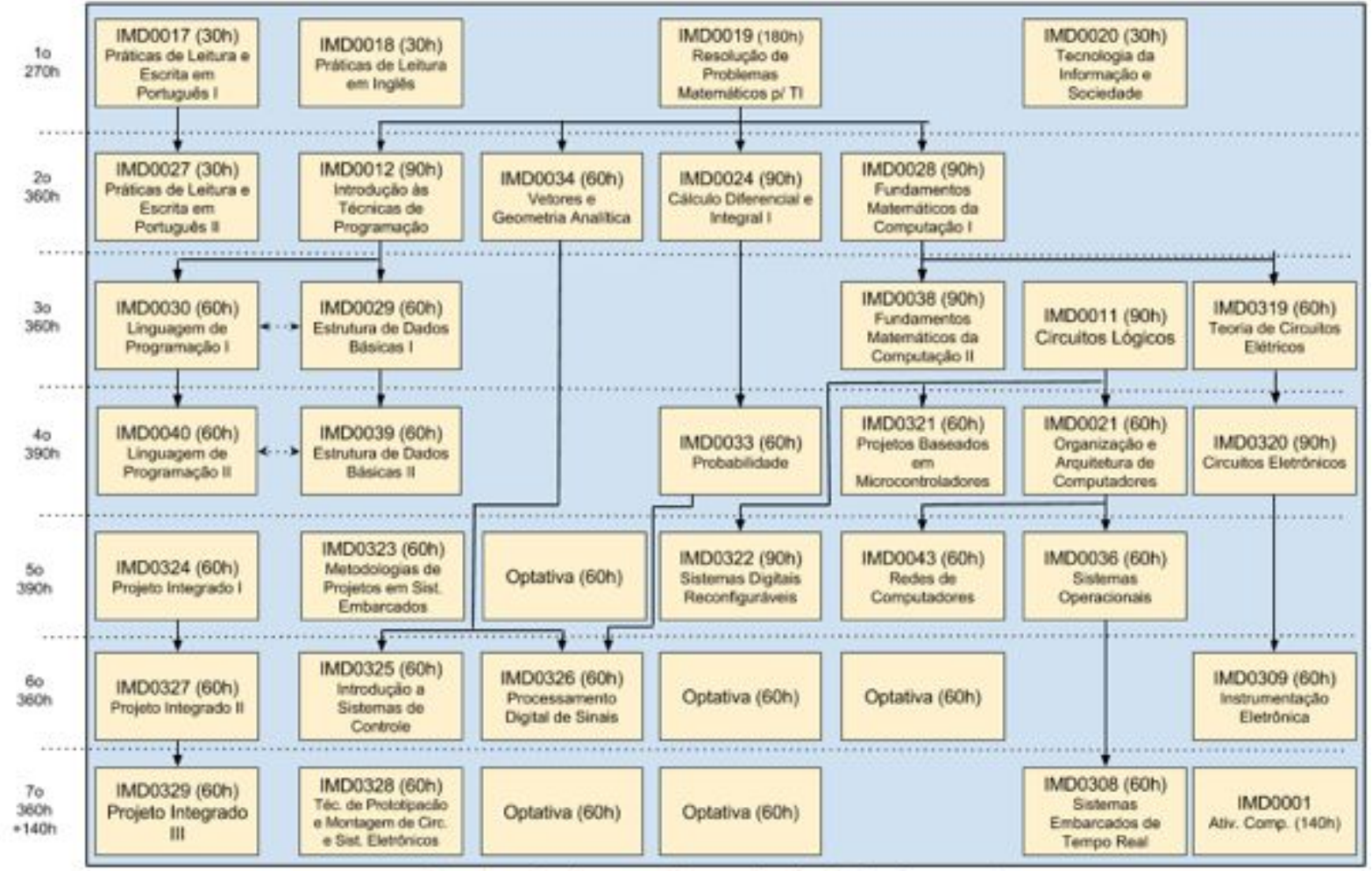
All the networks listed previously are simple because they have a regular or almost regular structure.

A simple network is simple not because it is small, but because it is regular.

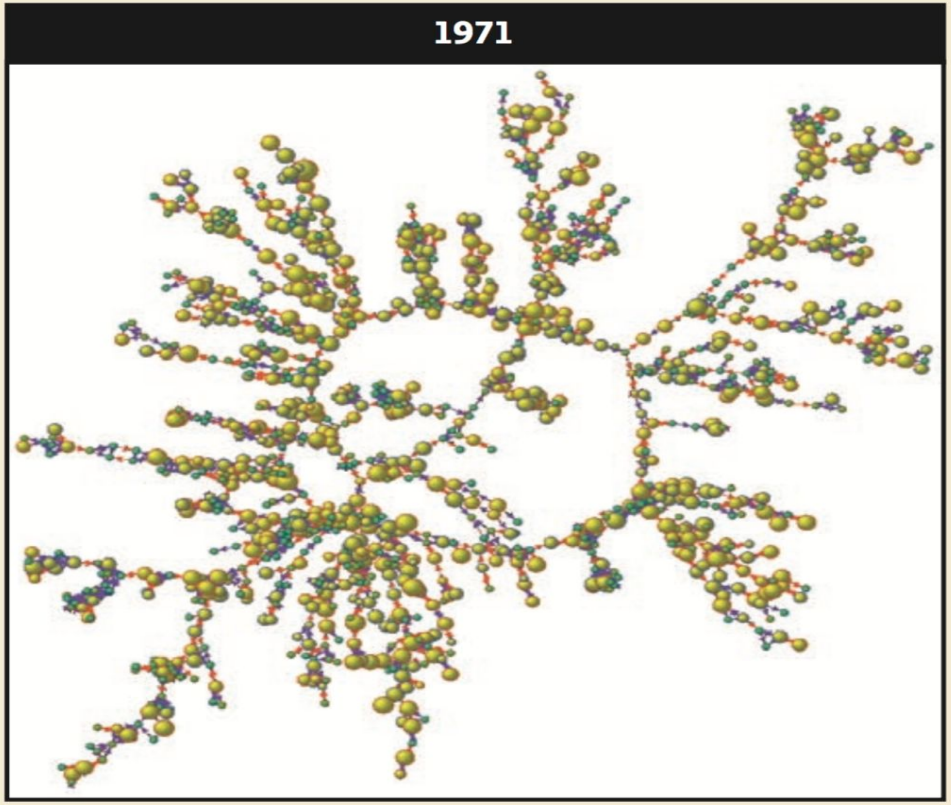
Complex Network Analysis (CNA)

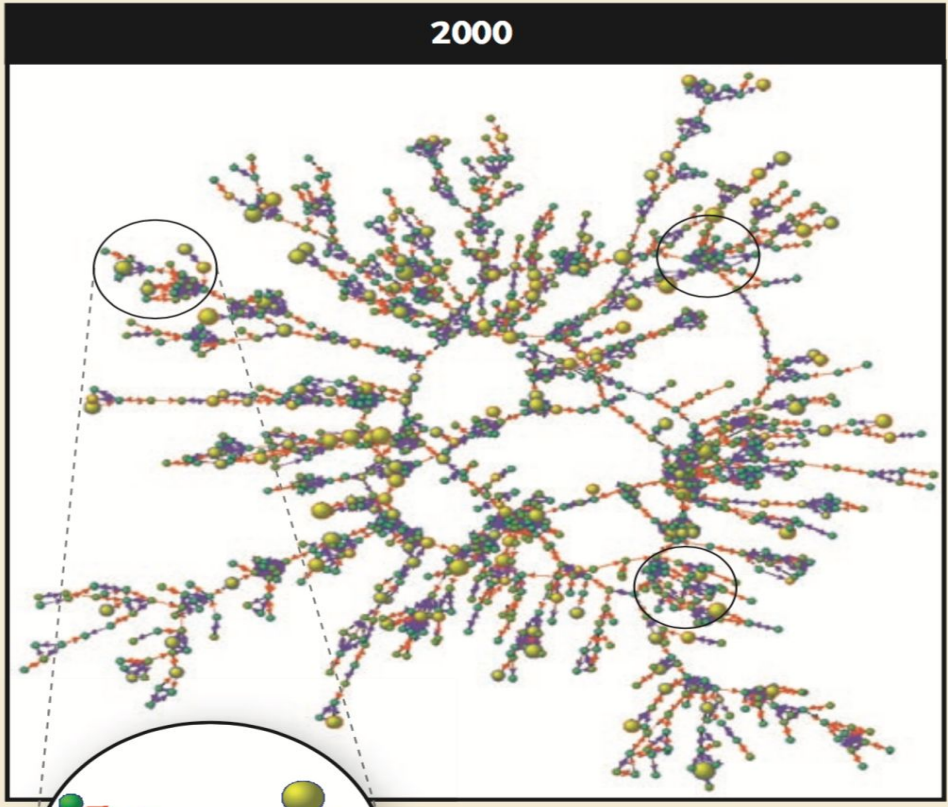


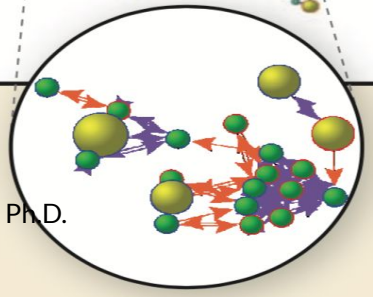
https://goo.gl/l8SS2X



Bacharelado em Tecnologia da Informação
Ênfase em Sistemas Embarcados (MT)

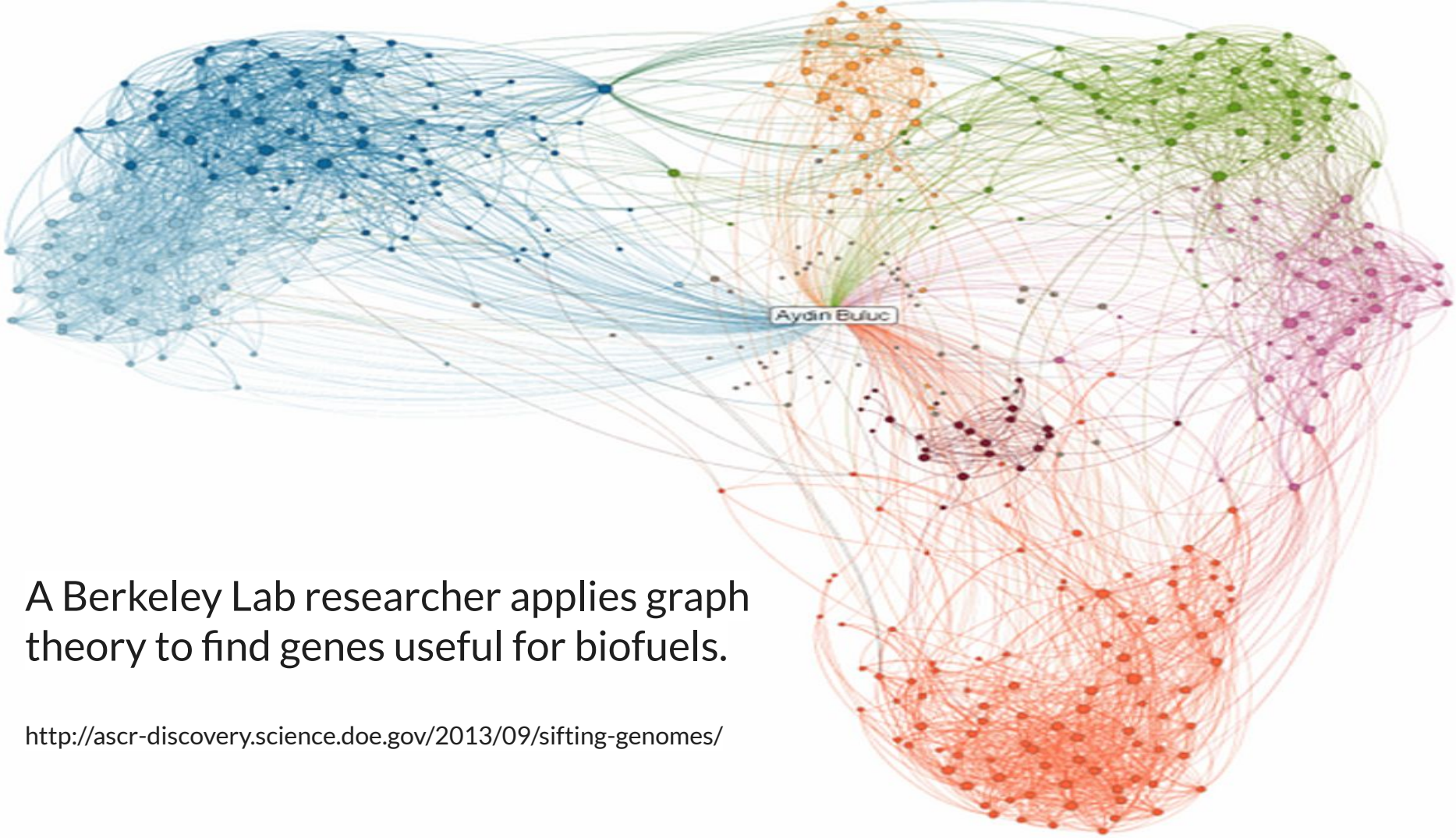






The Collective Dynamics of Smoking in a Large Social Network.
Nicholas A. Christakis, M.D., Ph.D., M.P.H., and James H. Fowler, Ph.D.
N Engl J Med 2008; 358:2249-2258May 22, 2008

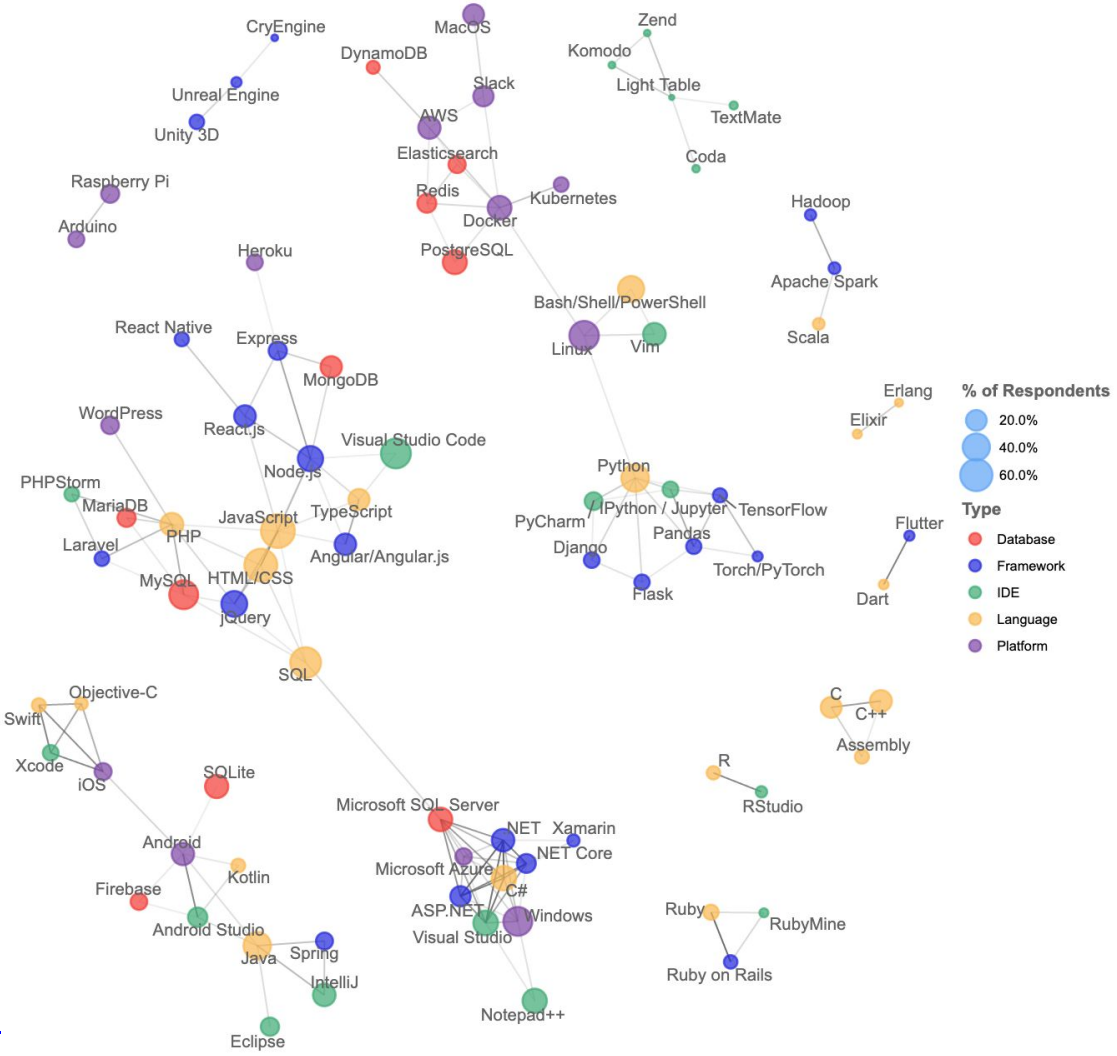
Red borders - women
Blue border - men
Interior color
Yellow >= 1 cigarette
Green => no cigarette



A Berkeley Lab researcher applies graph theory to find genes useful for biofuels.

http://ascr-discovery.science.doe.gov/2013/09/sifting-genomes/

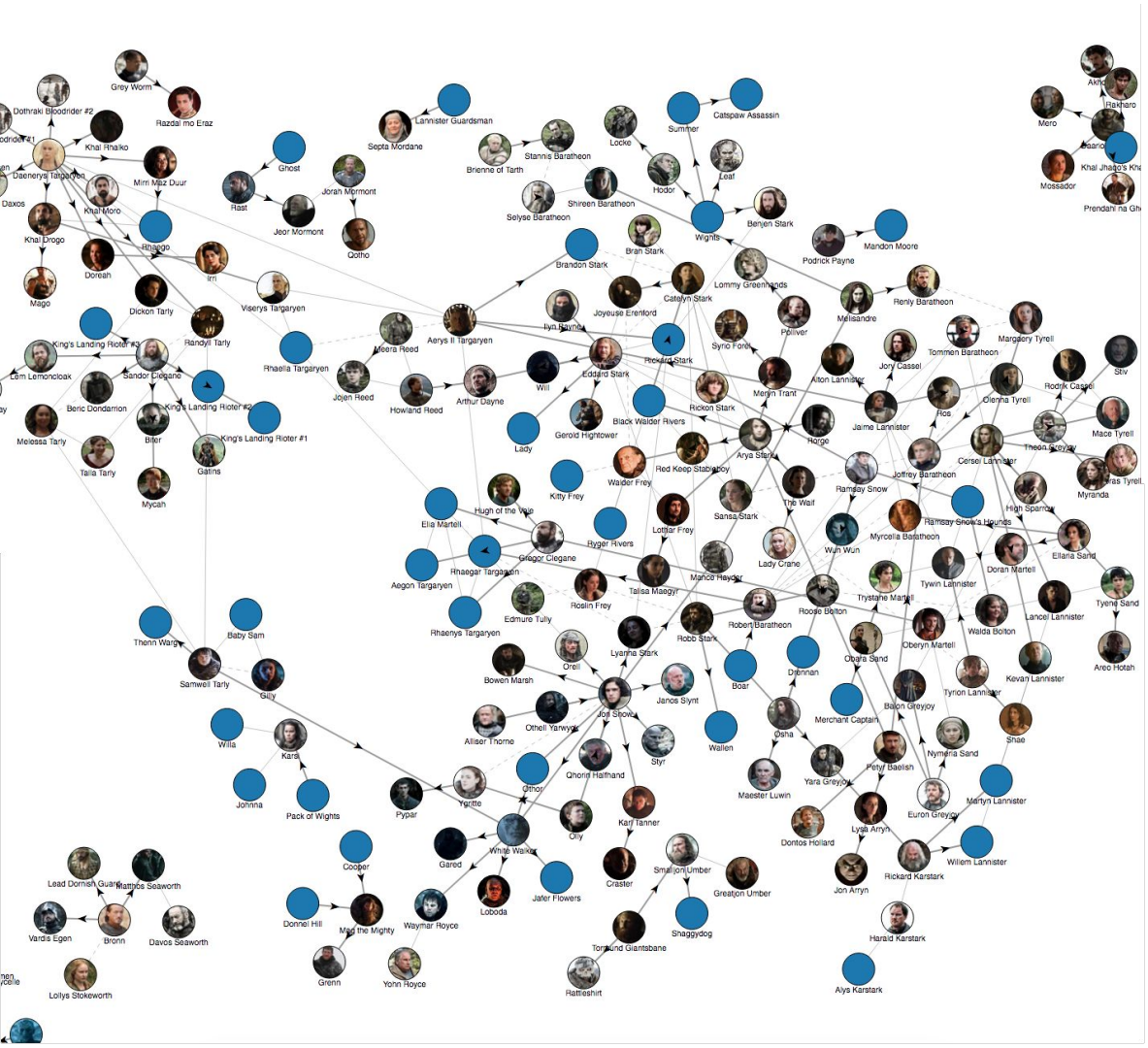
How the technologies are connected



https://insights.stackoverflow.com/survey/2019

Music for focus while coding

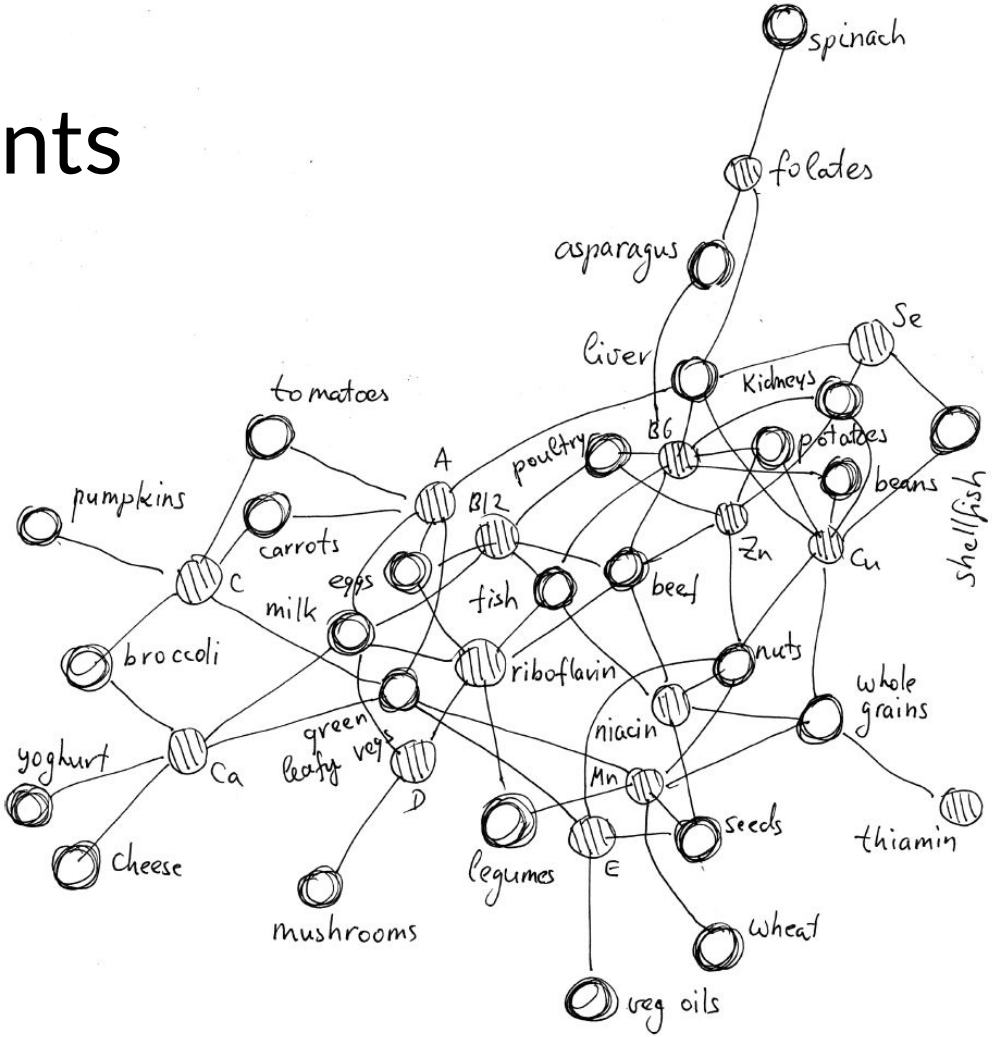
https://insights.stackoverflow.com/survey/2019



Game of Thrones character relationship

http://bit.do/gotchar

Food & Nutrients Network



NetworkX

Stable (notes)

2.3 — April 2019
download | doc | pdf

Latest (notes)

2.4 development
github | doc | pdf

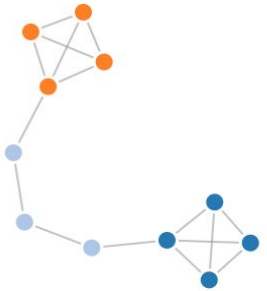
Archive

Contact

Mailing list
Issue tracker

Software for complex networks

https://networkx.github.io/



NetworkX is a Python package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks.

Features

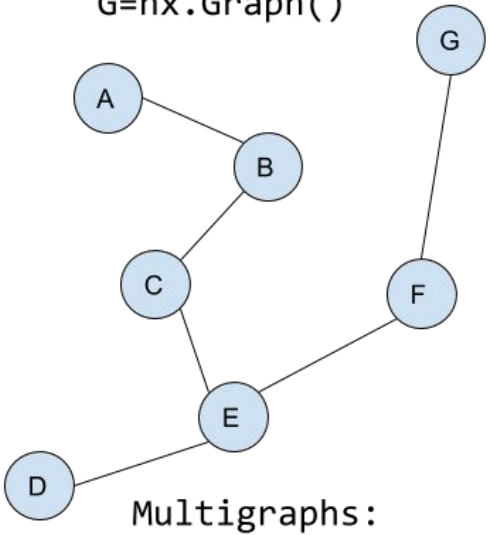
- Data structures for graphs, digraphs, and multigraphs
- Many standard graph algorithms
- Network structure and analysis measures
- Generators for classic graphs, random graphs, and synthetic networks
- Nodes can be "anything" (e.g., text, images, XML records)
- Edges can hold arbitrary data (e.g., weights, time-series)
- Open source 3-clause BSD license
- Well tested with over 90% code coverage
- Additional benefits from Python include fast prototyping, easy to teach, and multi-platform

```
import networkx as nx
```

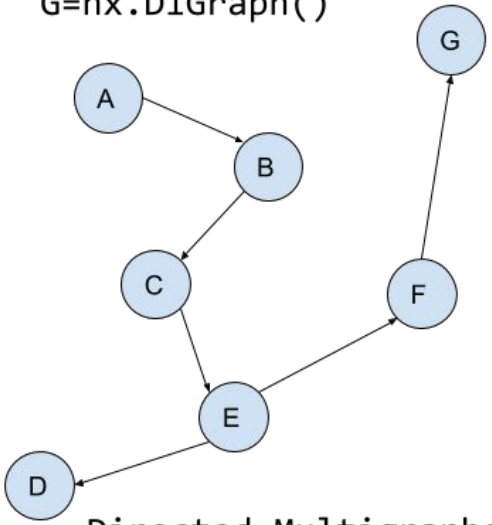
```
nx.__version__
```

```
'2.3'
```

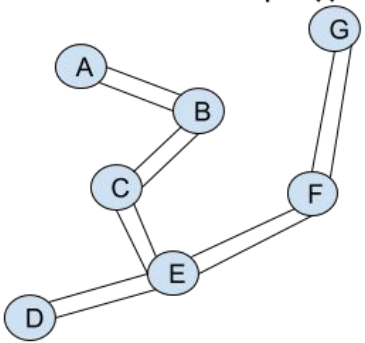
Undirected:
G=nx.Graph()



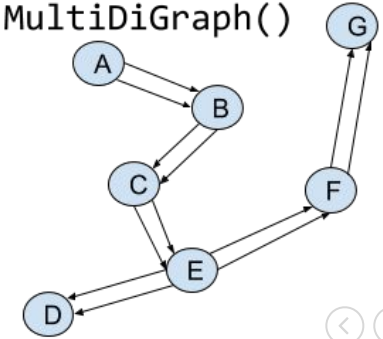
Directed:
G=nx.DiGraph()



Multigraphs:
G=nx.MultiGraph()



Directed Multigraphs:
G=nx.MultiDiGraph()



Add nodes and edges

```
G = nx.Graph([("A", "eggs")])

G.add_node("spinach") # Add a single node
G.add_node("Hg") # Add a single node by mistake
G.add_nodes_from(["folates", "asparagus", "liver"]) # Add a list of nodes

G.add_edge("spinach", "folates") # Add one edge, both ends exist
G.add_edge("spinach", "heating oil") # Add one edge by mistake
G.add_edge("liver", "Se") # Add one edge, one end does not exist
G.add_edges_from([("folates", "liver"), ("folates", "asparagus")])
```

Remove nodes and edges

```
G.remove_node("Hg")
G.remove_nodes_from(["Hg"]) # Safe to remove a missing node using a list
G.remove_edge("spinach", "heating oil")
G.remove_edges_from([("spinach", "heating oil")]) # See above
G.remove_node("heating oil") # Not removed yet
```

Look at Nodes list

```
G.nodes
NodeView(('A', 'eggs', 'spinach', 'folates', 'asparagus', 'liver', 'Se'))

G.nodes(data=True)
NodeDataView({'A': {}, 'eggs': {}, 'spinach': {}, 'folates': {},
              'asparagus': {}, 'liver': {}, 'Se': {}})

G.nodes["A"]
{}
```

Look at Edges list

```
G.edges
EdgeView([('A', 'eggs'), ('spinach', 'folates'), ('folates', 'liver'),
          ('folates', 'asparagus'), ('liver', 'Se')])

G.edges(data=True)
EdgeDataView([('A', 'eggs', {}), ('spinach', 'folates', {}),
              ('folates', 'liver', {}), ('folates', 'asparagus', {}),
              ('liver', 'Se', {})])

G.edges["A","eggs"]
{}

G["folates"]
AtlasView({'spinach': {}, 'liver': {}, 'asparagus': {}})
```

Up to section 2.2

Add attributes

```
G.add_node("Honey", edible=True)
G.add_nodes_from([("Steel", {"edible" : False})])

G.add_edge("Honey", "Steel", weight=0.0)
G.add_edges_from([("Honey", "Zn")], related=False)
```

```
G.node["Honey"]
{'edible': True}

G.node["Steel"]
{'edible': False}

G.edges["Honey","Steel"]
{'weight': 0.0}

G.edges["Honey","Zn"]
{'related': False}
```

G.add_edges_from() vs G.add_weighted_edges_from()

```
G.add_edges_from([("Honey", "Zn")], related=False)

G.add_weighted_edges_from([("Honey", "Zn", 0.01),
                           ("Honey", "Sugar", 0.99)])

G.edges["Honey","Zn"]
{'related': False, 'weight': 0.01}

G.edges["Honey","Sugar"]
{'weight': 0.99}
```

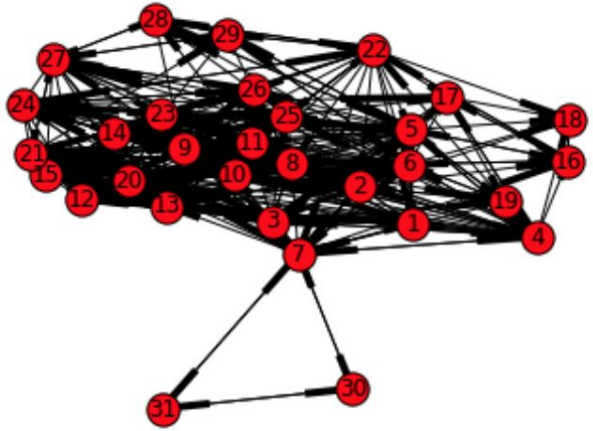
Update and remove attributes

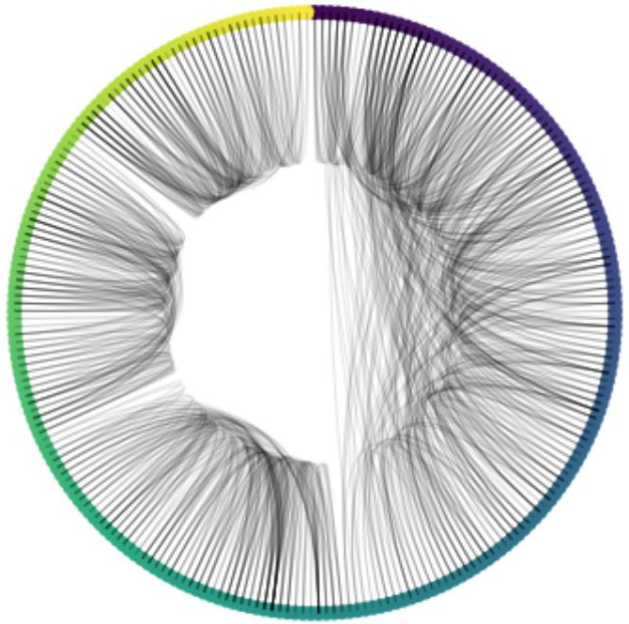
```
G.node["Zn"]["nutrient"] = True # Zinc is a nutrient
G.node["Zn"]
{'nutrient': True}

G.edges["Zn","Beef"]["weight"] = 0.95 # Zinc and beef are well connected
G.edges["Zn","Beef"]
{'weight': 0.95}


del G.node["Zn"]["nutrient"]
G.node["Zn"]
{}

del G.edges["Zn","Beef"]["weight"]
G.edges["Zn","Beef"]
{}
```

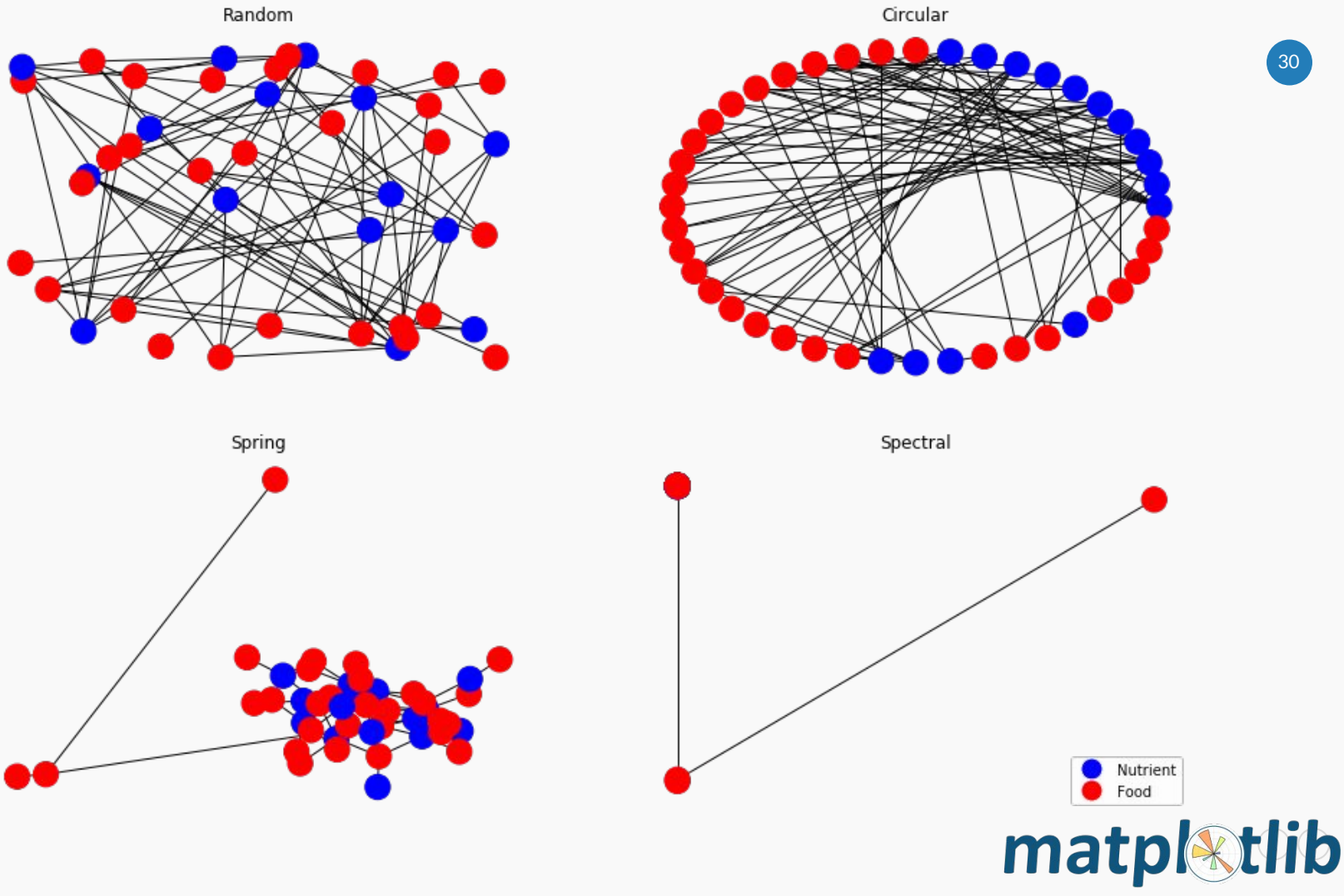
Define or change an attribute of existing nodes and edges by calling nx.set_node_attributes() or nx.set_edge_attributes():

```
nutrients = set(("B12", "Zn", "D", "B6",
                 "A", "Se", "Cu", "Folates",
                 "Ca", "Mn", "Thiamin", "Riboflavin",
                 "C", "E", "Niacin", "Starch","Mg","Na"))

nutrient_dict = {node: (node in nutrients) for node in G}
nx.set_node_attributes(G, nutrient_dict, "nutrient")

G.nodes(data=True)
NodeDataView({'A': {'nutrient': True}, 'B12': {'nutrient': True},
              'B6': {'nutrient': True}, 'C': {'nutrient': True}, ....
```

Irrational vs Rational Visualization






Random
Circular
Spring
Spectral
Nutrient
Food
matplotlib

```
import matplotlib.pyplot as plt

# Prepare for drawing
colors = ["blue" if n[1]["nutrient"] else "red" for n in G.nodes(data=True)]

# Create 4 subplots
fig, plot = plt.subplots(2, 2,figsize=(15,10))
subplots = plot.reshape(1, 4)[0]

# Configure the layouts and title of subplots
layouts = (nx.random_layout, nx.circular_layout,
           nx.spring_layout,nx.spectral_layout)
titles = ("Random", "Circular", "Spring", "Spectral")
```

```
# Main loop
for plot, layout, title in zip(subplots, layouts, titles):
  pos = layout(G)
  nx.draw_networkx(G, pos=pos, ax=plot, with_labels=False,node_color=colors)
  plot.set_title(title)

plt.show()
```

ericmjl / nxviz

Watch 15 | Star 196 | Fork 43

Code | Issues 22 | Pull requests 3 | Projects 2 | Wiki | Insights

Visualization Package for NetworkX http://nxviz.readthedocs.io/

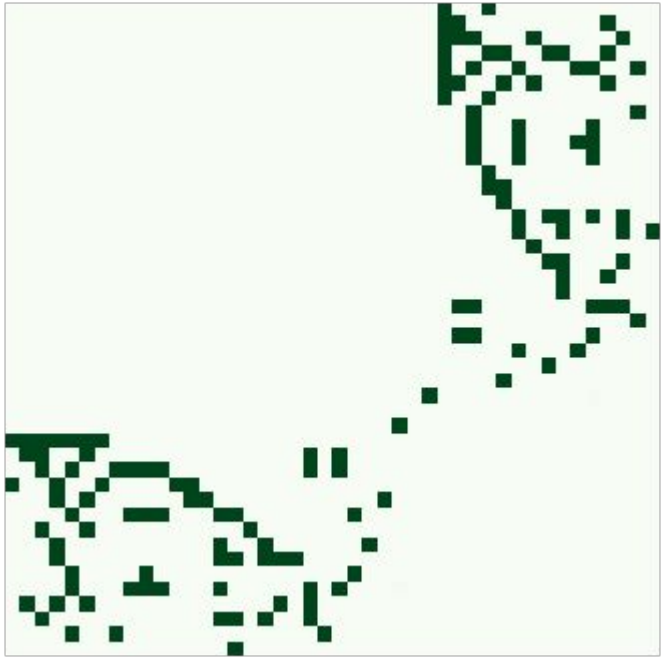
network-visualization | networkx | network | visualization

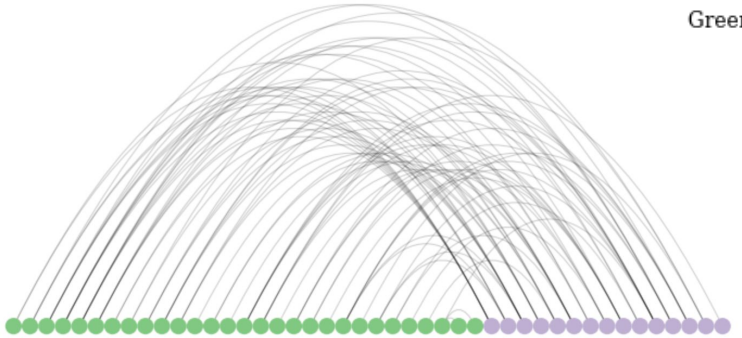
1,461 commits | 9 branches | 3 releases | 14 contributors | MIT

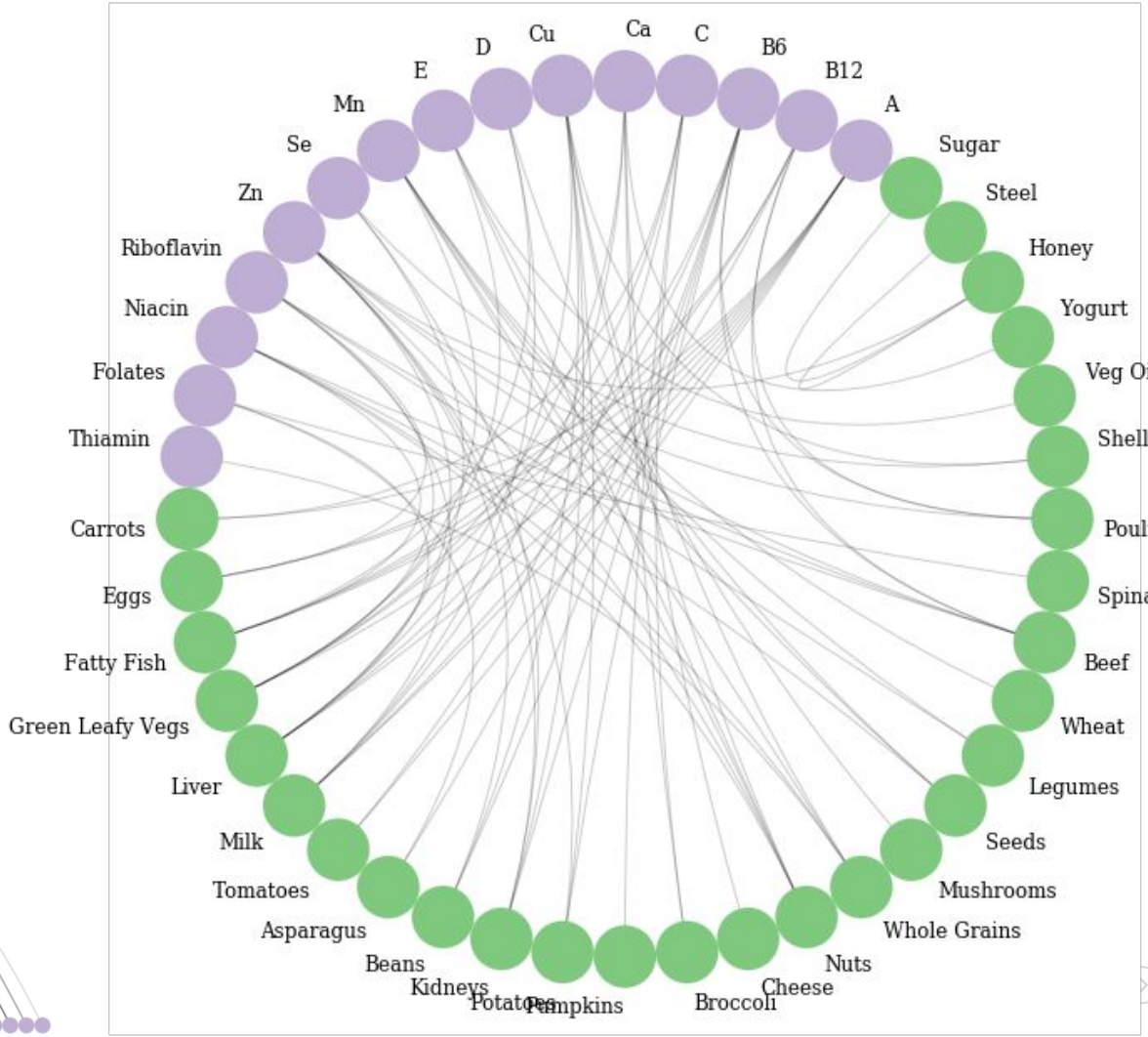
Branch: master | New pull request | Create new file | Upload files | Find File | Clone or download

ericmjl Merge pull request #547 from ericmjl/test-health-check-fixes ... Latest commit 6ea5823 8 days ago

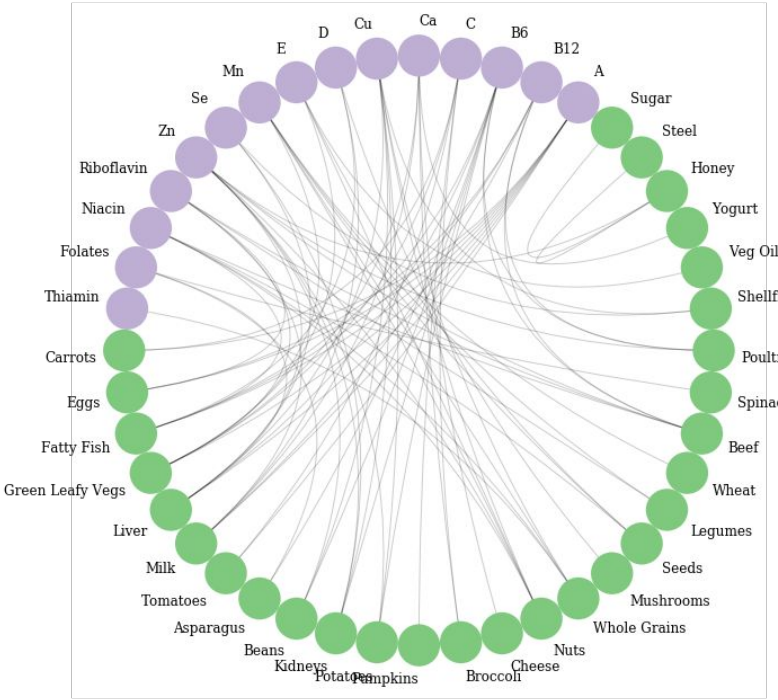
.github	Create pull_request_template.md	5 months ago
docs	docfixes	3 months ago
examples	applied black	8 days ago
nxviz	fix pycodestyle issue	8 days ago
tests	black formatting	8 days ago
.bumpversion.cfg	bumpversion 0.6.1	11 days ago
.editorconfig	Initial skeleton.	3 years ago






Ca
Cu
D
E
Mn
Se
Zn
Riboflavin
Niacin
Folates
Thiamin
Carrots
Eggs
Fatty Fish
Green Leafy Vegs
Liver
Milk
Tomatoes
Asparagus
Beans
Kidneys
Potatoes
Pumpkins
Broccoli
Cheese
Nuts
Whole Grains
Mushrooms
Seeds
Legumes
Wheat
Beef
Spinach
Poultry
Shellfish
Veg Oils
Yogurt
Honey
Steel
Sugar
A
B12
B6
C

```
# Import necessary modules to use Circos plot
import matplotlib.pyplot as plt
from nxviz import CircosPlot

# Create the CircosPlot object: c
c = CircosPlot(G, node_color='nutrient',
               node_grouping='nutrient',
               node_order="nutrient",
               node_labels=True,
               figsize = (10,10),
               nodeprops={"radius": 0.5},
               #node_label_layout="rotation",
               #node_label_layout="numbers",
               fontsize=12
               )
```



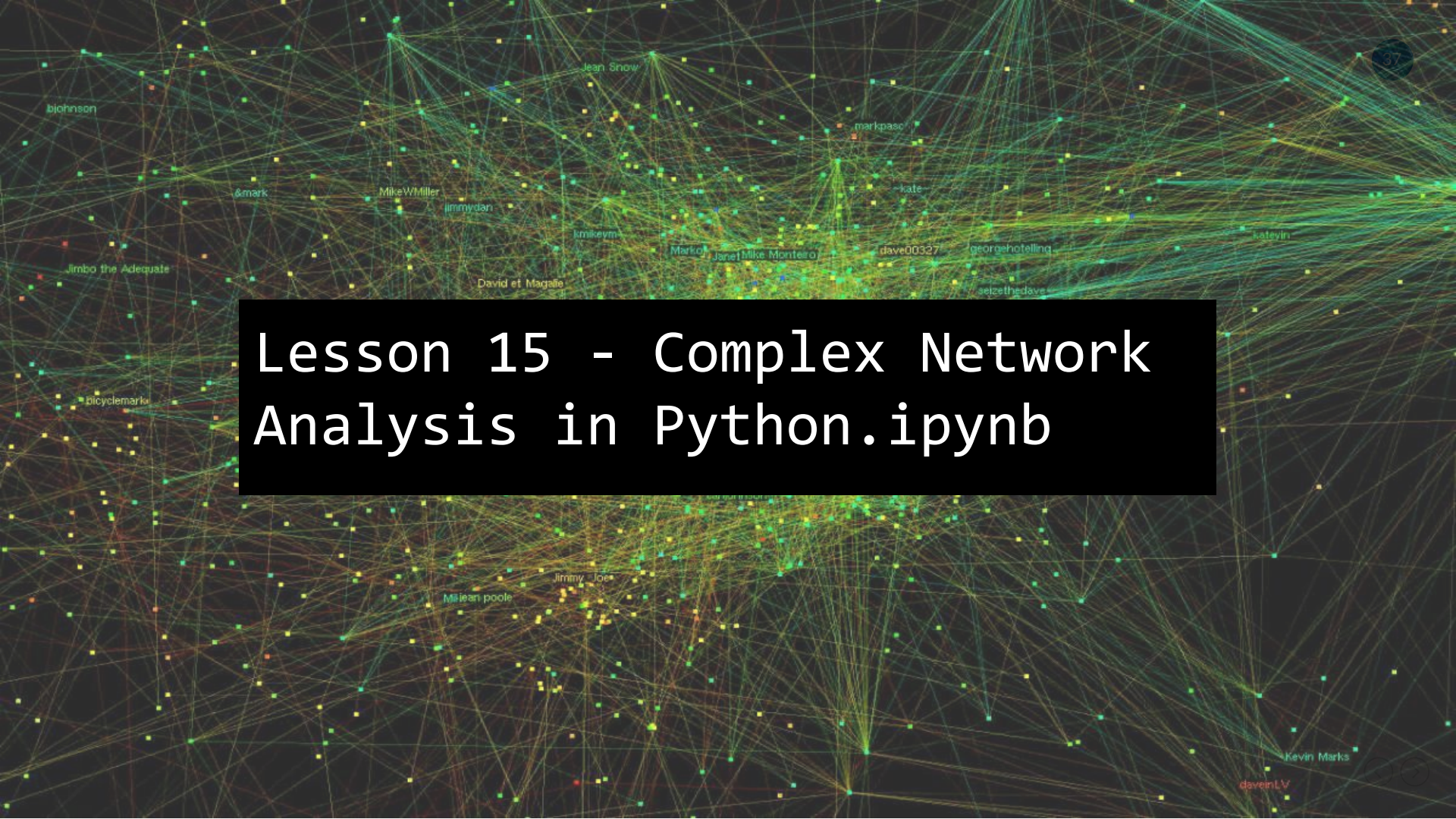

```
# Draw c to the screen
c.draw()
c.figure.tight_layout()

# Display the plot
plt.show()
```

```
NodeDataView({'A': {'nutrient': True},
              'B12': {'nutrient': True},
              'B6': {'nutrient': True},
              'C': {'nutrient': True},
              .....
             })
```

Update and remove attributes

Format	Attributes	Reader	Writer	Supported by Gephi?
Adjacency list	Not stored	nx.read_adjlist()	nx.write_adjlist()	Yes
Edge list	Not stored	nx.read_edgelist()	nx_write_edgelist()	Yes
Graph exchange XML format	Stored	nx.read_gexf()	nx.write_gexf()	Yes
Graph modeling language	Stored	nx.read_gml()	nx.write_gml()	w/o attributes
GraphML	Stored	nx.read_graphml()	nx.write_graphml()	Yes
Pajek NET	Not stored	nx.read_pajek()	nx.write_pajek()	Yes
Pickle	Stored	nx.read_gpickle()	nx.write_gpickle()	No
YAML	Stored	nx.read_yaml()	nx.write_yaml()	No

```
nx.write_graphml(G, "nutrients.graphml")
```



Lesson 15 - Complex Network Analysis in Python.ipynb