

NetworkX Tutorial

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Local Installation

- install manually from
`http://pypi.python.org/pypi/networkx`
- or use built-in python package manager, easy install
`$ easy_install networkx`
- or use macports
`$ sudo port install py27-networkx`
- use pip (replacement for easy_install)
`$ sudo pip install networkx`
- or use debian package manager
`$ sudo apt-get install python-networkx`

Using Corn

- networkx is already installed on the corn cluster
- Only works for python version 2.6, 2.7
- However default mapping of command 'python' is to version 2.4
- Just type 'python2.6' instead or make an alias in your shell configuration

Basic Usage

```
>>> import networkx as nx
>>> g = nx.Graph()
>>> g.add_node("spam")
>>> g.add_edge(1,2)
>>> print(g.nodes())
[1, 2, 'spam']
>>> print(g.edges())
[(1, 2)]
```

Graph Types

- Graph : Undirected simple (allows self loops)
- DiGraph : Directed simple (allows self loops)
- MultiGraph : Undirected with parallel edges
- MultiDiGraph : Directed with parallel edges
- can convert to undirected: `g.to_undirected()`
- can convert to directed: `g.to_directed()`

To construct, use standard python syntax:

```
>>> g = nx.Graph()
>>> d = nx.DiGraph()
>>> m = nx.MultiGraph()
>>> h = nx.MultiDiGraph()
```

Adding Nodes

- `add_nodes_from()` takes any iterable collection and any object

```
>>> g = nx.Graph()
>>> g.add_node('a')
>>> g.add_nodes_from(['b','c','d'])
>>> g.add_nodes_from('xyz')
>>> h = nx.path_graph(5)
>>> g.add_nodes_from(h)
>>> g.nodes()
[0, 1, 'c', 'b', 4, 'd', 2, 3, 5, 'x', 'y', 'z']
```

Adding Edges

- Adding an edge between nodes that don't exist will automatically add those nodes
- `add_nodes_from()` takes any iterable collection and any type (anything that has a `__iter__()` method)

```
>>> g = nx.Graph( [( 'a', 'b'), ('b', 'c'), ('c',  
    , 'a') ] )  
>>> g.add_edge('a', 'd')  
>>> g.add_edges_from([( 'd', 'c'), ('d', 'b')  
    ])
```


Node Attributes

- Can add node attributes as optional arguments along with most add methods

```
>>> g = nx.Graph()
>>> g.add_node(1, name='Obrian')
>>> g.add_nodes_from([2], name='Quintana'])
>>> g[1]['name']
'Obrian'
```

Edge Attributes

- Can add edge attributes as optional arguments along with most add methods

```
>>> g.add_edge(1, 2, w=4.7 )
>>> g.add_edges_from([(3,4),(4,5)], w =3.0)
>>> g.add_edges_from([(1,2,{'w':2.0})])
# adds third value in tuple as 'weight' attr
>>> g.add_weighted_edges_from([(6,7,3.0)])
>>> g.get_edge_data(3,4)
{'w' : 3.0}
>>> g.add_edge(5,6)
>>> g[5][6]
{}
```

HW0 - Loading the Wikipedia Graph

- We want to load in the Wikipedia graph as a directed graph.

```
>>> file = 'wiki.txt'
>>> wiki = nx.read_adjlist(file, delimiter
    = '\t', create_using=nx.DiGraph())
```

Importing Other Graph Formats

- GML
- Pickle
- GraphML
- YAML
- Pajek
- GEXF
- LEDA
- SparseGraph6
- GIS Shapefile

Simple Graph Generators

- located in `networkx.generators.classic` module
- Complete Graph

```
nx.complete_graph(5)
```

- Chain

```
nx.path_graph(5)
```

- Bipartite

```
nx.complete_bipartite_graph(n1, n2)
```

- Arbitrary Dimensional Lattice (nodes are tuples of ints)

```
nx.grid_graph([10,10,10,10]) # 4D, 100^4  
nodes
```

Random Graph Generators

- located in module `networkx.generators.random_graphs`
- Preferential Attachment

```
nx.barabasi_albert_graph(n, m)
```

- $G_{n,p}$

```
nx.gnp_random_graph(n, p)
```

```
nx.gnm_random_graph(n, m)
```

- ```
nx.watts_strogatz_graph(n, k, p}
```

# HW0 - Simple Properties

- Number of nodes :

```
>>> len(wiki)
```

- Number of Self-loops

```
>>> wiki.number_of_selfloops()
```

- Number of Directed Edges

```
>>> wiki.size()
```

- Number of Undirected Edges

```
>>> wiki.to_undirected().size()
```

# Degrees

```
>>> g.degree(0)
1
>>> g.degree([0,1])
{0: 1, 1: 2}
>>> g.degree()
{1: 1, 2: 2, 3: 2, 4: 1}
>>> g.degree().values() # useful for degree
 dist
[1, 2, 2, 1]
```



## HW0 - Simple Properties Continued

- Number of Reciprocated Edges :

```
>>> wiki.to_undirected(True).size()
```

- Number of Nodes with OutDegree 0

```
>>> reduce(lambda c, n: c + 1 if wiki.out_degree(n) < 1 else c, wiki.nodes(), 0)
```

- Number of Nodes with InDegree < 10

```
>>> reduce(lambda c, n: c + 1 if wiki.in_degree(n) < 10 else c, wiki.nodes(), 0)
```

# Neighbors

- Quickly find all of the neighbors of a node.

```
>>> g = nx.Graph()
>>> g.add_edge(1,2)
>>> g.add_edge(2,3)
>>> g.neighbors(2)
[1, 3]
```

# Algorithms Package (`networkx.algorithms`)

- bipartite
- block
- boundary
- centrality (package)
- clique
- cluster
- components (package)
- core
- cycles
- dag
- distance\_measures
- flow (package)
- isolates
- isomorphism (package)
- link\_analysis (package)
- matching
- mixing
- mst
- operators
- shortest\_paths (package)
- smetric

# Use the Python Help Viewer

```
>>> import networkx as nx
>>> help(nx.algorithms)
```

- pops up an instance of 'less' (the pager utility)

# A Few Useful Functions

- As subgraphs

```
nx.connected_component_subgraphs(G)
```

- Operations on Graph

```
nx.union(G,H), intersection(G,H),
complement(G)
```

- $k$ -cores

```
nx.find_cores(G)
```

# A Few More

- shortest path

```
nx.shortest_path(G,s,t)
```

- clustering

```
nx.average_clustering(G)
```

- diameter

```
nx.diameter(G)
```

# Matplotlib

- A python package which emulates matlab functionality
  - Well documented at  
<http://matplotlib.sourceforge.net/contents.html>
- Interfaces nicely with NetworkX
- Depends on Numpy which provides multidimensional array support:
  - <http://numpy.scipy.org/>
- We only really need it for plotting

# Setting up Matplotlib

- Need to specify a **backend**, which is the program which is responsible for either displaying or writing the plots to file
- For more info, see: [http://matplotlib.sourceforge.net/faq/installing\\_faq.html#what-is-a-backend](http://matplotlib.sourceforge.net/faq/installing_faq.html#what-is-a-backend)
- On corn, you simply add the following magic incantation to the top of your python scripts:

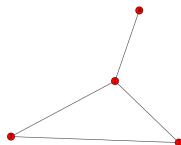
```
import matplotlib
matplotlib.use('Agg')
import matplotlib.pyplot as plt
```



# Basic Graph Drawing

```
def draw_graph():
 G = nx.Graph()
 G.add_edges_from([(1,2), (2,3), (1,3),
 (1,4)])
 nx.draw(G)
 plt.savefig("simple_graph.png")
```

- consult package `nx.drawing` for more options



# Data Plotting - Degree Distribution

First, we find the degree distribution as follows.

```
def plot_degree_distribution():
 degs = {}
 for n in wiki.nodes():
 deg = wiki.degree(n)
 if deg not in degs:
 degs[deg] = 0
 degs[deg] += 1
 items = sorted(degs.items())
```

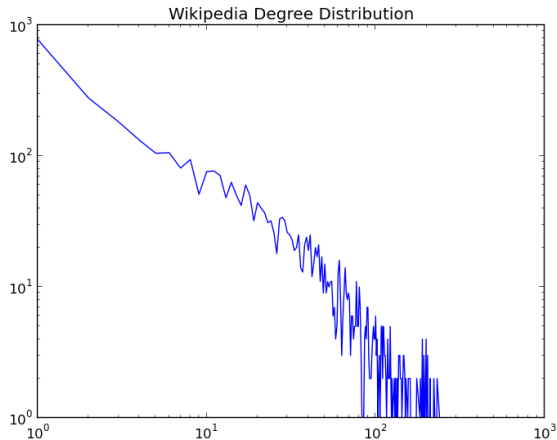
## Data Plotting - Degree Distribution continued

Then we plot it.

```
items = sorted(degs.items())
fig = plt.figure()
ax = fig.add_subplot(111)
ax.plot([k for (k,v) in items], [v for (k,
 v) in items])
ax.set_xscale('log')
ax.set_yscale('log')
plt.title("Wikipedia Degree Distribution")
fig.savefig("degree_distribution.png")
```

# Data Plotting - Degree Distribution continued

And voila!



# Resources

- NetworkX Docs  
<http://networkx.lanl.gov/tutorial/index.html>
- NetworkX Tutorial  
<http://networkx.lanl.gov/contents.html>
- Matplotlib Docs  
<http://matplotlib.sourceforge.net/contents.html>
- Matplotlib Tutorial  
[http://matplotlib.sourceforge.net/users/pyplot\\_tutorial.html](http://matplotlib.sourceforge.net/users/pyplot_tutorial.html)
- Numpy Docs  
<http://numpy.scipy.org/>
- MacPorts  
<http://macports.org>