3 - Getting Started with NetworkX

Drew Conway and Aric Hagberg

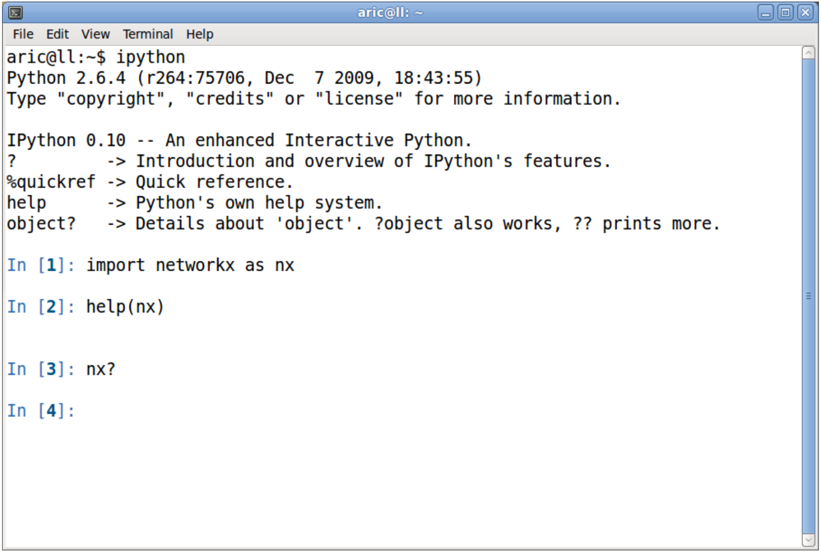
June 29, 2010

Outline

- Running Python and loading NetworkX
- Creating a Graph, adding nodes and edges
- Finding what is in NetworkX
- Interacting with NetworkX graphs
- Graph generators and operators
- Basic analysis of graphs

Running Python and loading NetworkX

IPython Command line

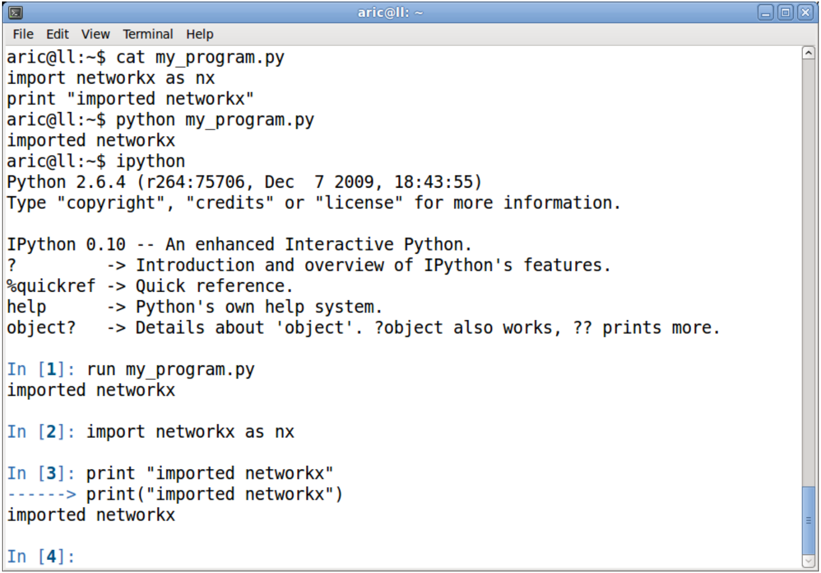


```
aric@ll:~$ ipython
Python 2.6.4 (r264:75706, Dec  7 2009, 18:43:55)
Type "copyright", "credits" or "license" for more information.

IPython 0.10 -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

In [1]: import networkx as nx

In [2]: help(nx)


In [3]: nx?

In [4]:
```

No GUI http://www.cryptonomicon.com/beginning.html

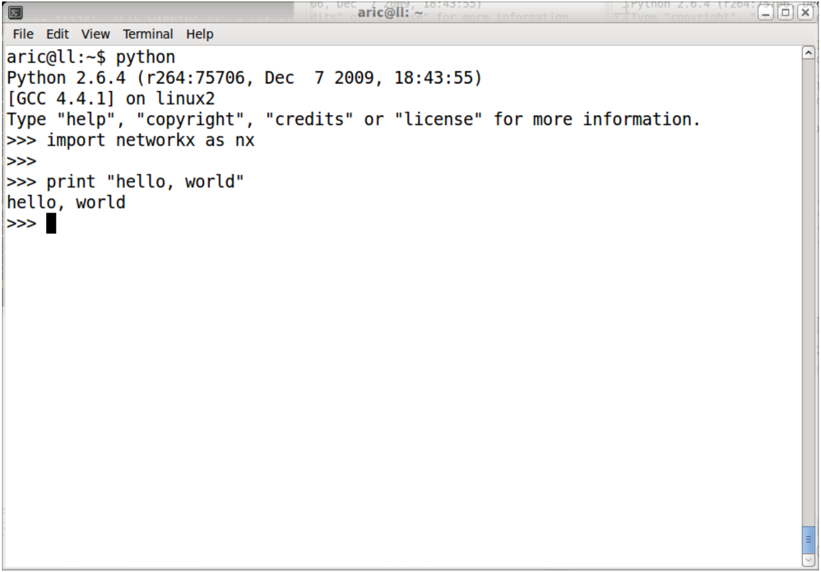
Command line vs executing file

You can type commands interactively or put them in a file and run them.



```
aric@ll:~$ cat my_program.py
import networkx as nx
print "imported networkx"
aric@ll:~$ python my_program.py
imported networkx
aric@ll:~$ ipython
Python 2.6.4 (r264:75706, Dec  7 2009, 18:43:55)
Type "copyright", "credits" or "license" for more information.

IPython 0.10 -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

In [1]: run my_program.py
imported networkx

In [2]: import networkx as nx

In [3]: print "imported networkx"
------> print("imported networkx")
imported networkx

In [4]:
```

The > > > (doctests)



```
aric@ll:~$ python
Python 2.6.4 (r264:75706, Dec  7 2009, 18:43:55)
[GCC 4.4.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import networkx as nx
>>>
>>> print "hello, world"
hello, world
>>> 
```

Creating a graph

The basic *Graph* object is used to hold the network information.
Create an empty graph with no nodes and no edges:

```
>>> import networkx as nx

>>> G=nx.Graph()
```

The graph G can be grown in several ways.
NetworkX includes many graph generator functions and facilities to read and write graphs in many formats.

Adding nodes

```
# One node at a time
>>> G.add_node(1)  # "method" of G

# A list of nodes
>>> G.add_nodes_from([2,3])

# A container of nodes
>>> H=nx.path_graph(10)
>>> G.add_nodes_from(H) # G now contains the nodes of H

# In contrast, you could use the graph H as a node in G.
>>> G.add_node(H) # G now contains Graph H as a node
```

Nodes can be any hashable object such as strings, numbers, files, functions, and more.

G can also be grown by adding edges.

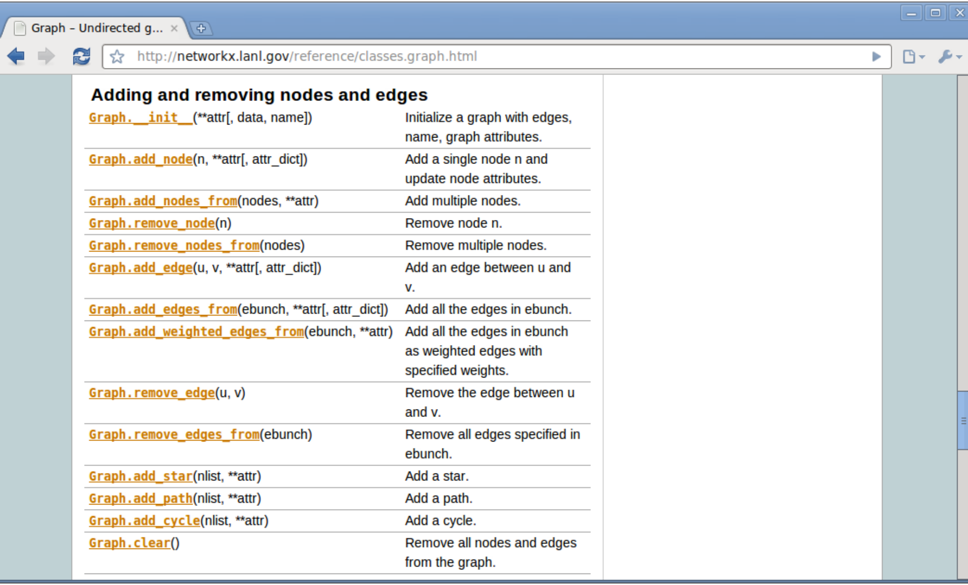
```
# Single edge
>>> G.add_edge(1,2)
>>> e=(2,3)
>>> G.add_edge(*e) # unpack edge tuple*

# List of edges

>>> G.add_edges_from([(1,2),(1,3)])

# Container of edges
>>> G.add_edges_from(H.edges())
```

If the nodes do not already exist they are automatically added to the graph.
You can demolish the graph similarly with

`G.remove_node`, `G.remove_nodes_from`,
`G.remove_edge`, `G.remove_edges_from`.

- How do I find out the names of the methods like add_edge?
- How do I see what is in my graph?

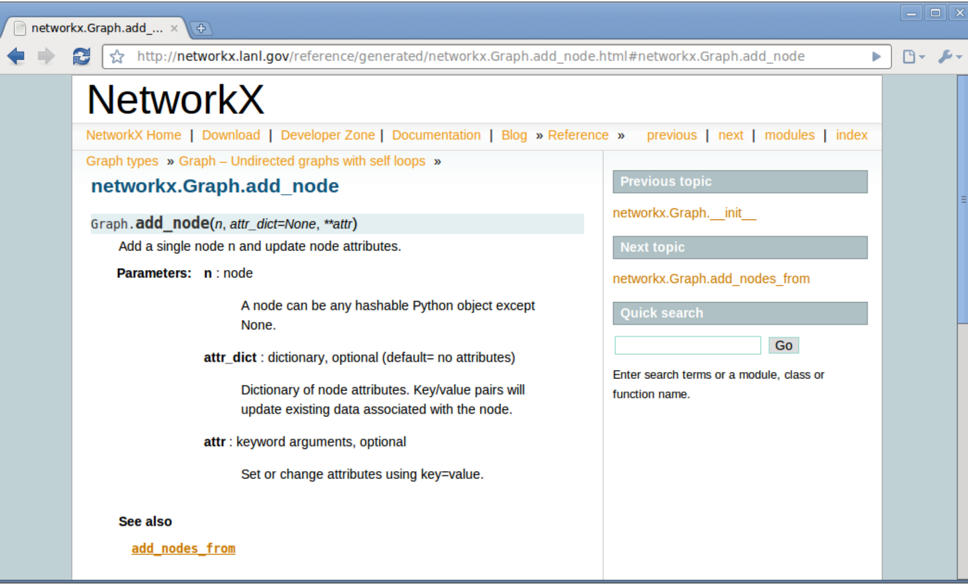
What’s in NetworkX?



Adding and removing nodes and edges

Graph.__init__(**attr[, data, name])	Initialize a graph with edges, name, graph attributes.
Graph.add_node(n, **attr[, attr_dict])	Add a single node n and update node attributes.
Graph.add_nodes_from(nodes, **attr)	Add multiple nodes.
Graph.remove_node(n)	Remove node n.
Graph.remove_nodes_from(nodes)	Remove multiple nodes.
Graph.add_edge(u, v, **attr[, attr_dict])	Add an edge between u and v.
Graph.add_edges_from(ebunch, **attr[, attr_dict])	Add all the edges in ebunch.
Graph.add_weighted_edges_from(ebunch, **attr)	Add all the edges in ebunch as weighted edges with specified weights.
Graph.remove_edge(u, v)	Remove the edge between u and v.
Graph.remove_edges_from(ebunch)	Remove all edges specified in ebunch.
Graph.add_star(nlist, **attr)	Add a star.
Graph.add_path(nlist, **attr)	Add a path.
Graph.add_cycle(nlist, **attr)	Add a cycle.
Graph.clear()	Remove all nodes and edges from the graph.

What’s in NetworkX?



networkx.Graph.add_...
http://networkx.lanl.gov/reference/generated/networkx.Graph.add_node.html#networkx.Graph.add_node

NetworkX

NetworkX Home | Download | Developer Zone | Documentation | Blog » Reference » previous | next | modules | index

Graph types » Graph – Undirected graphs with self loops »

networkx.Graph.add_node

`Graph.add_node(n, attr_dict=None, **attr)`

Add a single node n and update node attributes.

Parameters: **n** : node

A node can be any hashable Python object except None.

attr_dict : dictionary, optional (default= no attributes)

Dictionary of node attributes. Key/value pairs will update existing data associated with the node.

attr : keyword arguments, optional

Set or change attributes using key=value.

See also

add_nodes_from

Previous topic

networkx.Graph.__init__

Next topic

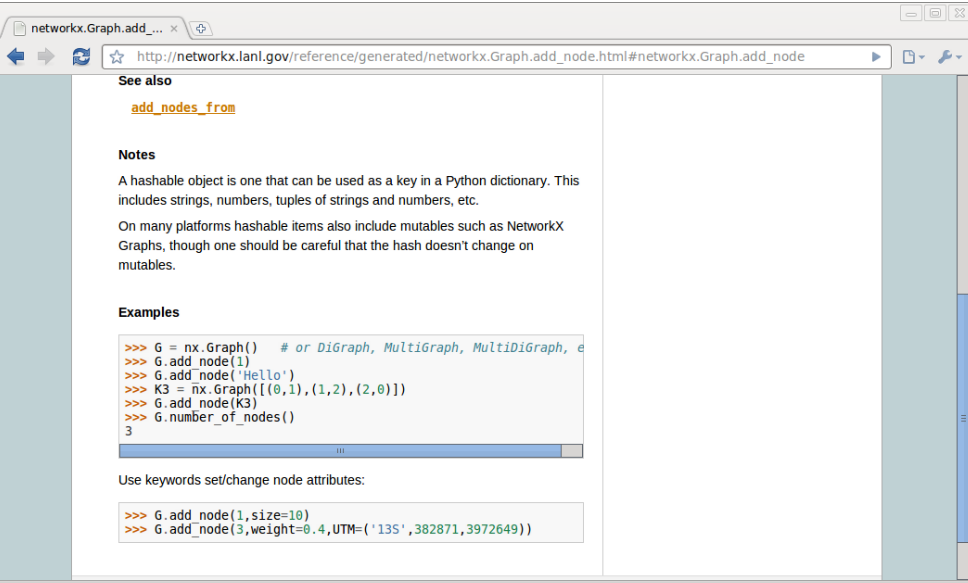
networkx.Graph.add_nodes_from

Quick search

Go

Enter search terms or a module, class or function name.

What's in Networkx?



networkx.Graph.add_...
http://networkx.lanl.gov/reference/generated/networkx.Graph.add_node.html#networkx.Graph.add_node

See also

add_nodes_from

Notes

A hashable object is one that can be used as a key in a Python dictionary. This includes strings, numbers, tuples of strings and numbers, etc.

On many platforms hashable items also include mutables such as NetworkX Graphs, though one should be careful that the hash doesn't change on mutables.

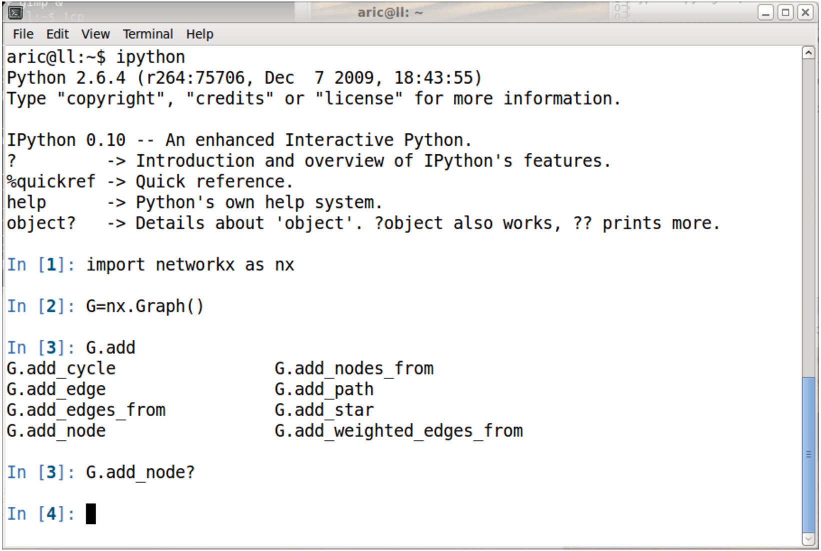
Examples

```
>>> G = nx.Graph()   # or DiGraph, MultiGraph, MultiDiGraph, e
>>> G.add_node(1)
>>> G.add_node('Hello')
>>> K3 = nx.Graph([(0,1),(1,2),(2,0)])
>>> G.add_node(K3)
>>> G.number_of_nodes()
3
```

Use keywords set/change node attributes:

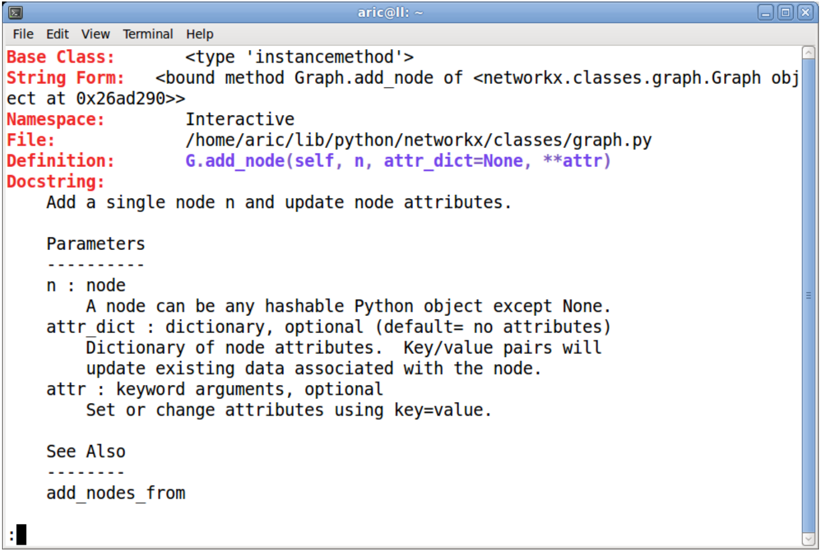
```
>>> G.add_node(1,size=10)
>>> G.add_node(3,weight=0.4,UTM=('13S',382871,3972649))
```

What’s in Networkx?



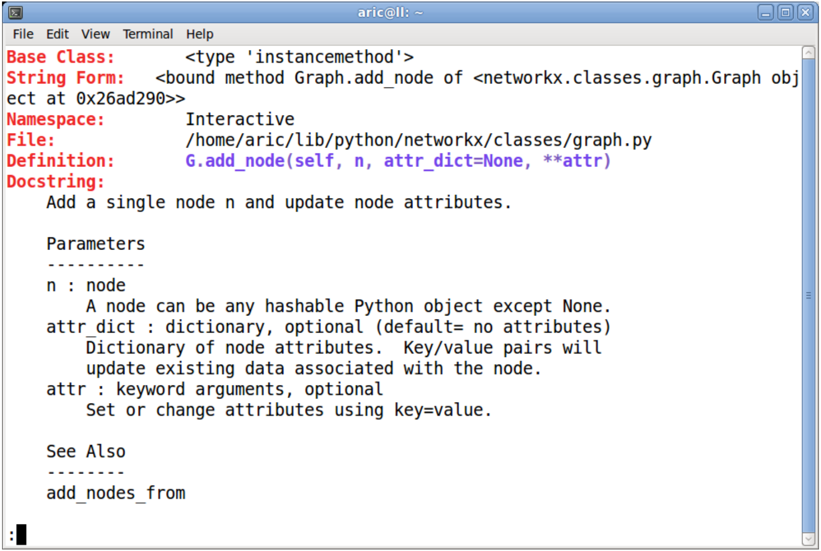
```
aric@ll:~$ ipython
Python 2.6.4 (r264:75706, Dec  7 2009, 18:43:55)
Type "copyright", "credits" or "license" for more information.

IPython 0.10 -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object'. ?object also works, ?? prints more.

In [1]: import networkx as nx

In [2]: G=nx.Graph()

In [3]: G.add
G.add_cycle                 G.add_nodes_from
G.add_edge                  G.add_path
G.add_edges_from            G.add_star
G.add_node                  G.add_weighted_edges_from

In [3]: G.add_node?

In [4]: 
```

What’s in Networkx?



```
Base Class:       <type 'instancemethod'>
String Form:    <bound method Graph.add_node of <networkx.classes.graph.Graph obj
ect at 0x26ad290>>
Namespace:        Interactive
File:             /home/aric/lib/python/networkx/classes/graph.py
Definition:       G.add_node(self, n, attr_dict=None, **attr)
Docstring:
    Add a single node n and update node attributes.

    Parameters
    ----------
    n : node
        A node can be any hashable Python object except None.
    attr_dict : dictionary, optional (default= no attributes)
        Dictionary of node attributes.  Key/value pairs will
        update existing data associated with the node.
    attr : keyword arguments, optional
        Set or change attributes using key=value.

    See Also
    --------
    add_nodes_from

:
```

What’s in Networkx?

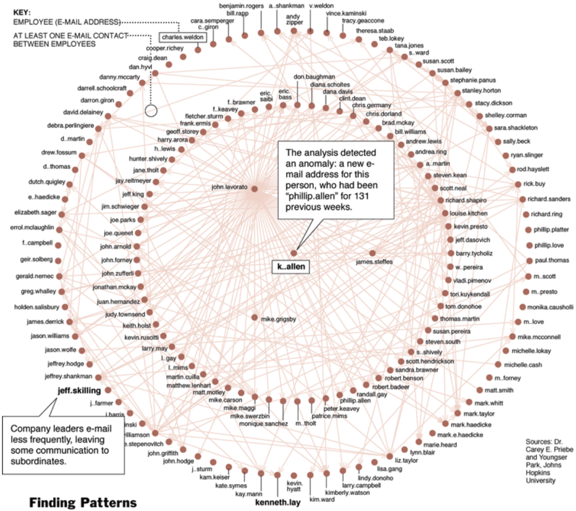


```
Base Class:       <type 'instancemethod'>
String Form:    <bound method Graph.add_node of <networkx.classes.graph.Graph obj
ect at 0x26ad290>>
Namespace:        Interactive
File:             /home/aric/lib/python/networkx/classes/graph.py
Definition:       G.add_node(self, n, attr_dict=None, **attr)
Docstring:
    Add a single node n and update node attributes.

    Parameters
    ----------
    n : node
        A node can be any hashable Python object except None.
    attr_dict : dictionary, optional (default= no attributes)
        Dictionary of node attributes.  Key/value pairs will
        update existing data associated with the node.
    attr : keyword arguments, optional
        Set or change attributes using key=value.

    See Also
    --------
    add_nodes_from

:
```

Adding attributes to graphs, nodes, and edges

(Almost) any Python object is allowed as graph, node, and edge data.

- number
- string
- image
- IP address
- email address



KEY:
EMPLOYEE (E-MAIL ADDRESS)
AT LEAST ONE E-MAIL CONTACT BETWEEN EMPLOYEES

The analysis detected an anomaly: a new e-mail address for this person, who had been "phillip.allen" for 131 previous weeks.

Company leaders e-mail less frequently, leaving some communication to subordinates.

Sources: Dr. Carey E. Priebe and Youngser Park, Johns Hopkins University

Finding Patterns In Corporate Chatter

Computer scientists are analyzing about a half million Enron e-mails. Here is a map of a week's e-mail patterns in May 2001, when a new name suddenly appeared. Scientists found that this week's pattern differed greatly from others, suggesting different conversations were taking place that might interest investigators. Next step: word analysis of these messages.

Graph attributes

```
>>> import networkx as nx
# Assign graph attributes when creating a new graph

>>> G = nx.Graph(day="Friday")
>>> G.graph
{’day’: ’Friday’} # Python dictionary

# Or you can modify attributes later

>>> G.graph[’day’]=’Monday’
>>> G.graph
{’day’: ’Monday’}
```

Node attributes

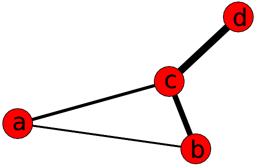
```

# Add node attributes using add_node(), add_nodes_from() or G.
>>> G.add_node(1, time='5pm')
>>> G.node[1]['time']
'5pm'
>>> G.node[1] # Python dictionray
{'time': '5pm'}

>>> G.add_nodes_from([3], time='2pm') # multiple nodes
>>> G.node[1]['room'] = 714 # add new attribute

>>> G.nodes(data=True)
[(1, {'room': 714, 'time': '5pm'}), (3, {'time': '2pm'})]
```

Edge attributes

```
# Add edge attributes using add_edge(), add_edges_from(),
# subscript notation, or G.edge.
>>> G.add_edge(1, 2, weight=4.0 )
>>> G[1][2][’weight’] = 4.0 # edge already added
>>> G.edge[1][2][’weight’] = 4.0 # edge already added

>>> G[1][2][’weight’]
 4.0
>>> G[1][2]
 {’weight’: 4.0}

>>> G.add_edges_from([(3,4),(4,5)], color=’red’)
>>> G.add_edges_from([(1,2,{’color’:’blue’}), (2,3,{’weight’:8

>>> G.edges()
 [(1, 2), (2, 3), (3, 4), (4, 5)]
>>> G.edges(data=True)
 [(1, 2, {’color’: ’blue’, ’weight’: 4.0}), (2, 3, {’weight’: 8
```

Weighted graph example

The special attribute ’weight’ should be numeric and holds values used by algorithms requiring weighted edges.
Use Dijkstra’s algorithm to find the shortest path:



```
>>> G=nx.Graph()
>>> G.add_edge(’a’,’b’,weight=0.3)
>>> G.add_edge(’b’,’c’,weight=0.5)
>>> G.add_edge(’a’,’c’,weight=2.0)
>>> G.add_edge(’c’,’d’,weight=1.0)
>>> print nx.shortest_path(G,’a’,’d’)
[’a’, ’c’, ’d’]
>>> print nx.shortest_path(G,’a’,’d’,weighted=True)
[’a’, ’b’, ’c’, ’d’]
```

More ways to build graphs: operators and generators

Applying classic graph operations

subgraph(G, nbunch) - induce subgraph of G on nodes in nbunch

union(G1,G2) - graph union

disjoint_union(G1,G2) - graph union assuming all nodes are different

cartesian_product(G1,G2) - return Cartesian product graph

compose(G1,G2) - combine graphs identifying nodes common to both

complement(G) - graph complement

create_empty_copy(G) - return an empty copy of the same graph class

convert_to_undirected(G) - return an undirected representation of G

convert_to_directed(G) - return a directed representation of G

Call a graph generator

```
# small graphs
petersen=nx.petersen_graph()
tutte=nx.tutte_graph()
maze=nx.sedgewick_maze_graph()
tet=nx.tetrahedral_graph()

# classic graphs
K_5=nx.complete_graph(5)
K_3_5=nx.complete_bipartite_graph(3,5)
barbell=nx.barbell_graph(10,10)
lollipop=nx.lollipop_graph(10,20)

# random graphs
er=nx.erdos_renyi_graph(100,0.15)
ws=nx.watts_strogatz_graph(30,3,0.1)
ba=nx.barabasi_albert_graph(100,5)
red=nx.random_lobster(100,0.9,0.9)
```

Read a graph stored in a file using common graph formats.

- edge lists
- adjacency lists
- GML
- GraphML
- Pajek
- LEDA

Basic analysis of graphs

```
>>> G=nx.Graph()
>>> G.add_edges_from([(1,2),(1,3)])
>>> G.add_node("spam")

# Structure of G can be analyzed using various
# graph−theoretic functions
>>> nx.connected_components(G)
[[1, 2, 3], [’spam’]]

# Functions that return node properties return
# dictionaries keyed by node label.
>>> nx.degree(G)
{1: 2, 2: 1, 3: 1, ’spam’: 0}

>>> sorted(nx.degree(G).values())
[0, 1, 1, 2]

>>> nx.clustering(G)
{1: 0.0, 2: 0.0, 3: 0.0, ’spam’: 0.0}
```