3 - Getting Started with NetworkX

Drew Conway and Aric Hagberg

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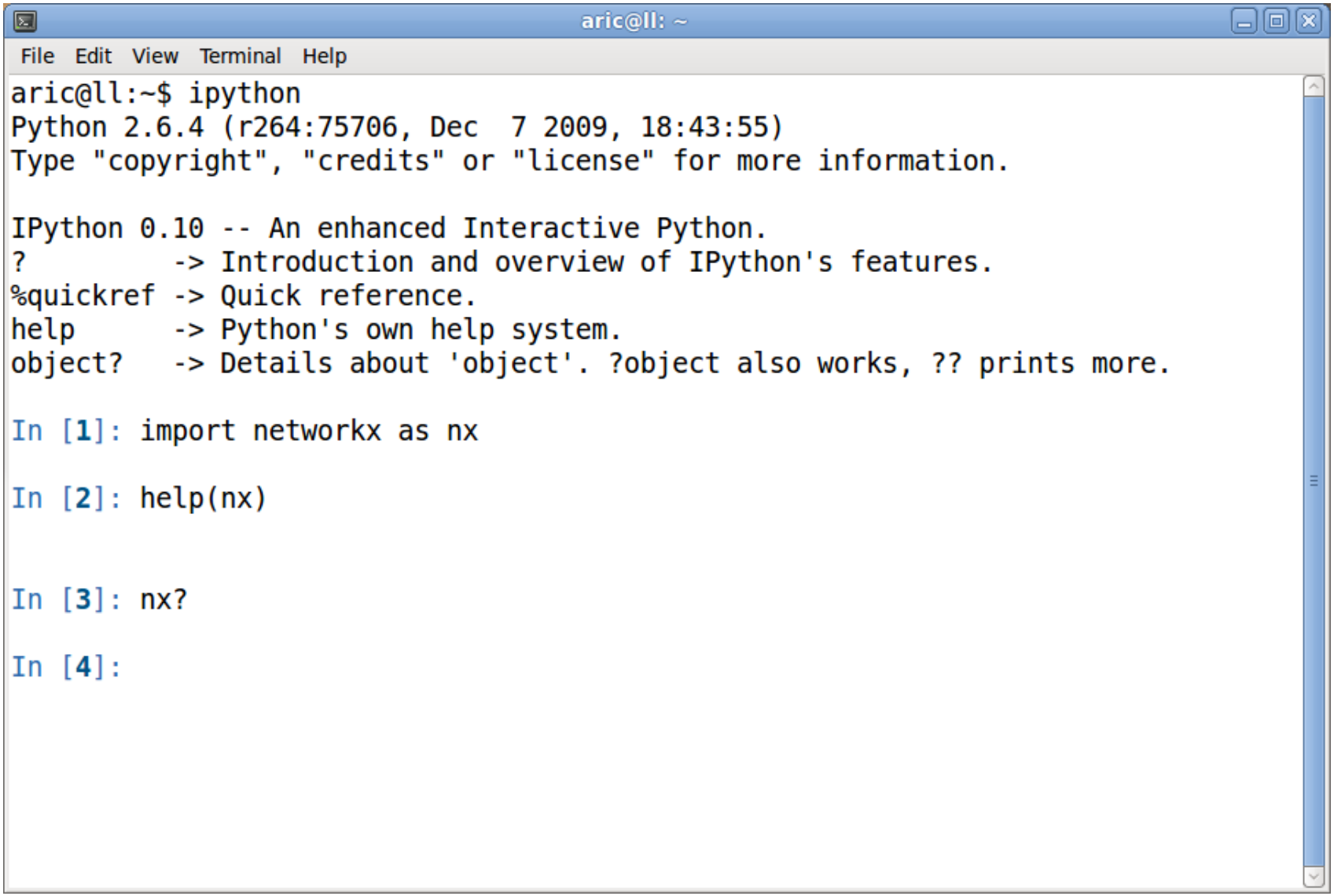
Outline

- 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

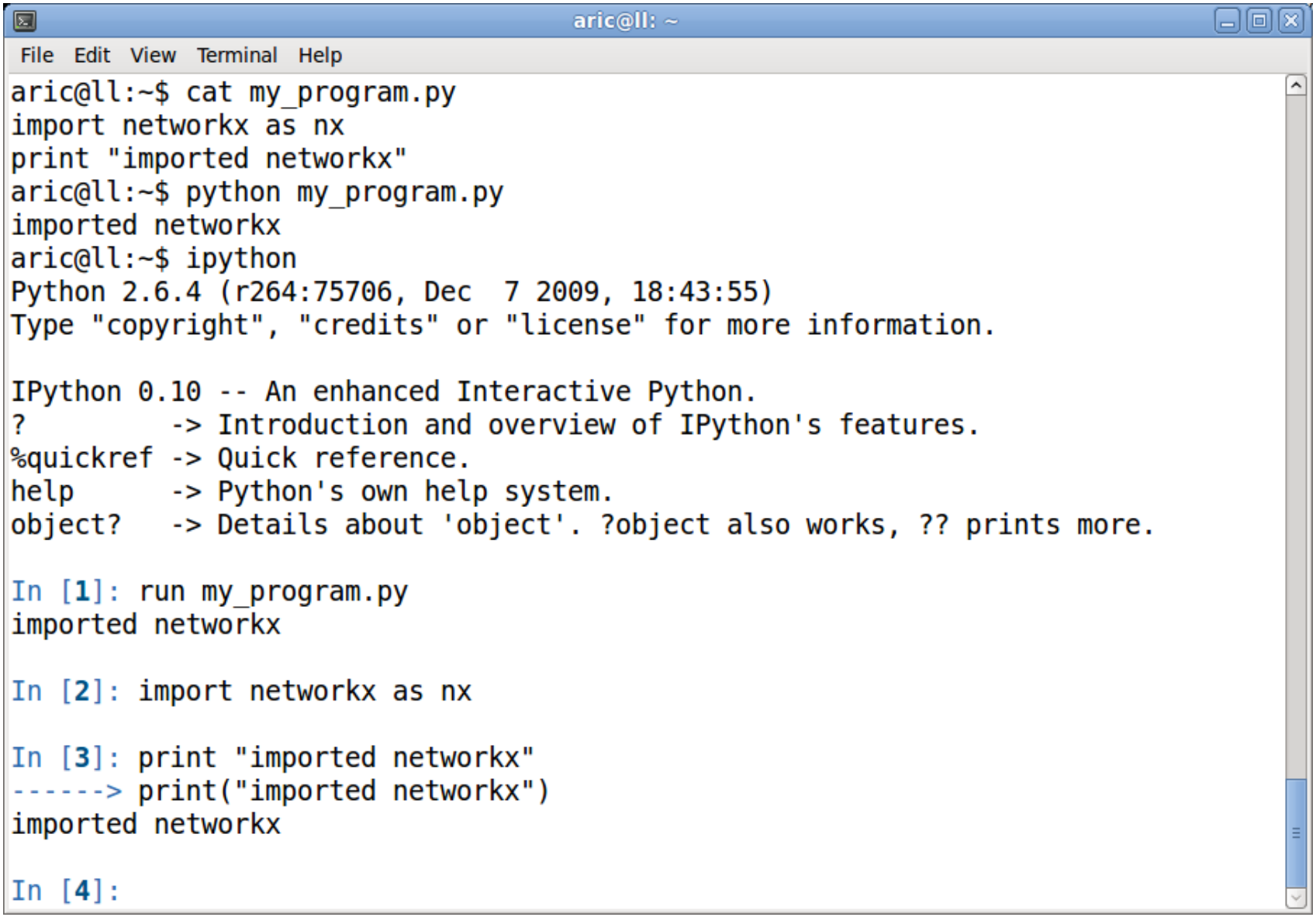
IPython Command line



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.



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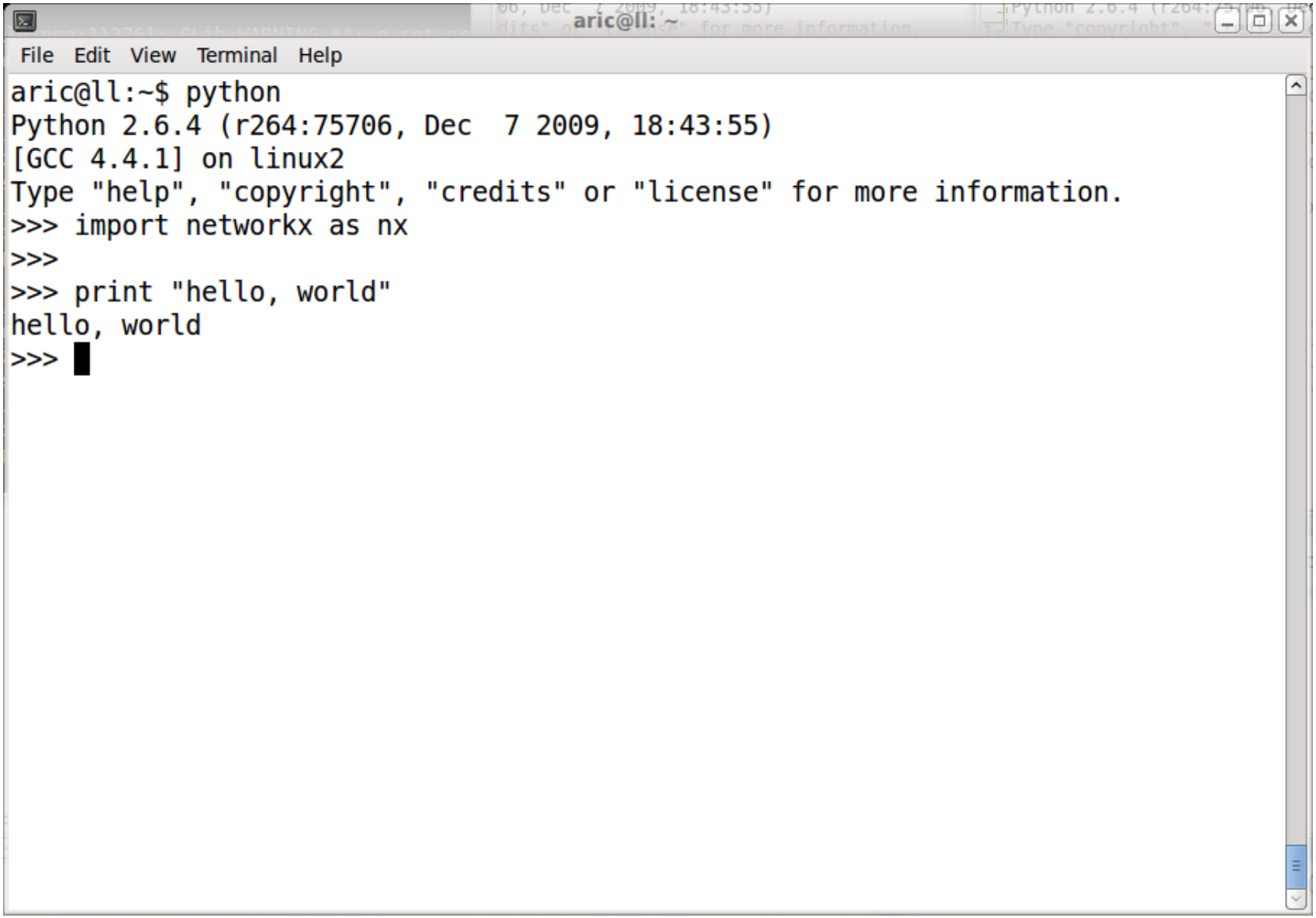


Creating a graph

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.

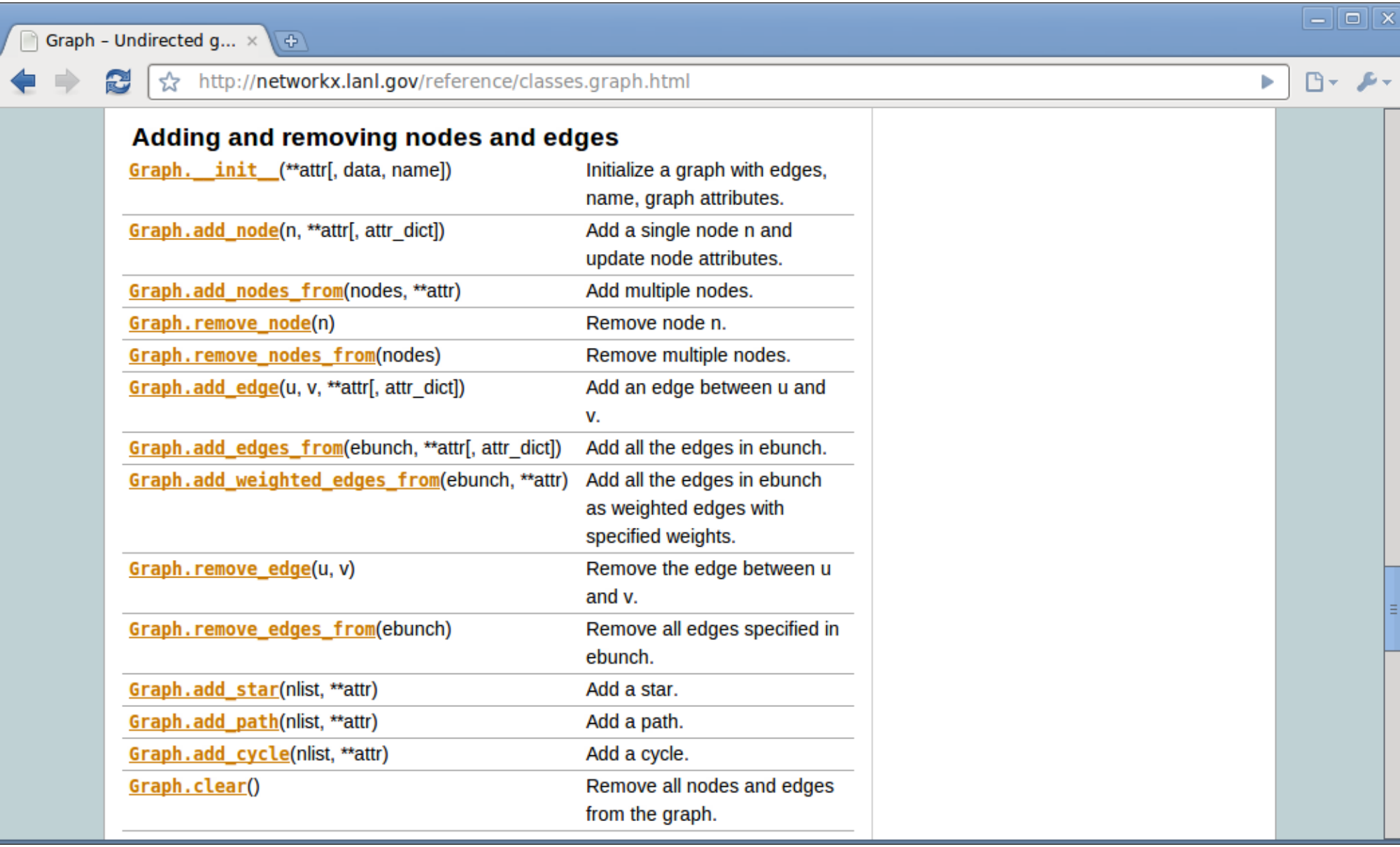
```
# Single edge
>>> G.add_edge(1,2)
>>> e=(2,3)
>>> G.add_edge(*e) # unpack edge tuple*

# 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?

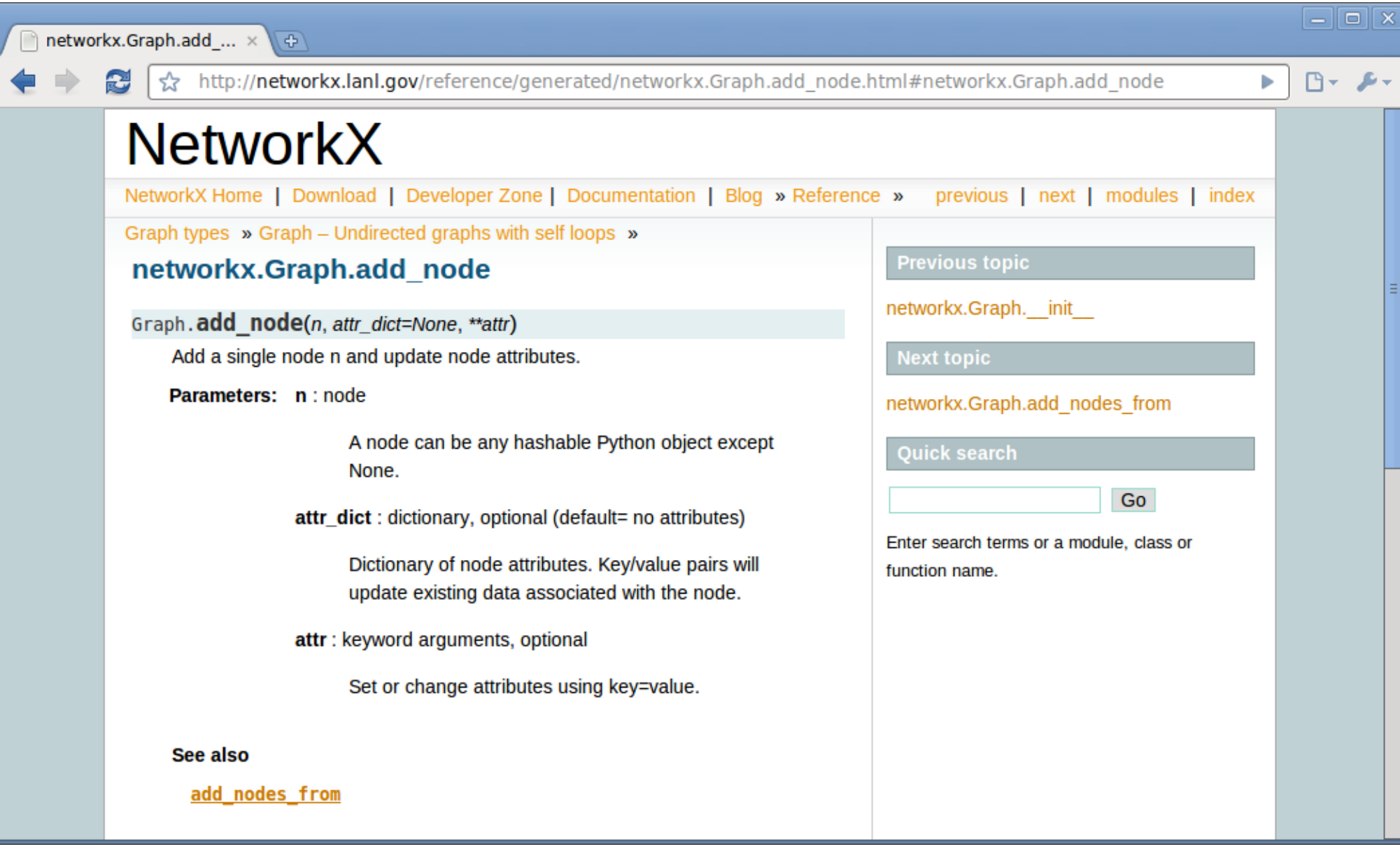
What's in NetworkX?



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?



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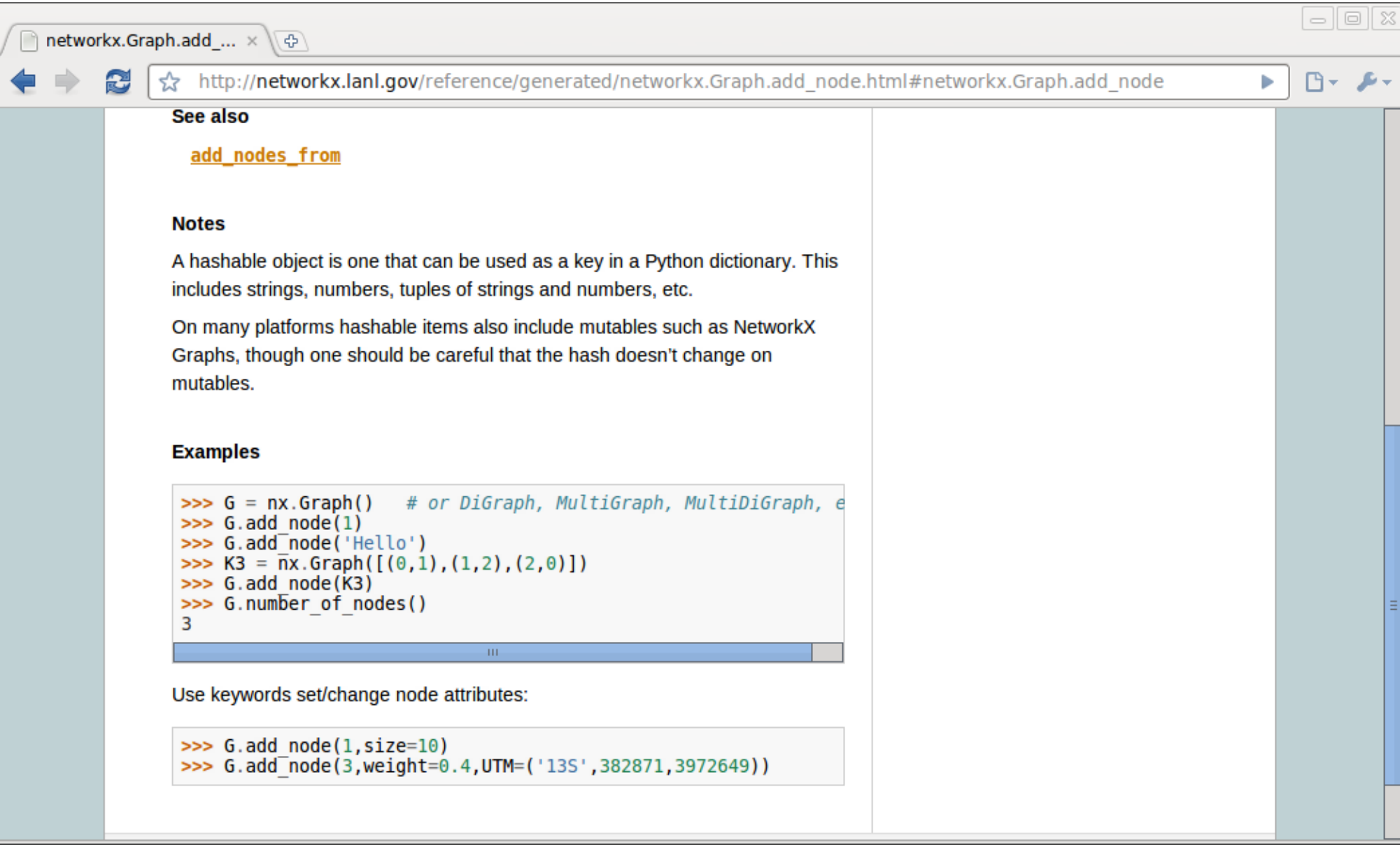

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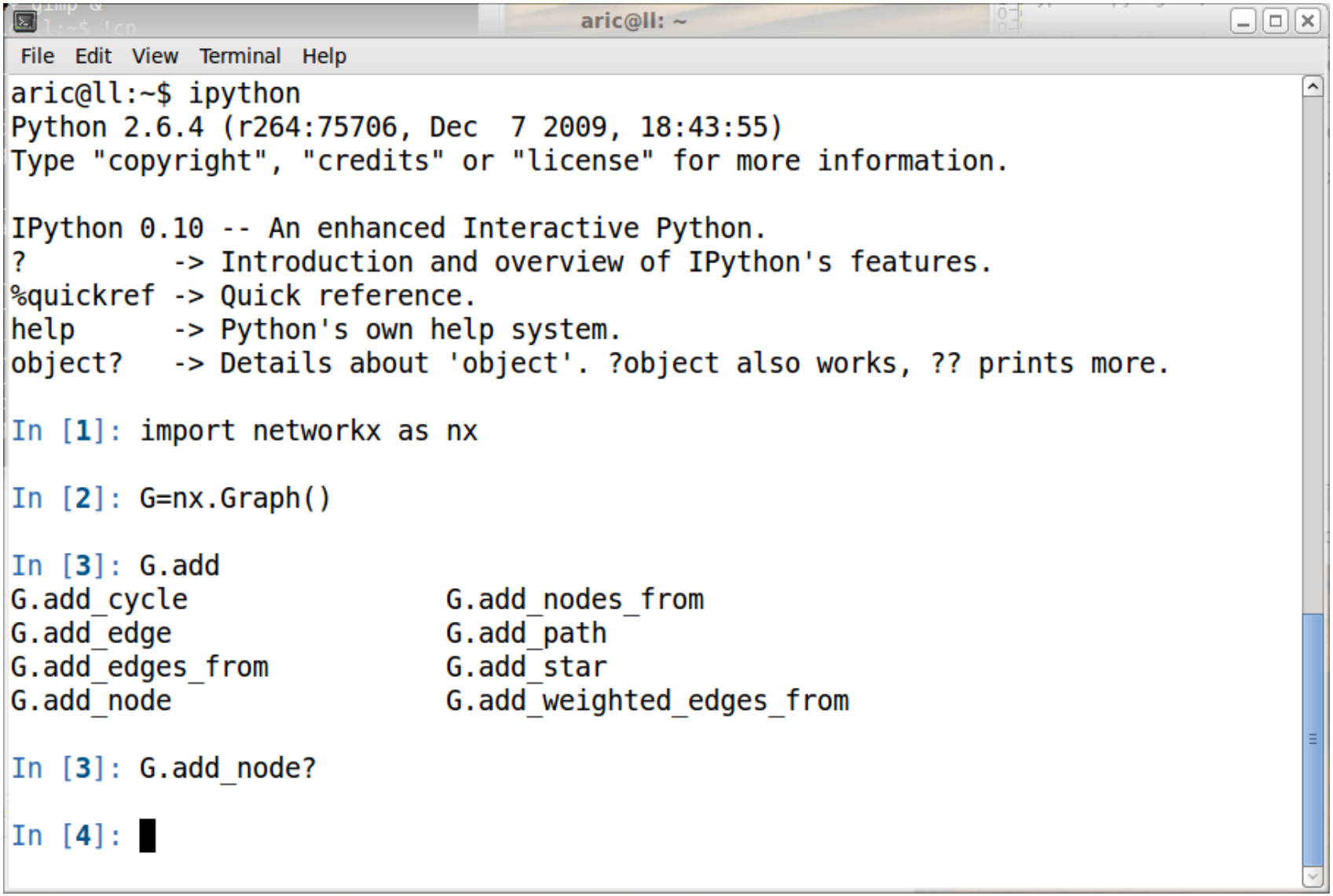

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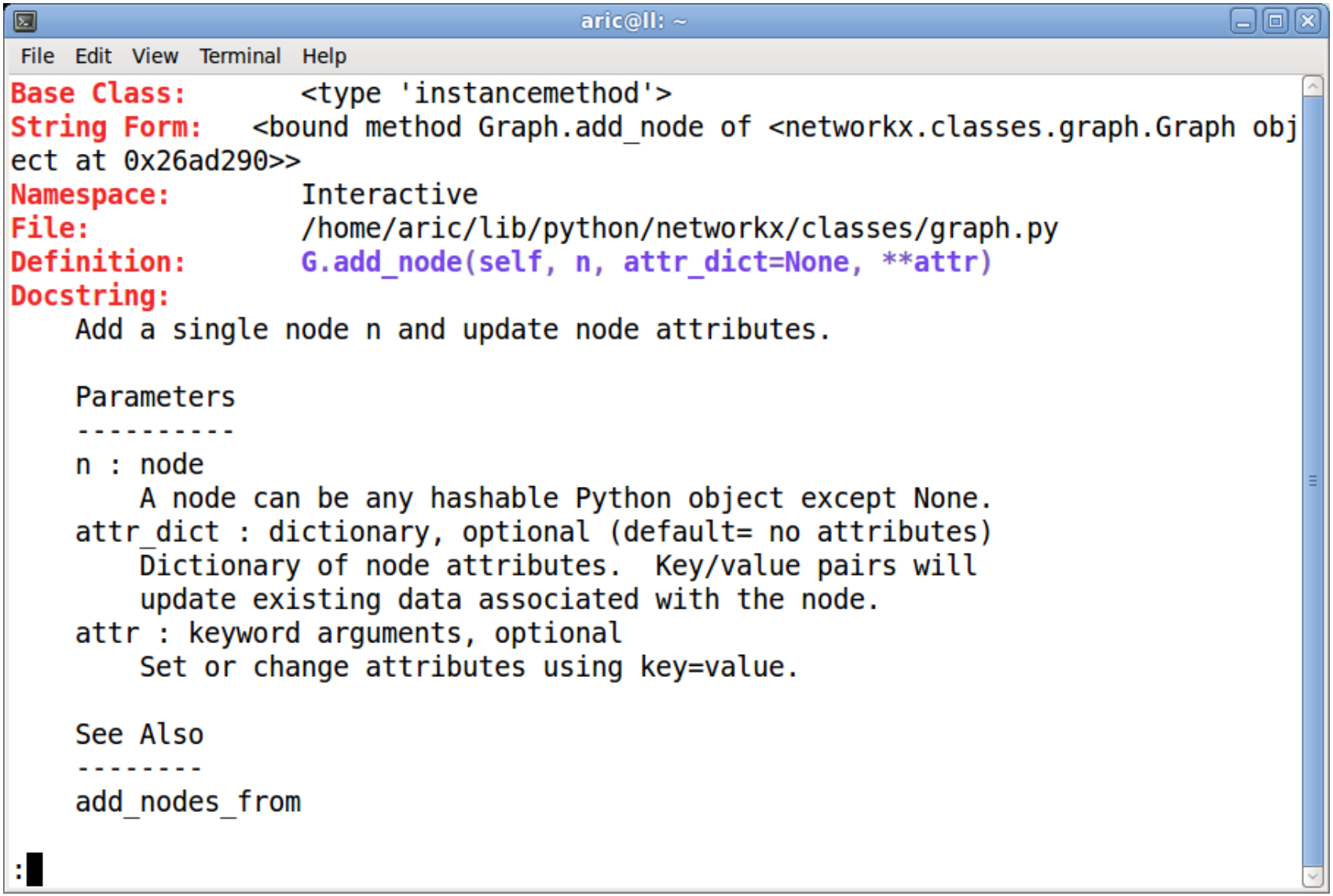

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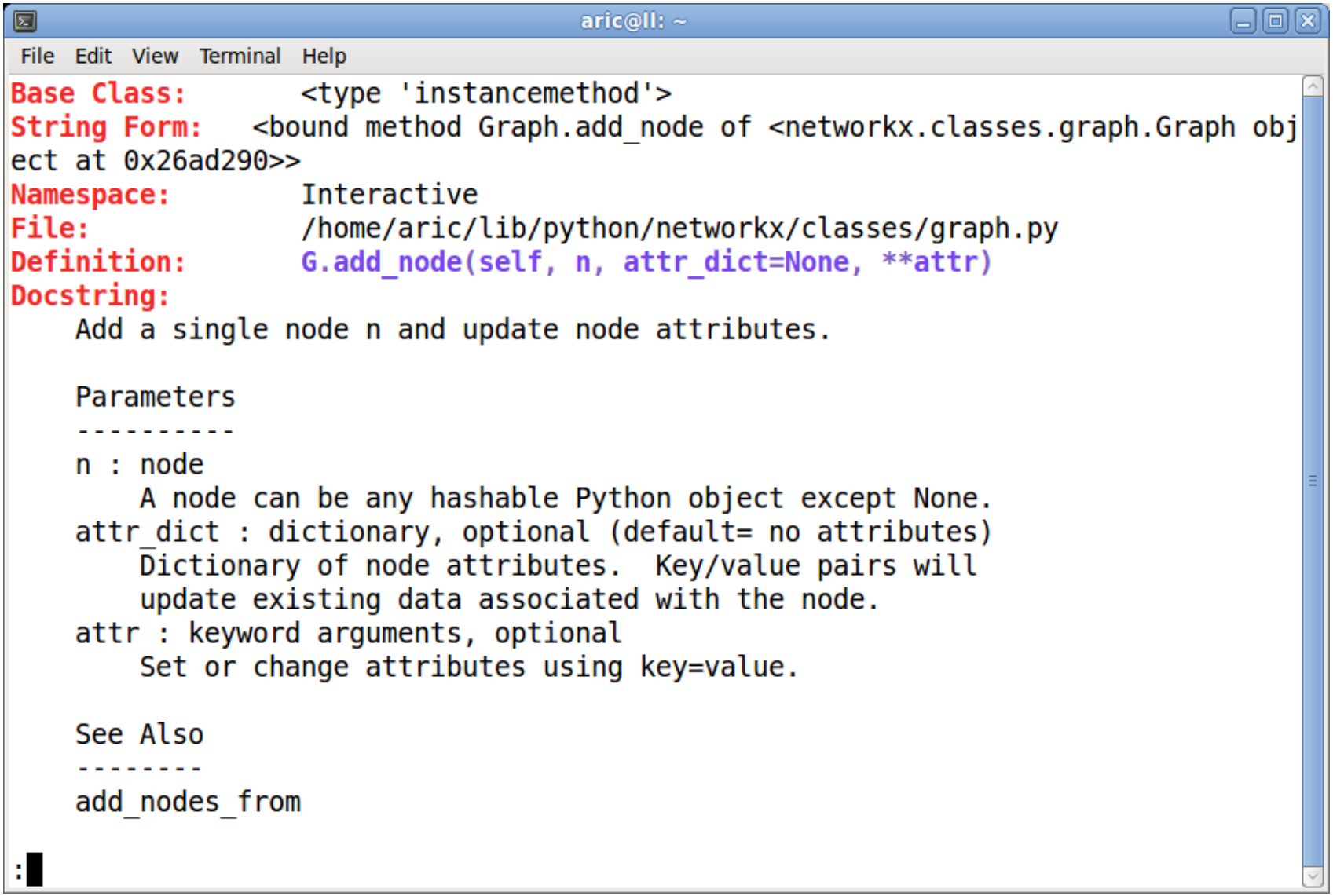
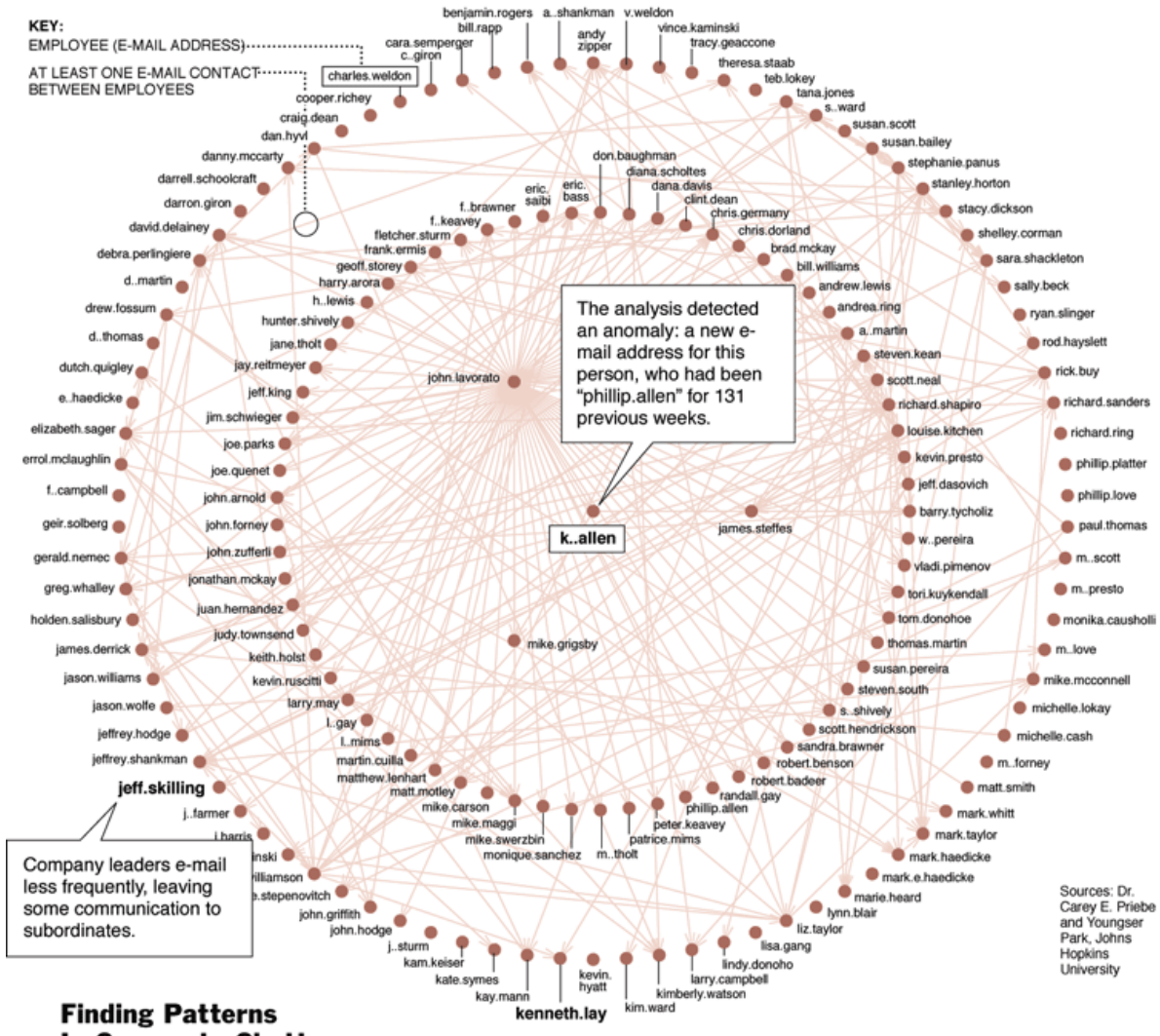


Adding attributes to graphs, nodes, and edges

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

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



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

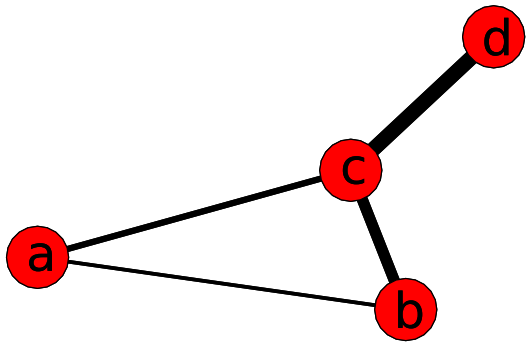
```
13
14 # Add node attributes using add_node(), add_nodes_from() or G.node
15 >>> G.add_node(1, time='5pm')
16 >>> G.node[1]['time']
17  '5pm'
18 >>> G.node[1] # Python dictionray
19 {'time': '5pm'}
20
21 >>> G.add_nodes_from([3], time='2pm') # multiple nodes
22 >>> G.node[1]['room'] = 714 # add new attribute
23
24 >>> G.nodes(data=True)
25 [(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}), (3,
```

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}
```