Introduction to NetworkX

EECS 4414/5414 – Information Networks

Department of Electrical Engineering and Computer Science

Tutorial

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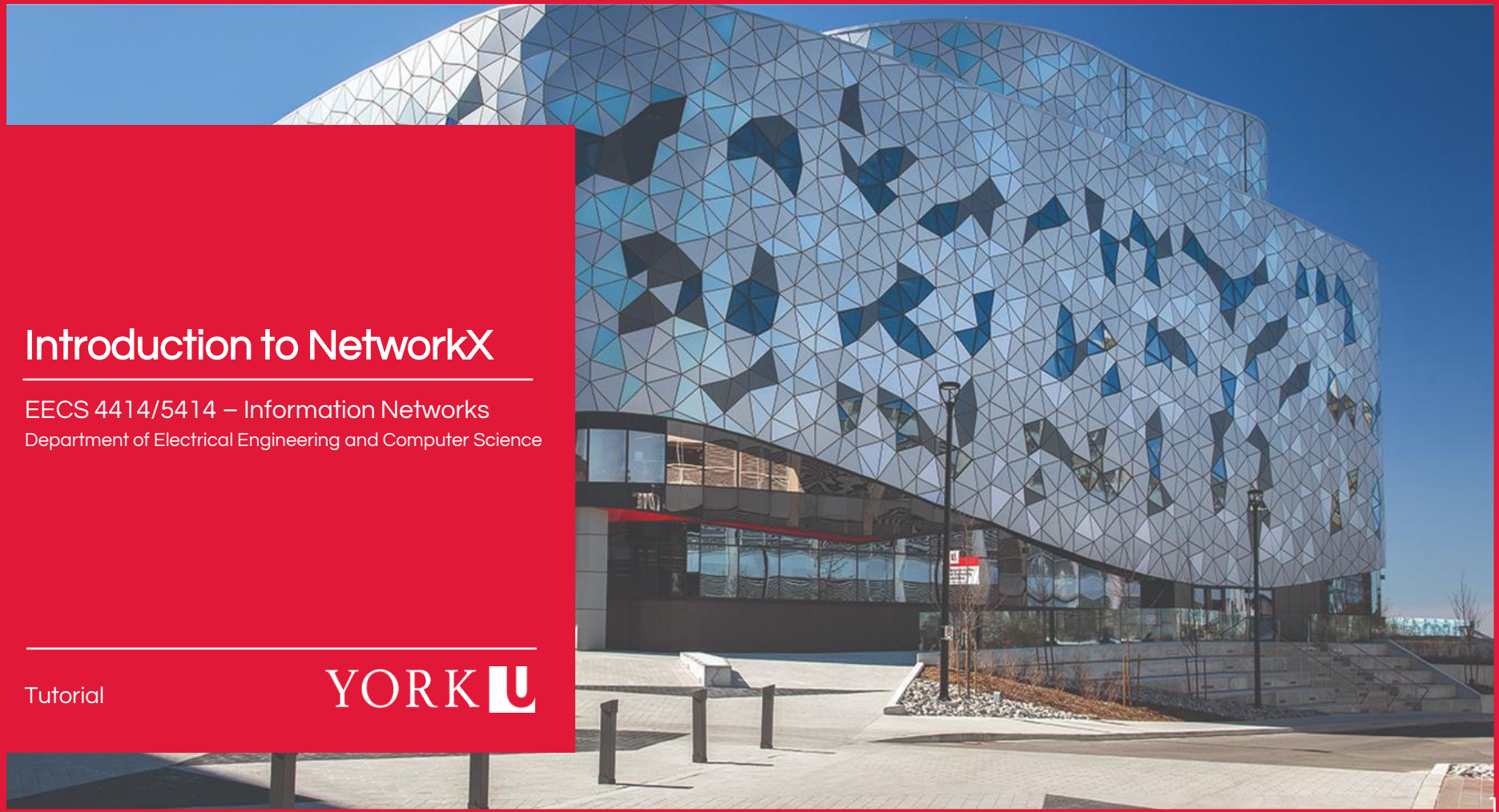
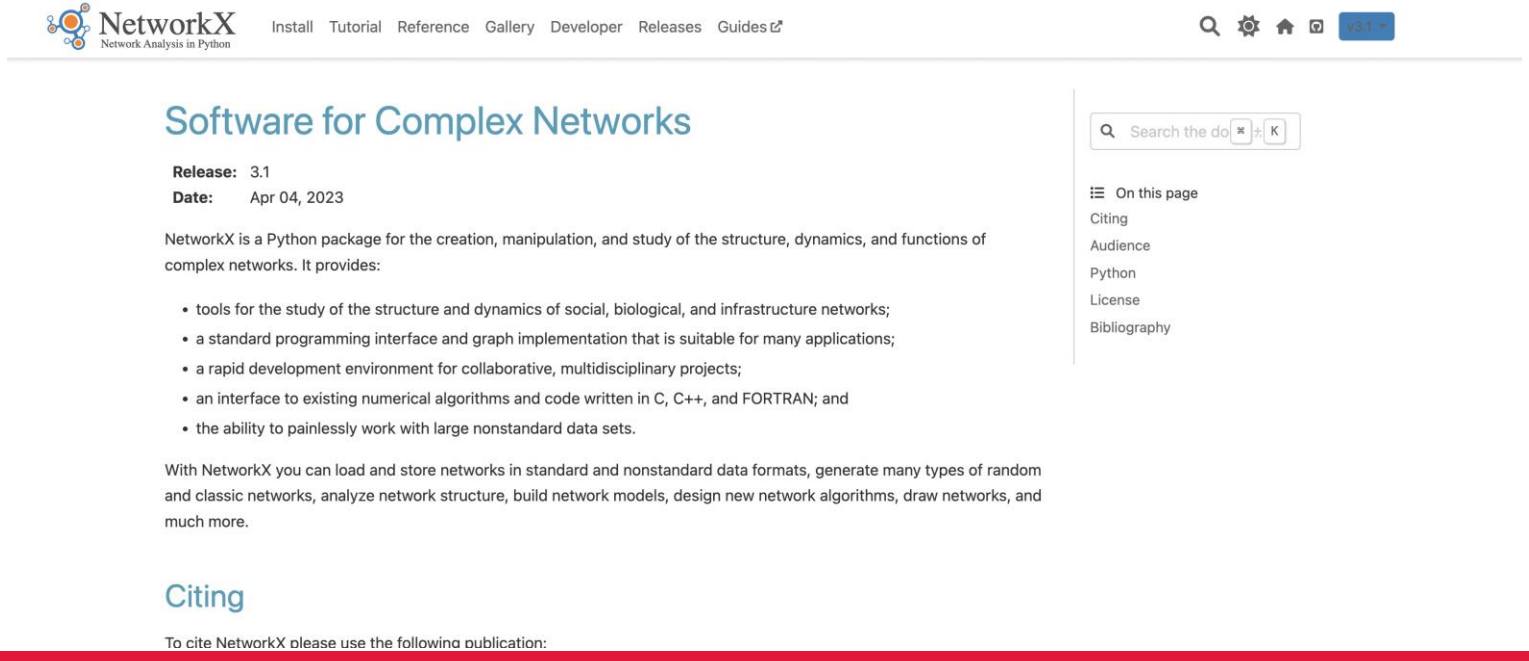


What is NetworkX?

- A Python package for the creation, manipulation, and study of the structure, dynamics, and functions of complex graphs and networks.
- https://networkx.org/



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Installation

- Version 3.1
- Install manually from

  https://pypi.python.org/pypi/networkx

- Using `pip`

```
$ pip install networkx
```

- **Usage**

```
import networkx as nx
```

Basic Example

In [ ]:

```
G = nx.Graph()          # creates a graph
G.add_node('donut') # creates a new node in the graph
                          called 'donut'
G.add_edge(3,4)       # creates an edge in the graph (3,4)
                          while also creating new nodes
print(G.nodes())     # prints list of nodes in G
print(G.edges())     # prints list of edges in G
```

```
['donut', 3, 4]
[(3, 4)]
```

Graph Types

- **Graph**: undirected simple (allows self-loops)
- **DiGraph**: directed simple (allows self-loops)
- **MultiGraph**: undirected with parallel edges
- **MultiDiGraph**: directed with parallel edges

In [ ]:

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

Adding Nodes to a Graph

In [ ]:

```
G = nx.Graph()
G.add_node('m')
G.add_nodes_from(['n','p'])
G.add_nodes_from('abc')
print(G.nodes())

G2 = nx.path_graph(5)
print(G2.nodes())
G.add_nodes_from(G2)
print(G.nodes())
```

```
['m', 'n', 'p', 'a', 'b', 'c']
[0, 1, 2, 3, 4]
['m', 'n', 'p', 'a', 'b', 'c', 0, 1, 2, 3, 4]
```

Adding Edges to a Graph

In [ ]:

```
G = nx.Graph([('w', 'x'), ('x', 'y'), ('y', 'w')])
print(G.edges())

G.add_edge('w', 'z')
G.add_edges_from([('z', 'y'), ('z', 'x')])
print(G.edges())
```

```
[('w', 'x'), ('w', 'y'), ('x', 'y')]
[('w', 'x'), ('w', 'y'), ('w', 'z'), ('x', 'y'), ('x',
'z'), ('y', 'z')]
```

Node Attributes - 1

- Each node can have an attribute that you can assign. Then you are also able to easily access them through `G.nodes[]`

In [ ]:
```
G = nx.Graph()
G.add_node(1, color='green’)
G.add_nodes_from([2,3], color='red’)
print(G.nodes[1])
print(G.nodes[1]['color’])
print(G.nodes[2]['color'])
print(G.nodes[3]['color'])
```

```
{'color': 'green'}
green
red
red
```

Node Attributes - 2

- Can also use `nx.set_node_attributes()`

In [ ]:
```
G.nodes[3]['color'] = 'blue'
nx.set_node_attributes(G, 0.5, 'weight')
print(G.nodes[1])
print(G.nodes[2])
print(G.nodes[3])
```

```
{'color': 'green', 'weight': 0.5}
{'color': 'red', 'weight': 0.5}
{'color': 'blue', 'weight': 0.5}
```

In [ ]:
```
# you can also use a dict to specify the attributes
label_dict = dict(zip(range(1,4), range(1,4)))
nx.set_node_attributes(G, label_dict, 'label')
print(G.nodes[1])
```

```
{'color': 'green', 'weight': 0.5, 'label': 1}
```

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Edge Attributes - 1

- Each edge can have an attribute that you can assign. Then you are also able to easily access them through `G.edge[]`

In [ ]:
```
G.add_edge(1, 2, thickness=1.5)
G.add_edges_from([(2,3), (3,4)], thickness=2.0)
print(G.edges[1,2])
print(G.edges[2,3])
print(G.edges[3,4])
print(G.edges[2,1])
```

```
{'thickness': 1.5}
{'thickness': 2.0}
{'thickness': 2.0}
{'thickness': 1.5}
```

Edge Attributes - 2

- One can also add a third argument (a `dict`) to specify an edge attribute and its value

In [ ]:
```
G.add_edges_from([(1,2,{'size':15})])
```

- The `'weight'` attribute

In [ ]:
```
G.add_weighted_edges_from([(10,20,4.9)])
```

In [ ]:
```
# print each edge of G and their attributes
for e1, e2 in G.edges():
   print('edge (' + str(e1) + ', ' + str(e2) + '): ' +
         str(G.edges[e1, e2]))
```

```
edge (1, 2): {'thickness': 1.5, 'size': 15}
edge (2, 3): {'thickness': 2.0}
edge (3, 4): {'thickness': 2.0}
edge (10, 20): {'weight': 4.9}
```

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Graph Attributes

In [ ]:

```
# number of nodes
print('The number of nodes in G:')
print(len(G))
print(G.number_of_nodes())
print(G.order())

# number of edges
print('The number of edges in G:')
print(G.number_of_edges())

# node membership
print('Check node membership in G:')
print(G.has_node(1))

# edge presence
print('Check edge presence in G:')
print(G.has_edge(1, 2))
```

Node Neighbors

In [ ]:

```
# new Graph (path graph)
G = nx.path_graph(4)

# use list comprehension to list all edges
print([e for e in G.edges()])

# adjacency list
print([(n, nbrs) for n,nbrs in G.adjacency()])
```

```
[(0, 1), (1, 2), (2, 3)]
[(0, {1: {}}), (1, {0: {}, 2: {}}), (2, {1: {}, 3: {}}),
(3, {2: {}})]
```

Node Degrees

- A node `v`'s degree describes the number of nodes in the graph connected to `v`. We use the `degree()` method.

In [ ]:

```
# return the degree of node 0
print(G.degree(0))

# return a list of (node, degree) pairs
print(G.degree())

# using list comprehension to for degree distribution
print([x[1] for x in G.degree()])
```

```
1
[(0, 1), (1, 2), (2, 2), (3, 1)]
[1, 2, 2, 1]
```

Graph Generators

- Complete Graph `nx.complete_graph()`
- Path (or Chain) Graph `nx.path_graph()`
- Bipartite Graph `nx.complete_bipartite_graph()`
- Random Graph `nx.erdos_renyi_graph()`
- Watts Strogatz Graph `nx.watts_strogatz_graph()`
- Barabasi Albert Graph `nx.barabasi_albert_graph()`

- Consult the API (https://networkx.org/documentation/stable/reference/generators.html) for more info about these generators

Other Useful Functions

- Includes shortest path, betweenness centrality, average clustering, and diameter

In [ ]:

```
g = nx.Graph([(0,1), (3, 4), (4,5), (5,3), (5,0)])

print('Shortest path:')
print(nx.shortest_path(g, 0, 4))

print('Betweenness Centrality:')
print(nx.betweenness_centrality(g))

print('Average Clustering:')
print(nx.average_clustering(g))

print('Diameter:')
print(nx.diameter(g))
```

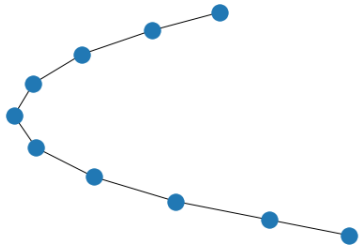
Visual Representation

- Use `matplotlib` module to draw (plot) graphs
  - Note that visual representation is not unique!
- Use `plt.savefig()` to save the figure onto a file.

In [ ]:

```
import matplotlib.pyplot as plt

G = nx.path_graph(10)
nx.draw(G)
# plt.savefig('chain_graph.pdf')
plt.show()
```



Resources

- NetworkX Docs
  - https://networkx.org/documentation/stable/reference/index.html
- NetworkX Tutorial
  - https://networkx.org/documentation/stable/tutorial.html

Thank you!

Questions?