# CSCI5070 Advanced Topics in Social Computing

## Tutorial 3: NetworkX & Graphviz

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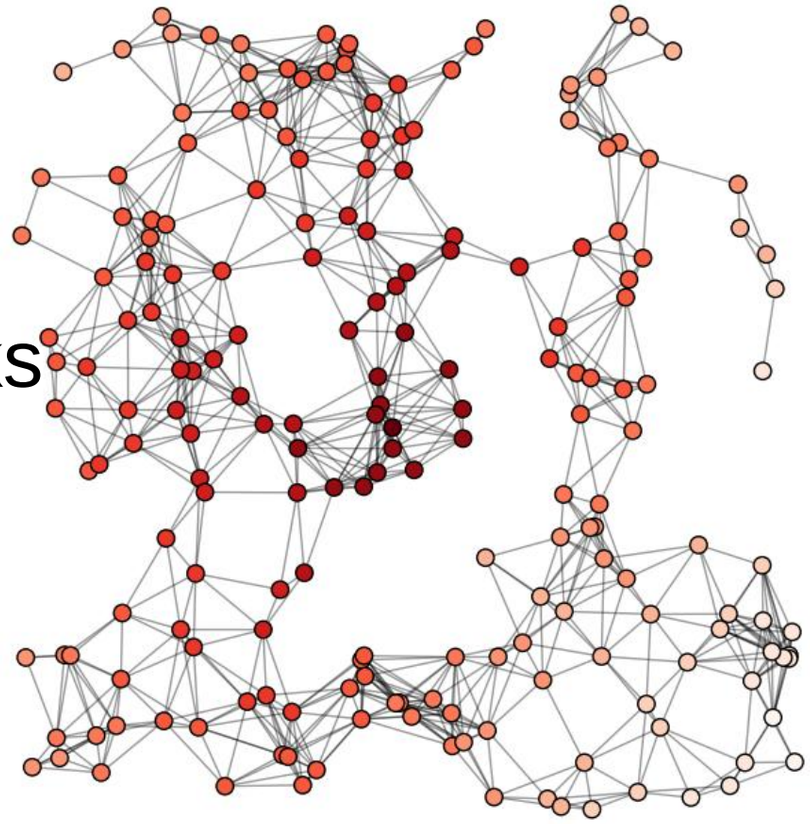
# Outline

- NetworkX
  - Creating A Graph
  - Adding Attributes
  - Directed Graphs
  - Graph Generators
  - Analyzing Graphs
  - Drawing Graphs
- Graphviz
  - Dot Language
  - Sample Graphs

# NETWORKX

# Introduction

- A Python language software package for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks
- What can it do?
  - Load and store networks
  - Generate random and classic networks
  - Analyze network structure
  - Build network models
  - Draw networks
  - ...



# Installing

- Quick install
  - Python Egg: http://pypi.python.org/pypi/networkx
  - **easy_install networkx** or **pip install networkx**
- Current version: **1.7**
- Requirement: Python version 2.6 or later
- Optional packages
  - NumPy, SciPy, Matplotlib, Pyparsing, etc.

# Creating A Graph

- Create an empty graph with no nodes and no edges

```
>>> import networkx as nx
>>> G=nx.Graph()
```

- In NetworkX, nodes can be any hashable object e.g. a text string, an image, an XML object, another Graph, a customized node object, etc.

# Nodes

- Add one node at a time

```
>>> G.add_node(1)
```

- Add a list of nodes

```
>>> G.add_nodes_from([2,3])
```

- Add *nbunch* of nodes
  - An *nbunch* is any iterable container of nodes that is not itself a node in the graph
  - E.g., a list, set, graph, file, etc.

```
>>> H=nx.path_graph(10)
>>> G.add_nodes_from(H)
```

- Add a graph as a node

```
>>> G.add_node(H)
```

# Demolishing A Graph

- Functions
  - remove_node()
  - remove_nodes_from()
  - remove_edge()
  - remove_edges_from()
  - clear()

# Graph Properties

- Functions
  - nodes()
  - number_of_nodes()
  - edges()
  - number_of_edges()
  - neighbors()
  - degree()
  - …

# Adding Attributes

- Attributes
  - Weights, labels, colors, etc.

```
>>> G = nx.Graph(day="Friday")
>>> G.graph
{'day': 'Friday'}
```

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

# Node and Edge Attributes

```
>>> G.add_node(1, time='5pm')
>>> G.add_nodes_from([3], time='2pm')
>>> G.node[1]
{'time': '5pm'}
>>> G.node[1]['room'] = 714
```

```
>>> G.add_edge(1, 2, weight=4.7 )
>>> G.add_edges_from([(3,4),(4,5)], color='red')
>>> G.add_edges_from([(1,2,{'color':'blue'}), (2,3,{'weight':8})])
>>> G[1][2]['weight'] = 4.7
>>> G.edge[1][2]['weight'] = 4
```

# Directed Graph

- Additional functions
  - out_edges(), in_degree()
  - predecessors(), successors()

```
>>> DG=nx.DiGraph()
>>> DG.add_weighted_edges_from([(1,2,0.5), (3,1,0.75)])
>>> DG.out_degree(1,weight='weight')
0.5
>>> DG.degree(1,weight='weight')
1.25
>>> DG.successors(1)
[2]
>>> DG.neighbors(1)
[2]
```

# Graph 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

# Graph Generators (cont.)

- Calling graph generators

```
>>> petersen=nx.petersen_graph()
>>> tutte=nx.tutte_graph()
>>> maze=nx.sedgewick_maze_graph()
>>> tet=nx.tetrahedral_graph()
```

```
>>> 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)
```

```
>>> 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)
```

Refer to http://networkx.lanl.gov/reference/generators.html for details

# Graph Generators (cont.)

- Loading from files
  - Common graph formats: edge lists, adjacency lists, GML, GraphML, pickle, LEDA, etc.

```
>>> nx.write_gml(red,"path.to.file")
>>> mygraph=nx.read_gml("path.to.file")
```

- Download *pyparsing* from http://pypi.python.org/pypi/pyparsing/

# Analyzing Graphs

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

```
>>> nx.connected_components(G)
[[1, 2, 3], ['spam']]
```

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

```
>>> nx.degree(G)
{1: 2, 2: 1, 3: 1, 'spam': 0}
```

Refer to http://networkx.lanl.gov/reference/algorithms.html for details

# Drawing Graphs

- First import Matplotlib's plot interface

```
>>> import matplotlib.pyplot as plt
```

- Draw

```
>>> nx.draw(G)
>>> nx.draw_random(G)
>>> nx.draw_circular(G)
>>> nx.draw_spectral(G)
```

- Show the graph

```
>>> plt.show()
```

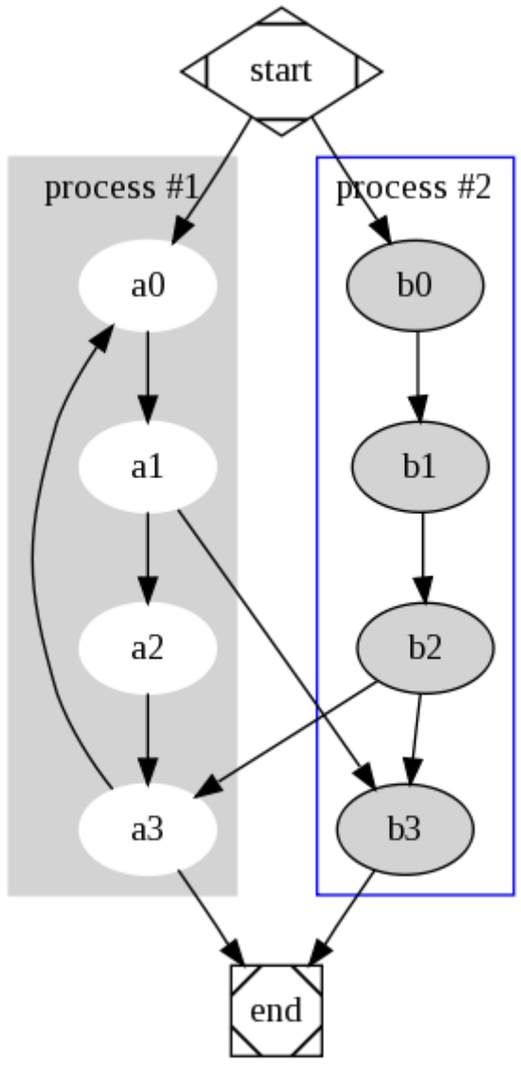
- Save

```
>>> plt.savefig("path.png")
```

# GRAPHVIZ

# Introduction

- An open source graph visualization software
  - Graph drawing
  - Graph layout
- Features
  - Take descriptions of graphs in a simple text language
  - Make diagrams in useful formats
  - Colors, fonts, tabular node layouts, line styles, hyperlinks, etc.



# Installing

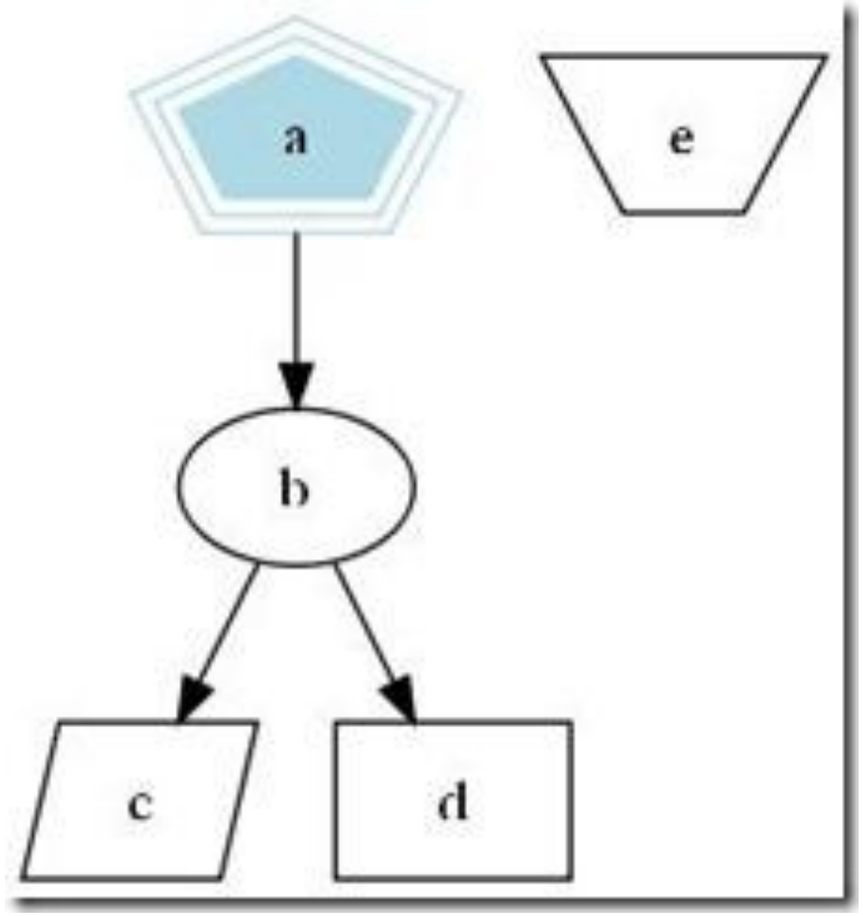
- Download at http://www.graphviz.org/Download.php
- Work on
  - FreeBSD
  - Linux
  - Mac
  - Solaris
  - Windows

# The Dot Language

*graph* : [ **strict** ] (**graph** | **digraph**) [ *ID* ] **'{'** *stmt_list* **'}'**
*stmt_list* : [ *stmt* [ **';'** ] [ *stmt_list* ] ]
*stmt* : *node_stmt*
| *edge_stmt*
| *attr_stmt*
| *ID* **'='** *ID*
| *subgraph*
*attr_stmt* : (**graph** | **node** | **edge**) *attr_list*
*attr_list* : **'['** [ *a_list* ] **']'** [ *attr_list* ]
*a_list* : *ID* [ **'='** *ID* ] [ **','** ] [ *a_list* ]
*edge_stmt* : (*node_id* | *subgraph*) *edgeRHS* [ *attr_list* ]
*edgeRHS* : *edgeop* (*node_id* | *subgraph*) [ *edgeRHS* ]
*node_stmt* : *node_id* [ *attr_list* ]
*node_id* : *ID* [ *port* ]
*port* : **':'** *ID* [ **':'** *compass_pt* ]
| **':'** *compass_pt*
*subgraph* : [ **subgraph** [ *ID* ] ] **'{'** *stmt_list* **'}'**
*compass_pt* : (**n** | **ne** | **e** | **se** | **s** | **sw** | **w** | **nw** | **c** | **_**)

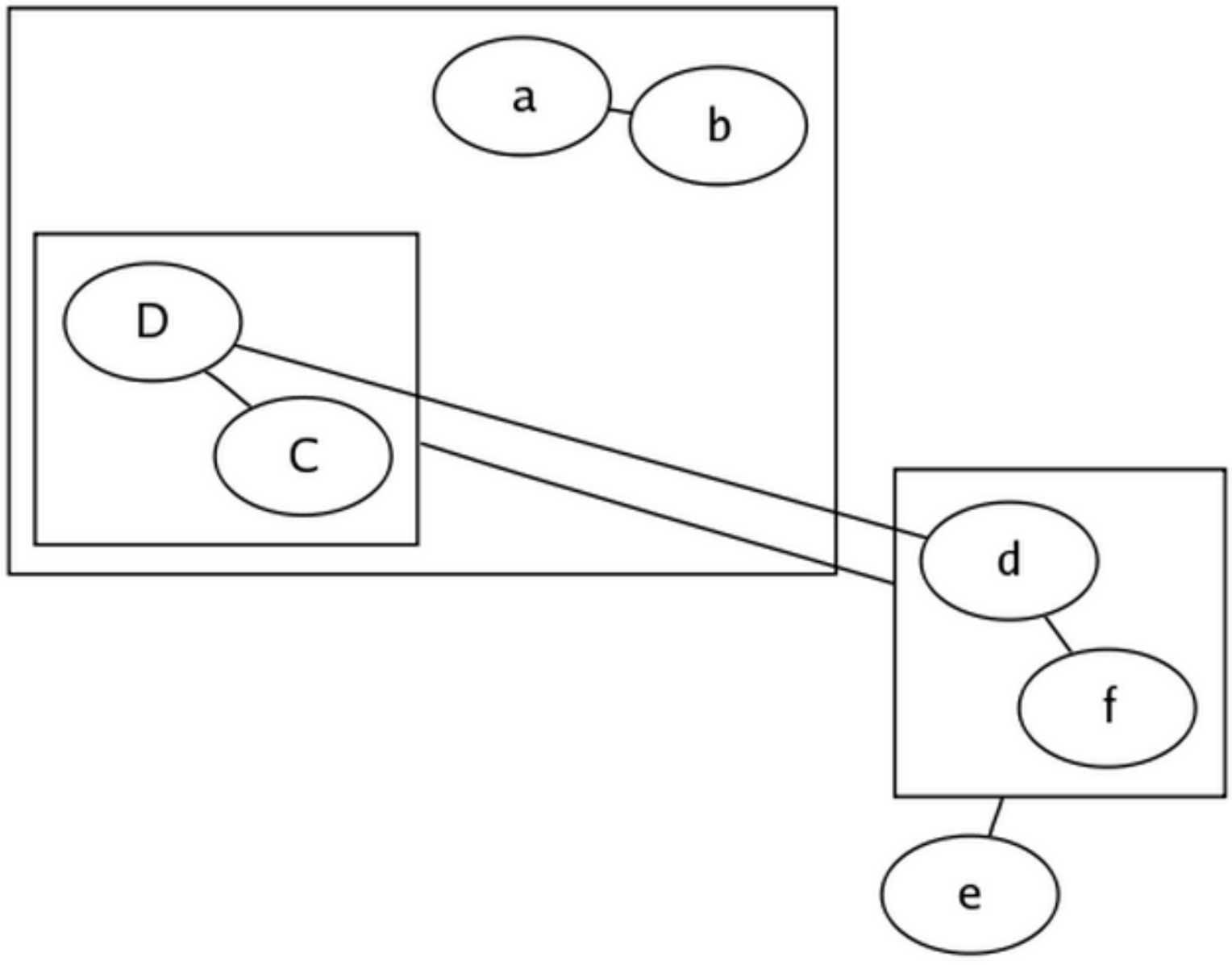
# Sample Graphs

```
digraph G{
        size = "4, 4"
        a->b->c;
        b->d;

        a[shape = polygon, sides = 5, peripheries=3,
        color = lightblue, style = filled];

        c[shape = polygon, sides = 4, skew= 0.4,
        lable = "hello world"];

        d[shape = invtriange];

        e[shape = polygon, side = 4, distortion = .7];

}
```



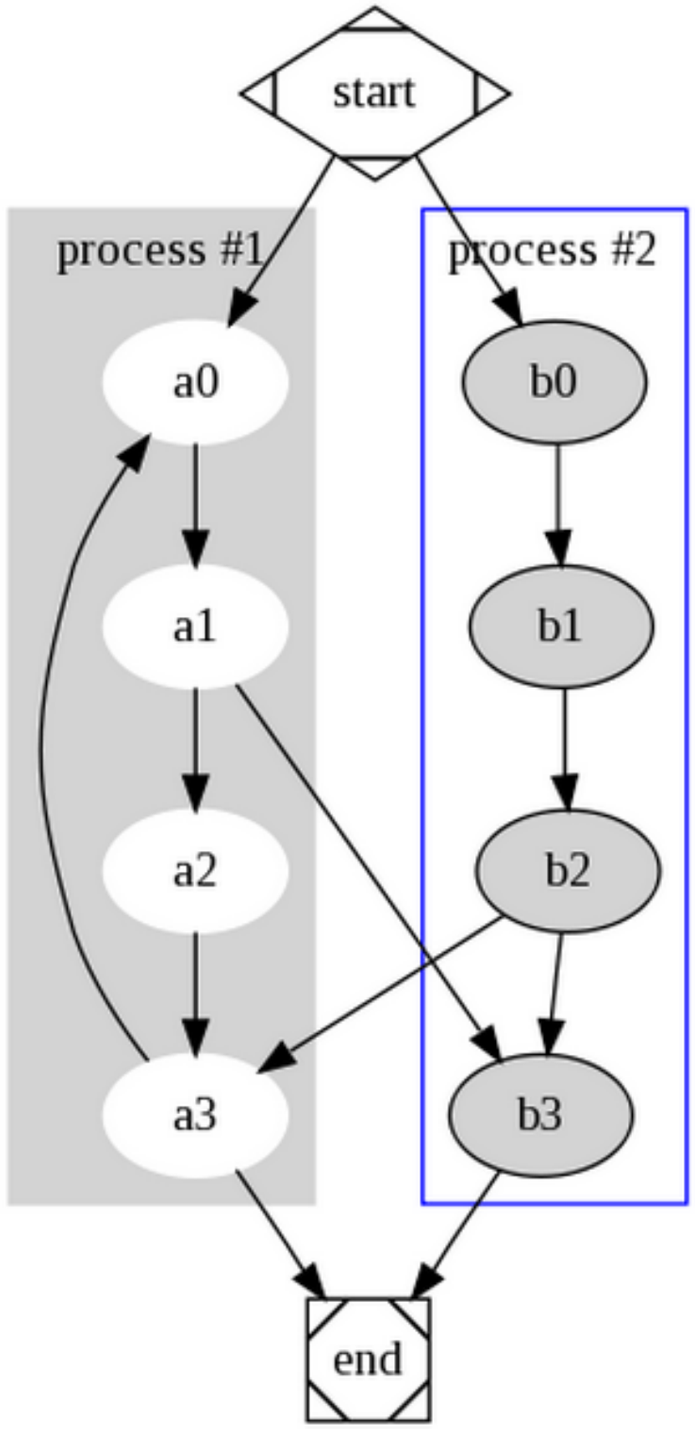
# Sample Graphs (cont.)

```
graph G {
  e
  subgraph clusterA {
    a -- b;
    subgraph clusterC {
      C -- D;
    }
  }
  subgraph clusterB {
    d -- f
  }
  d -- D
  e -- clusterB
  clusterC -- clusterB
}
```



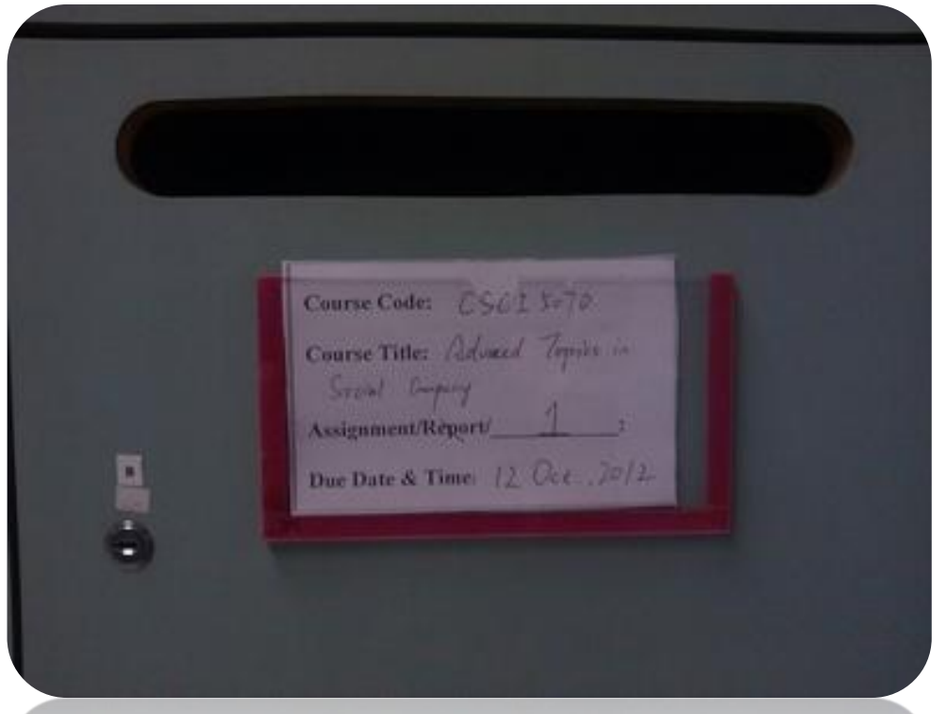
# Sample Graphs (cont.)

```
digraph G {

        subgraph cluster_0 {
                style=filled;
                color=lightgrey;
                node [style=filled,color=white];
                a0 -> a1 -> a2 -> a3;
                label = "process #1";
        }

        subgraph cluster_1 {
                node [style=filled];
                b0 -> b1 -> b2 -> b3;
                label = "process #2";
                color=blue
        }
        start -> a0;
        start -> b0;
        a1 -> b3;
        b2 -> a3;
        a3 -> a0;
        a3 -> end;
        b3 -> end;

        start [shape=Mdiamond];
        end [shape=Msquare];
}
```



# Assignment 1

- Deadline: October 12 (23:59:59, Hong Kong Time)
- Submit your answer sheet to the course mailbox on 10th floor of Ho Sin-Hang Engineering Building



# Declaration

- All graphs in this tutorial are from the following websites:
  - http://networkx.lanl.gov/
  - http://www.graphviz.org
  - http://www.cnblogs.com/sld666666/archive/2010/06/25/1765510.html

# References

- http://networkx.lanl.gov/_downloads/networkx_tutorial.pdf
- http://networkx.lanl.gov/contents.html
- http://www.graphviz.org/content/dot-language
- http://www.cnblogs.com/sld666666/archive/2010/06/25/1765510.html