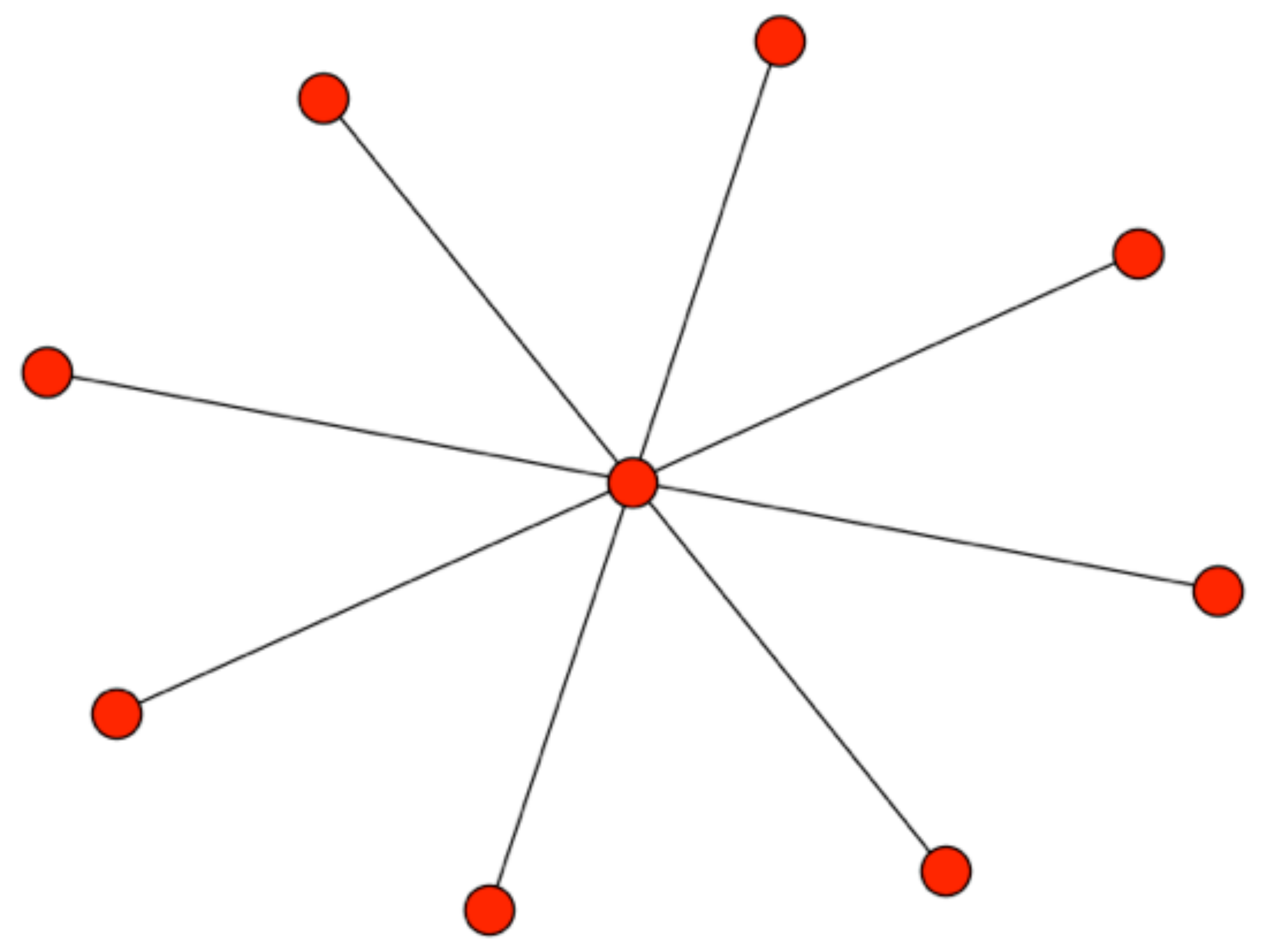
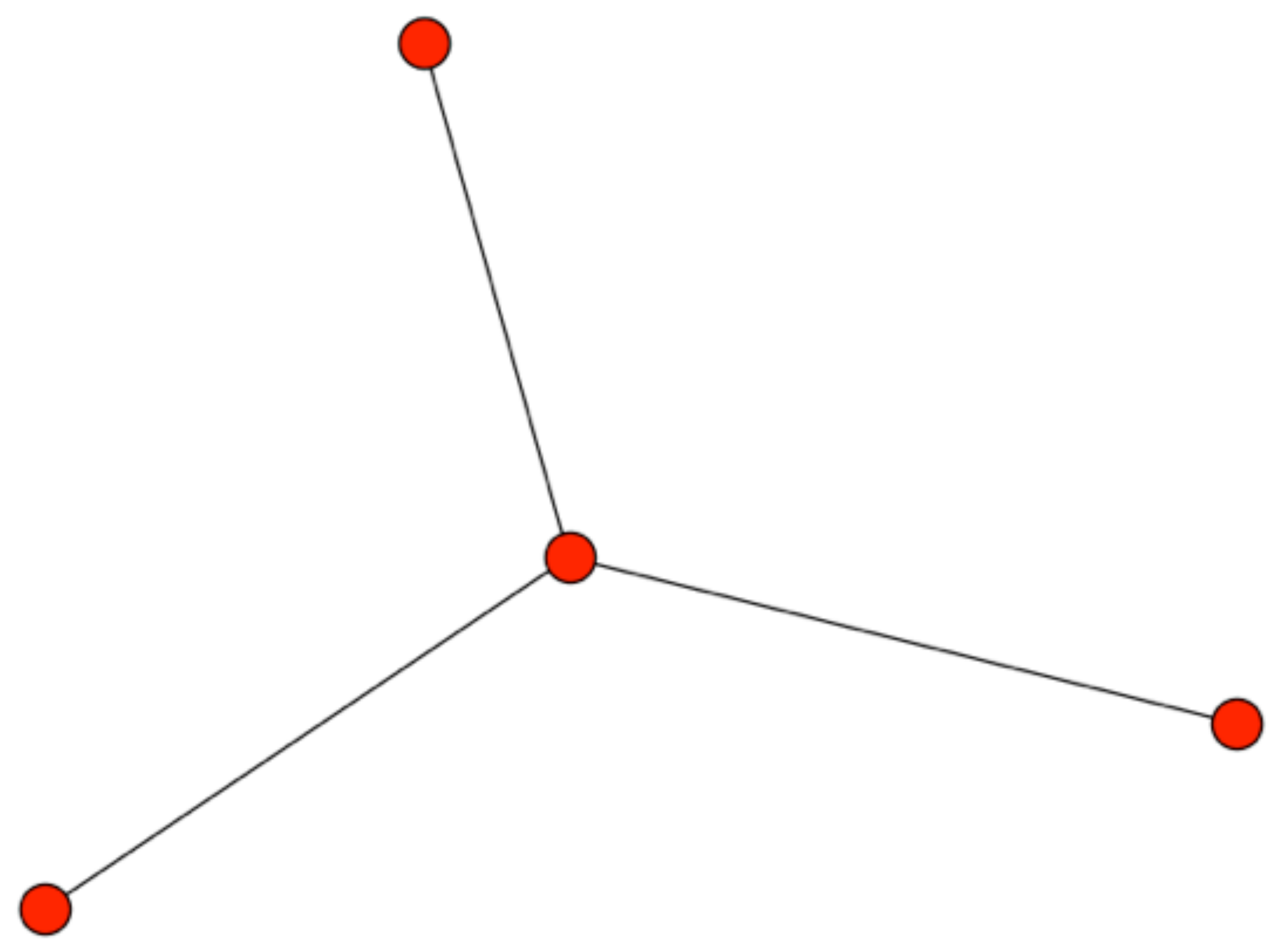
Degree centrality

Important nodes

- Which nodes are important?
  - Degree centrality
  - Betweenness centrality

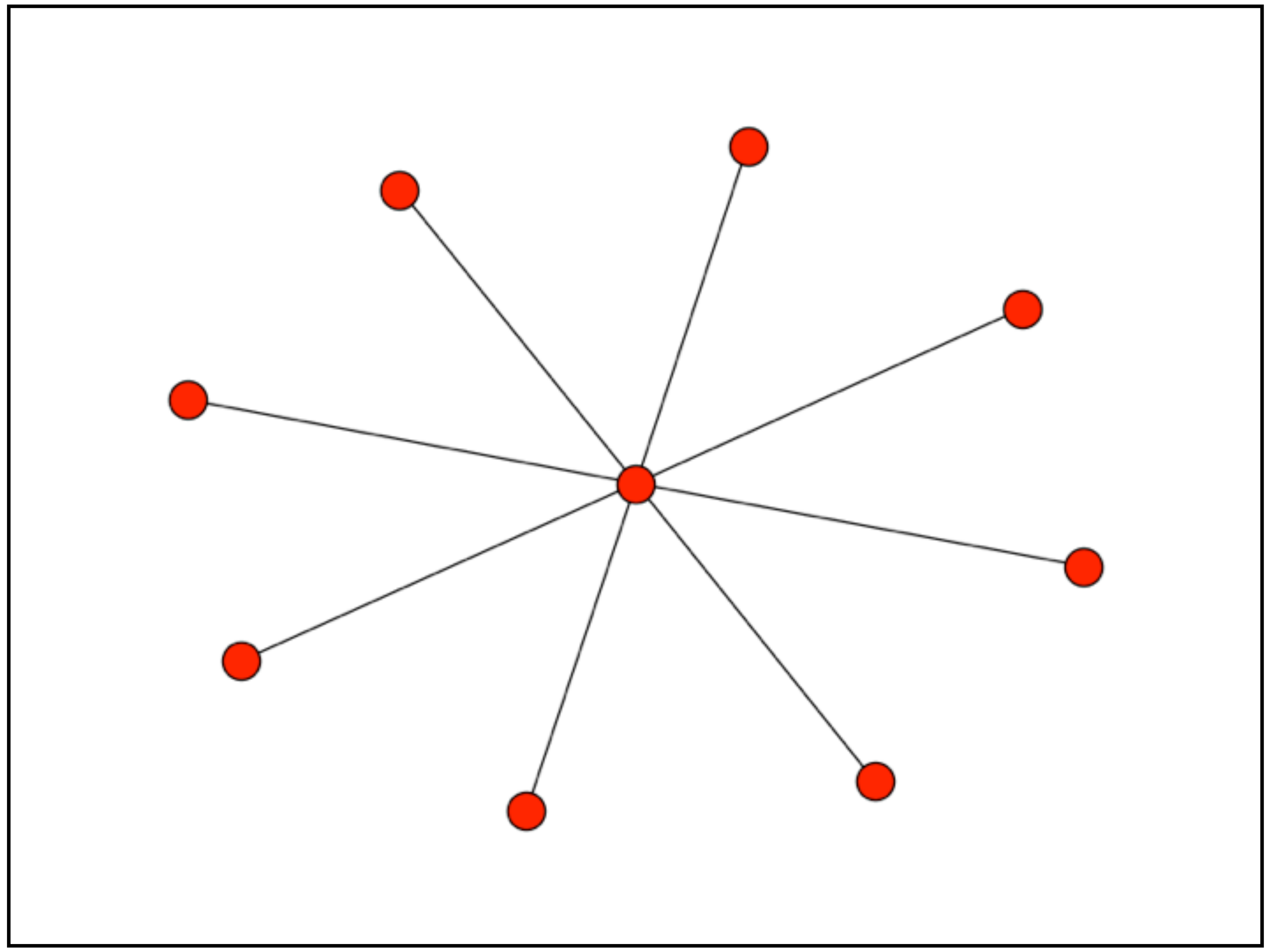
Important nodes

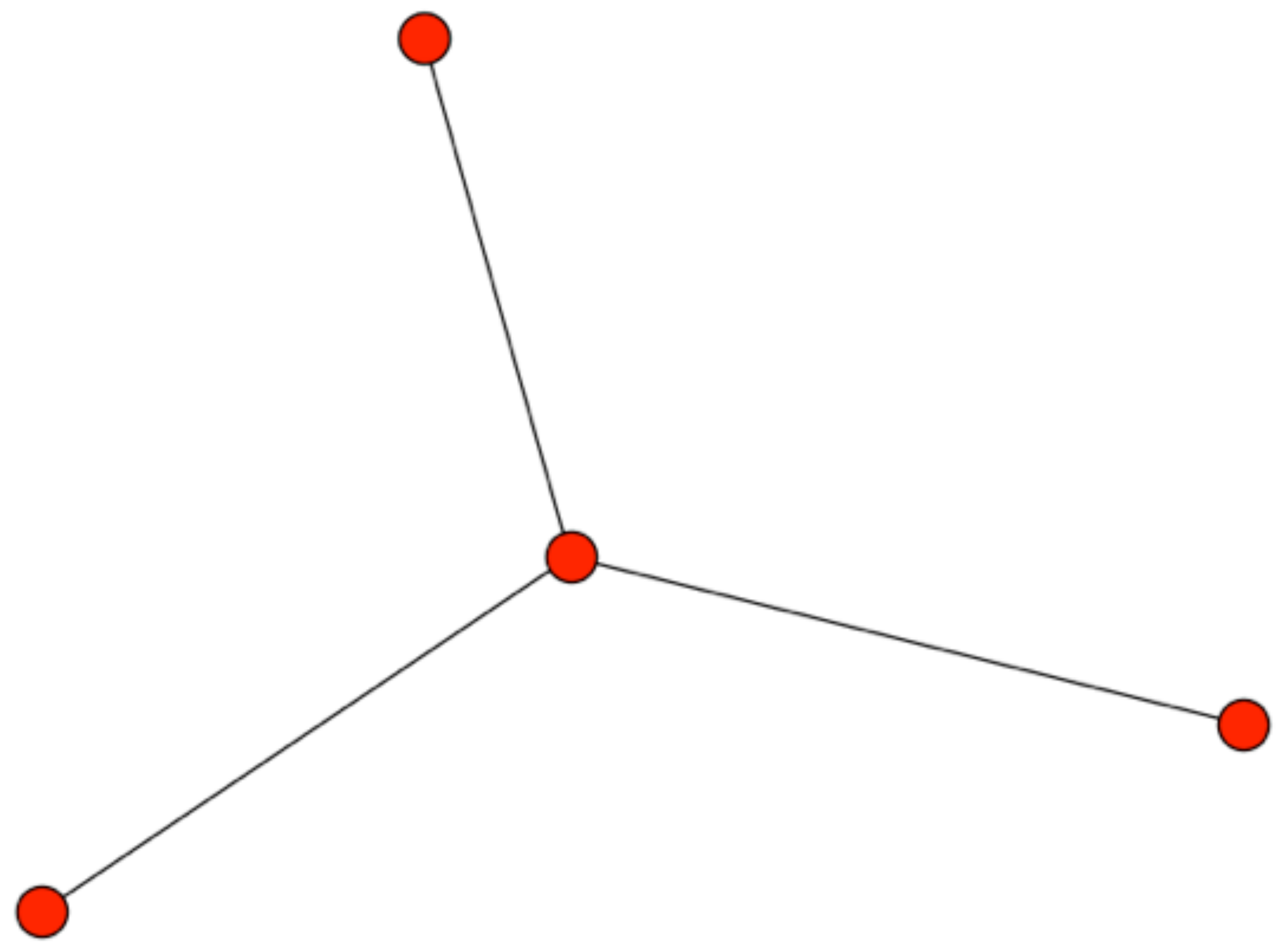
- Which centre node might be more important?

Important nodes

- Which centre node might be more important?





Degree centrality

- Definition:

$$\frac{\text{Number of Neighbours I Have}}{\text{Number of Neighbours I Could Possibly Have}}$$

- Examples of nodes with high degree centrality:
    - Twitter broadcasters
    - Airport transportation hubs
    - Disease super-spreaders

Number of neighbors

```
In [1]: G.edges()
Out[1]: [(1, 2), (1, 3), (1, 4), (1, 5), (1, 6), (1, 7), (1, 8),
(1, 9)]

In [2]: G.neighbors(1)
Out[2]: [2, 3, 4, 5, 6, 7, 8, 9]

In [3]: G.neighbors(8)
Out[3]: [1]

In [4]: G.neighbors(10)
......
NetworkXError: The node 10 is not in the graph.
```

Degree centrality

```
In [5]: nx.degree_centrality(G)
Out[5]:
{1: 1.0,
 2: 0.125,
 3: 0.125,
 4: 0.125,
 5: 0.125,
 6: 0.125,
 7: 0.125,
 8: 0.125,
 9: 0.125}
```

Let’s practice!

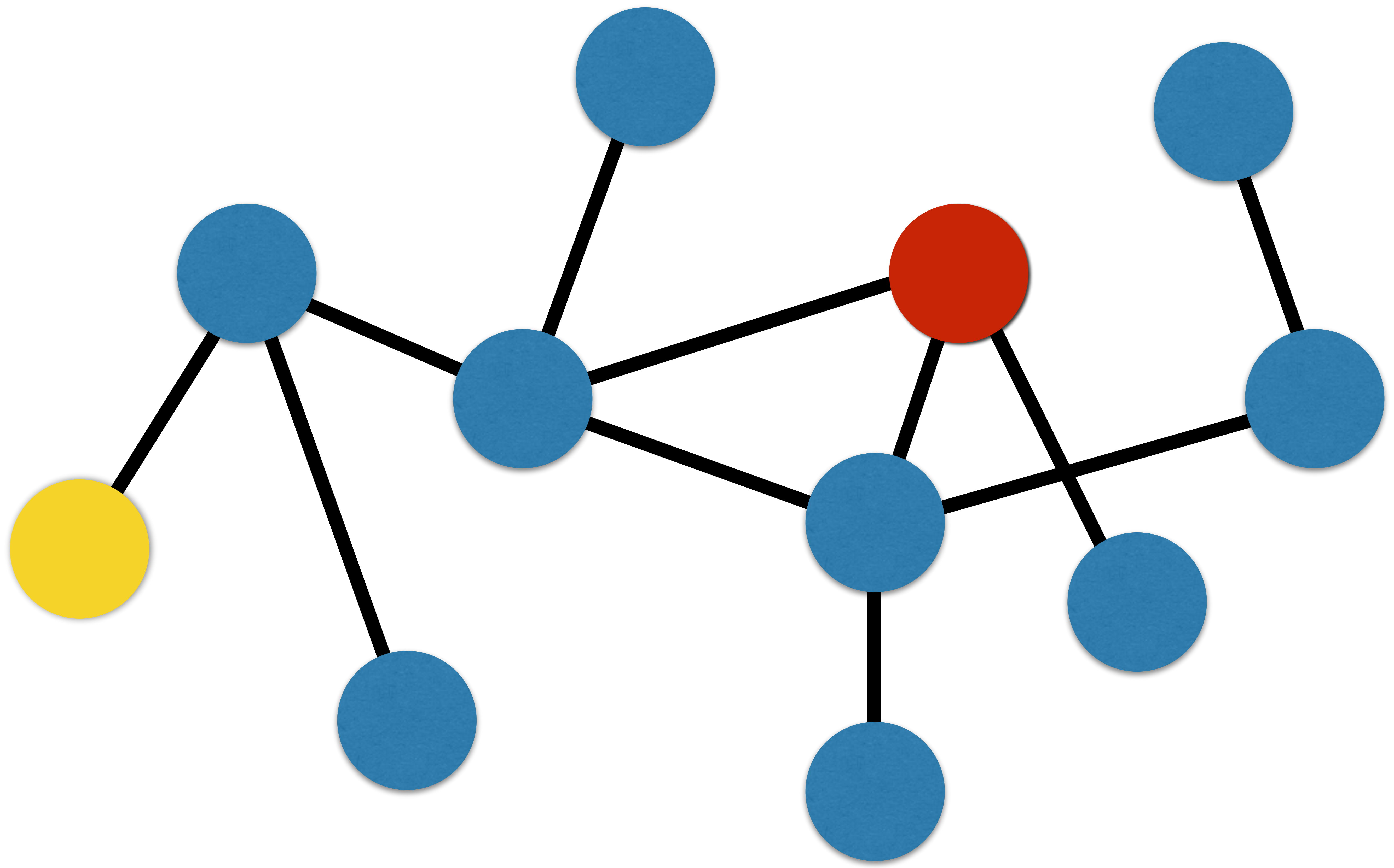
Graph algorithms

Finding paths

- Pathfinding is important for
    - Optimization: e.g. shortest transport paths
    - Modeling: e.g. disease spread, information passing
- Algorithm: Breadth-first search

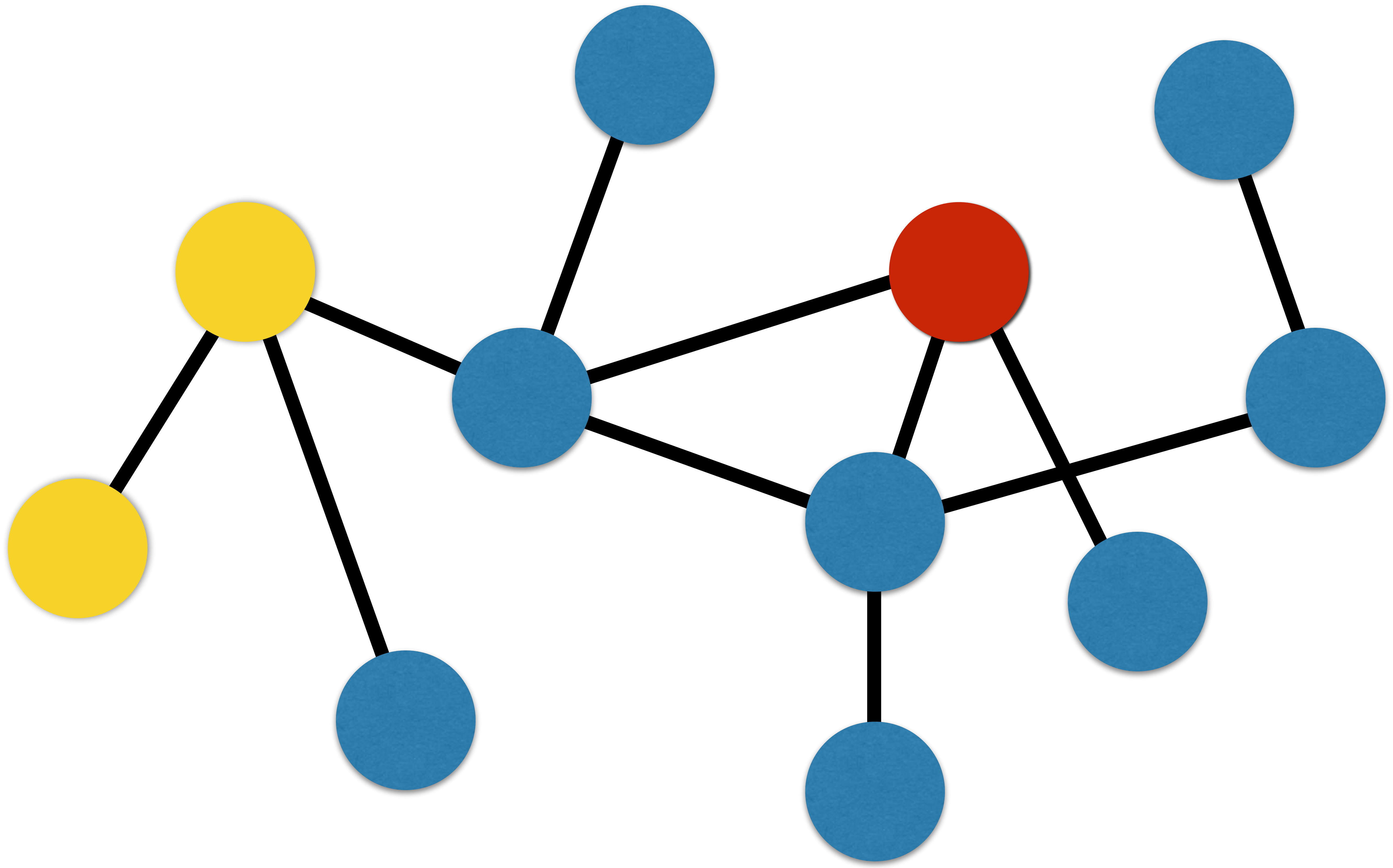
Breadth-first search (BFS)

- Example: Shortest path between two nodes



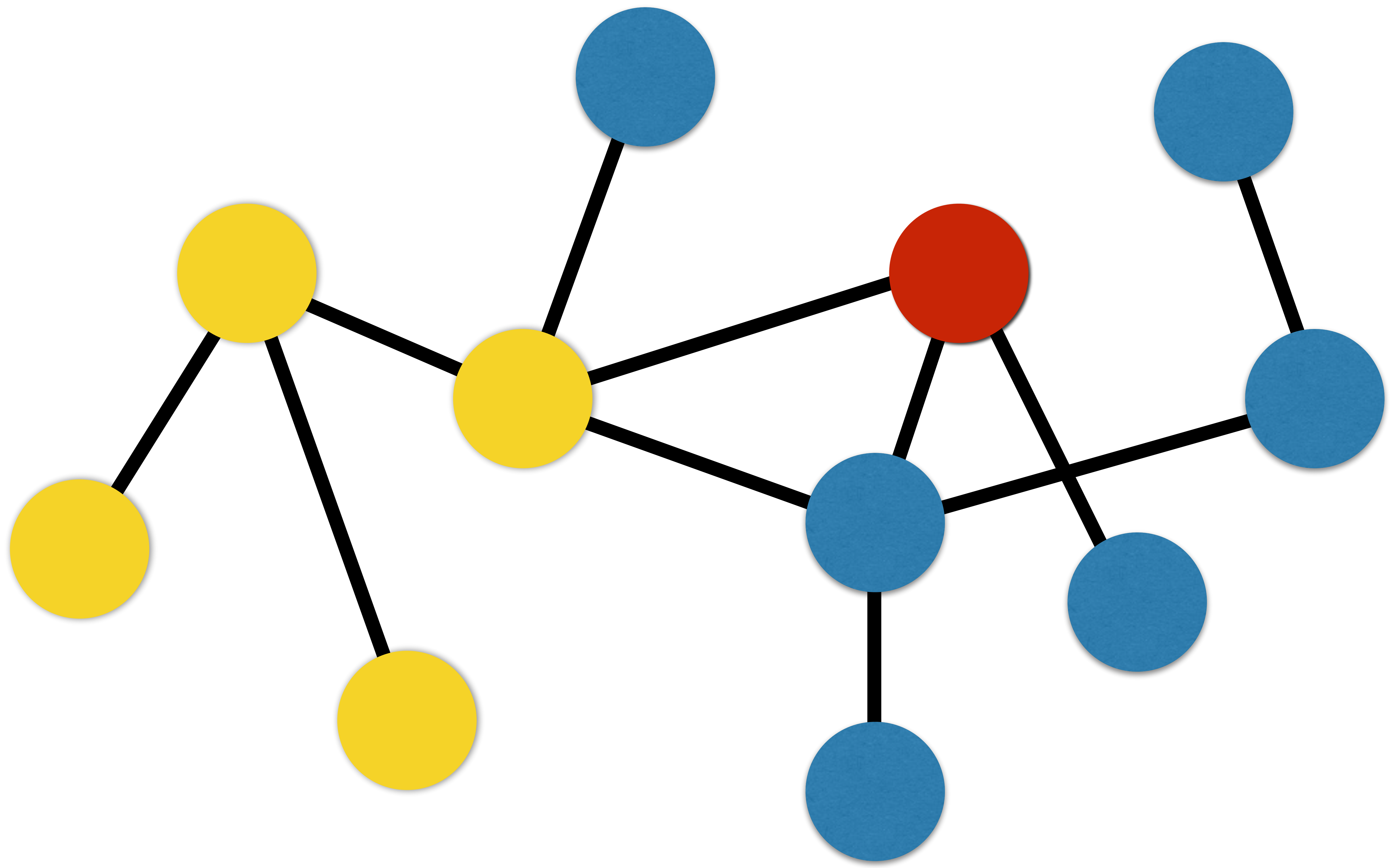
Breadth-first search (BFS)

- Example: Shortest path between two nodes



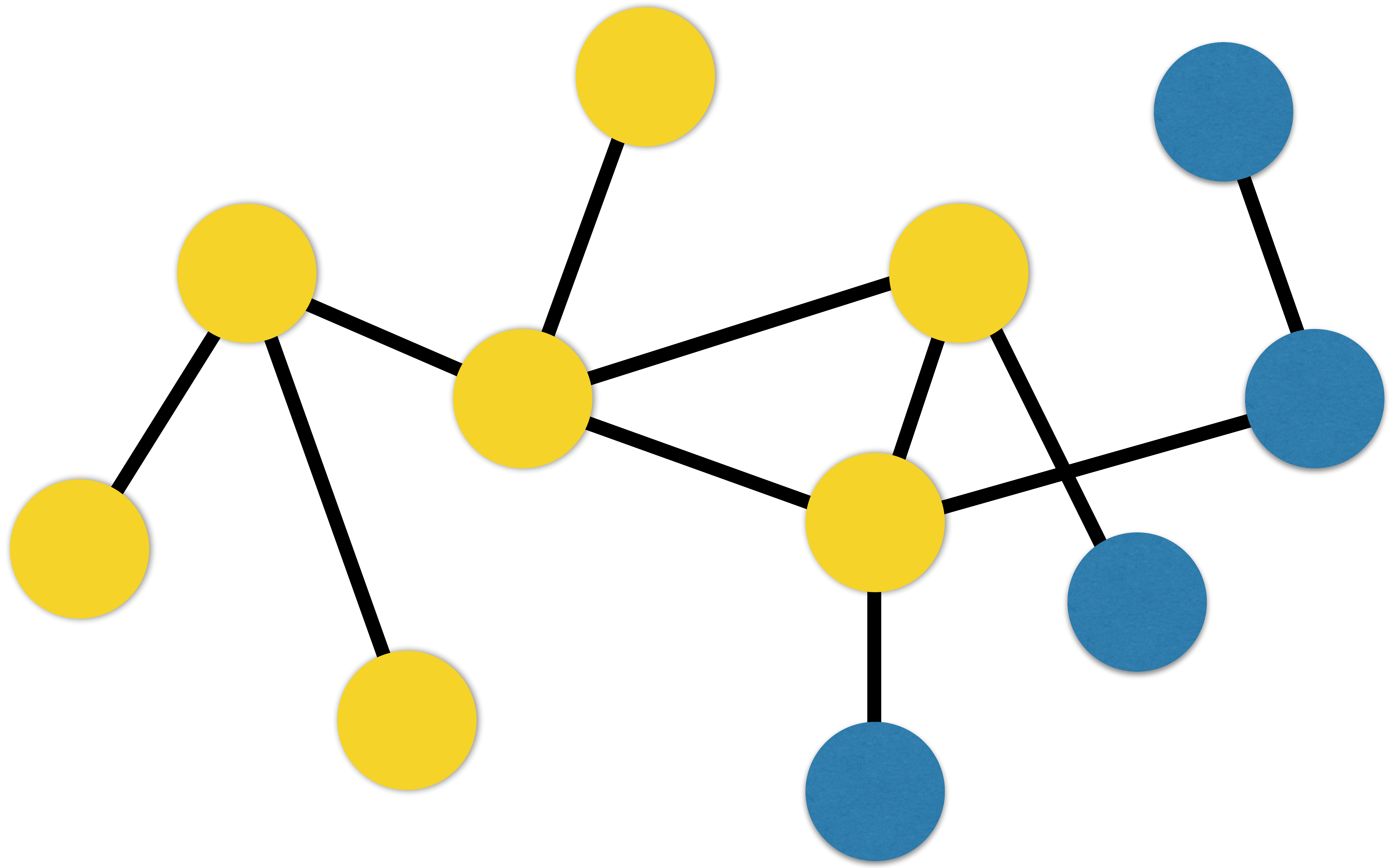
Breadth-first search (BFS)

- Example: Shortest path between two nodes



Breadth-first search (BFS)

- Example: Shortest path between two nodes



Recall: Neighbors

```
In [1]: G
Out[1]: <networkx.classes.graph.Graph at 0x10cc08828>

In [2]: len(G.edges())
Out[2]: 57

In [3]: len(G.nodes())
Out[3]: 20

In [4]: G.neighbors(1)
Out[4]: [10, 5, 14, 7]

In [5]: G.neighbors(10)
Out[5]: [1, 19, 5, 17, 8, 9, 13, 14]
```

Let’s practice!

Betweenness centrality

All shortest paths

- Set of paths
- Each path is shortest path between a given pair of nodes
- Done for all node pairs

Betweenness centrality

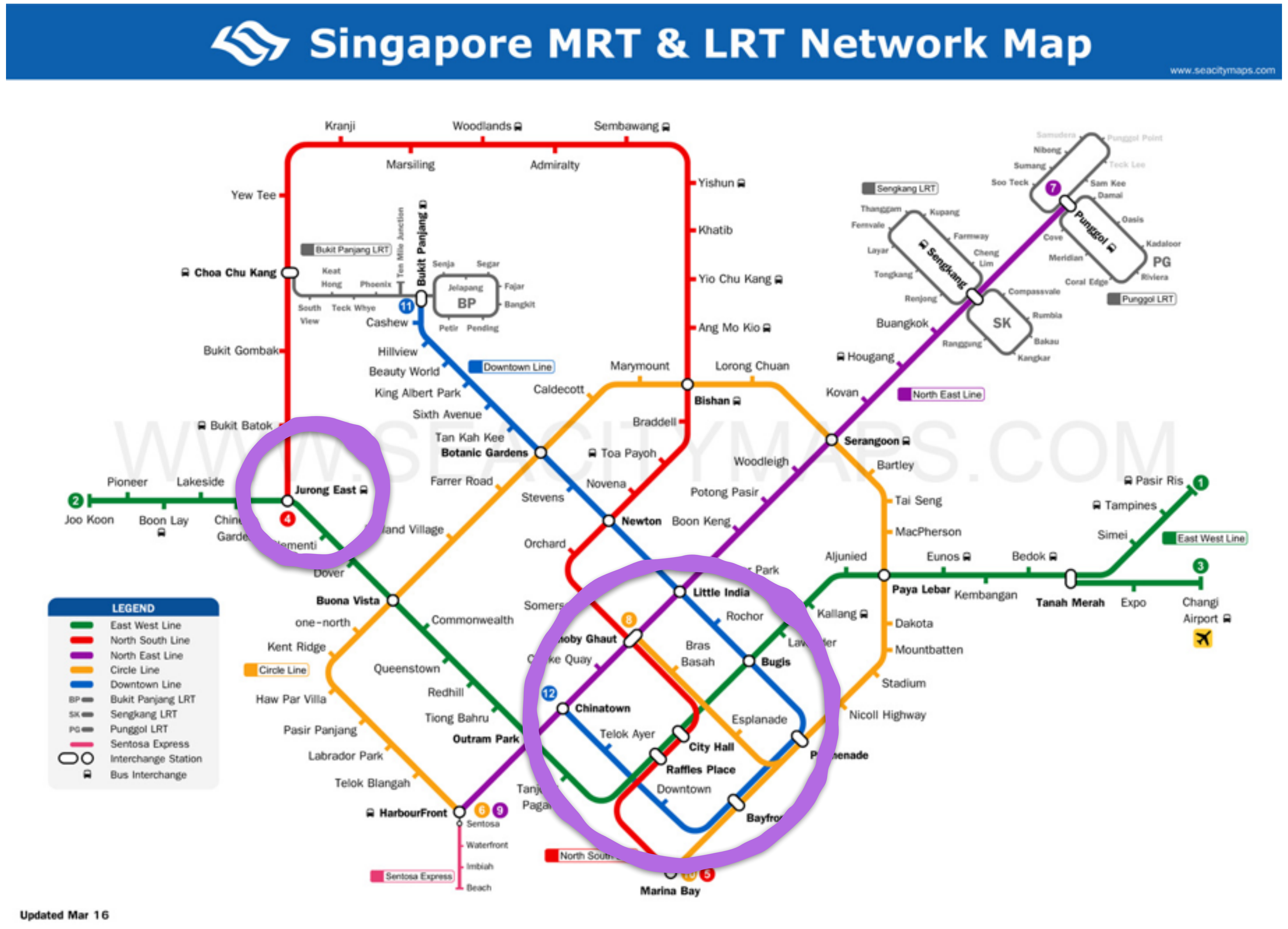
- Definition:

$$\frac{\text{num. shortest paths through node}}{\text{all possible shortest paths}}$$

- Application:
  - Bridges between liberal- and conservative-leaning Twitter users
  - Critical information transfer links

Examples

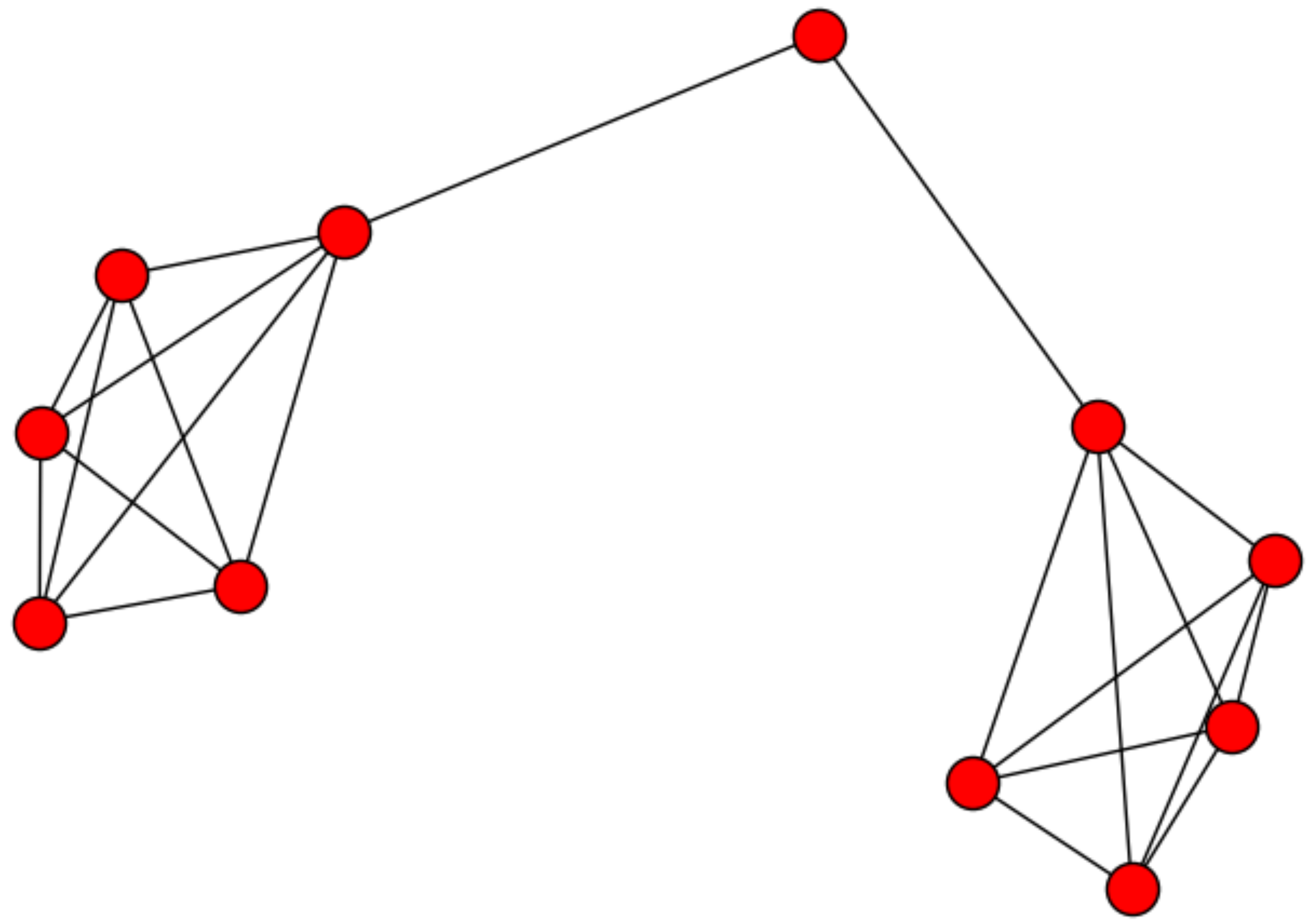
- Singapore: Raffles Place & Jurong East



Source: http://www.seacitymaps.com/singapore/singapore_mrt_map.jpg

Example

- High betweenness centrality, low degree centrality?

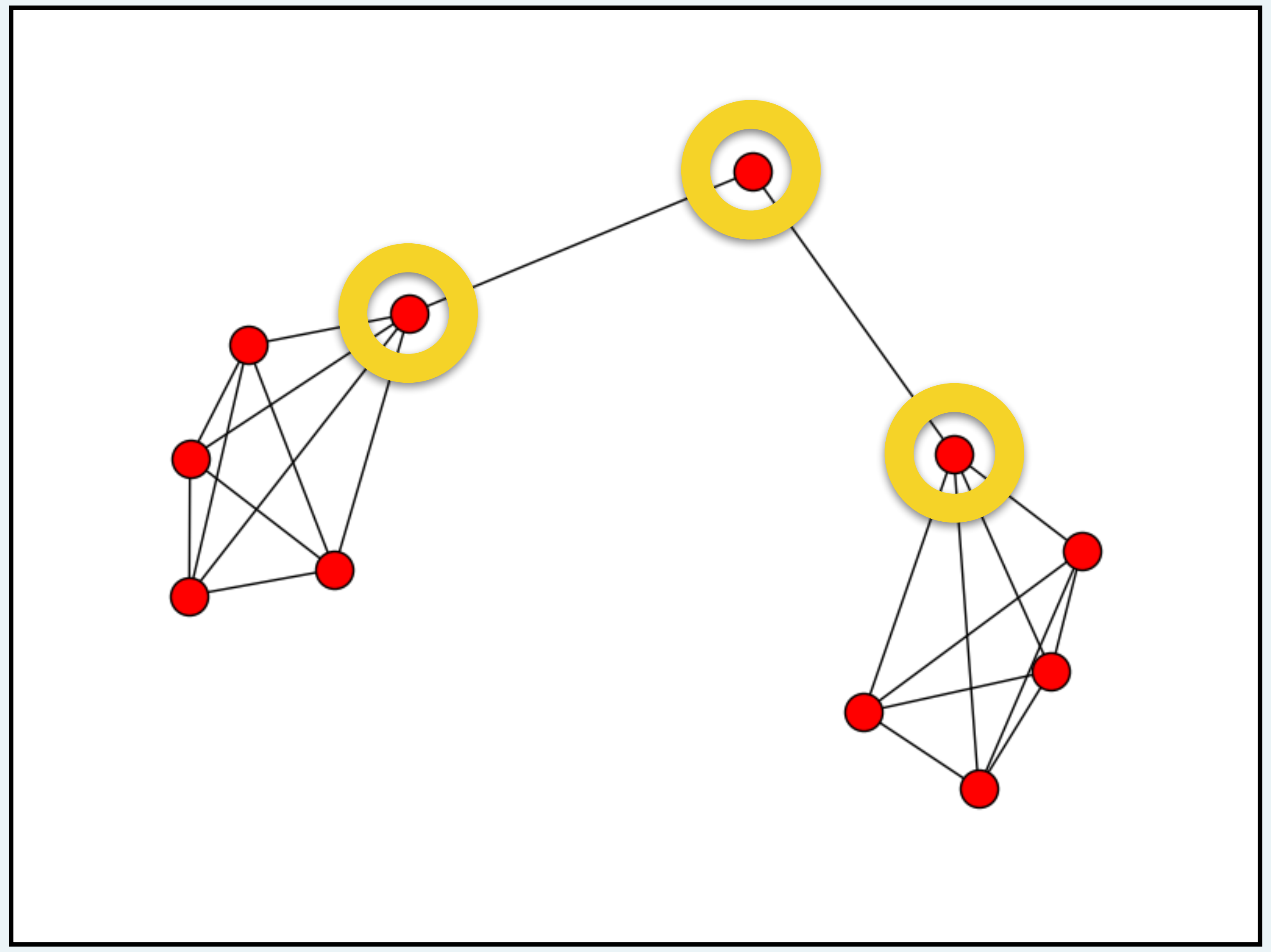


Betweenness centrality

```
In [5]: import networkx as nx

In [6]: G = nx.barbell_graph(m1=5, m2=1)

In [10]: nx.betweenness_centrality(G)
Out[10]:
{0: 0.0,
 1: 0.0,
 2: 0.0,
 3: 0.0,
 4: 0.5333333333333333,
 5: 0.5555555555555556,
 6: 0.5333333333333333,
 7: 0.0,
 8: 0.0,
 9: 0.0,
 10: 0.0}
```



Let’s practice!