

Social Network Analysis

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Week 1: Introduction

Why Studying Networks or Systems?

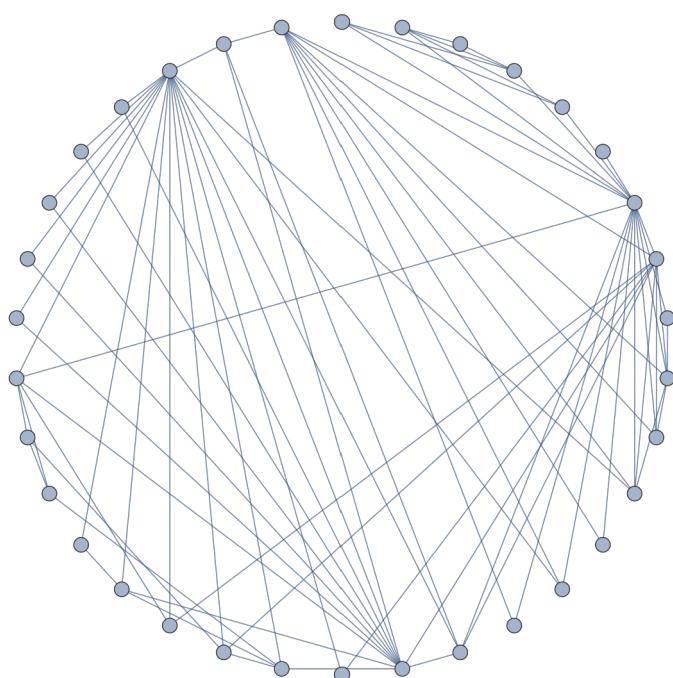
- Understanding complex behavior / mechanisms
- Example: Zachary Karate Club
 - Studied by Wayne W. Zachary in the years from 1970- 1972. The network has 34 vertices where each vertex represents a member of the karate club and 78 edges between participants of the karate club.

Example

```
In[1]:= Karate = Graph[ExampleData[{"NetworkGraph", "ZacharyKarateClub"}],  
VertexLabels → Placed["Name", Tooltip]];
```

```
In[2]:= Graph[Karate, GraphLayout → "CircularEmbedding"]
```

Out[2]=

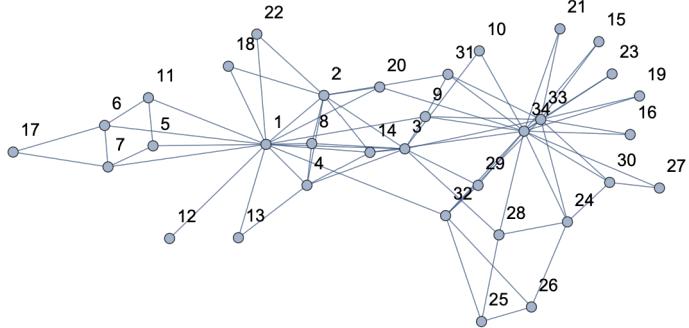


- During the study, a conflict arose between the administrator “John A”, and the instructor “Mr. Hi” (pseudonyms), which led to the split of the club into two. Half of the members formed a new club around Mr. Hi, while members from the other part found a new instructor or gave up karate.

Using a network

```
In[4]:= Graph[Karate, VertexLabels → "Name"]
```

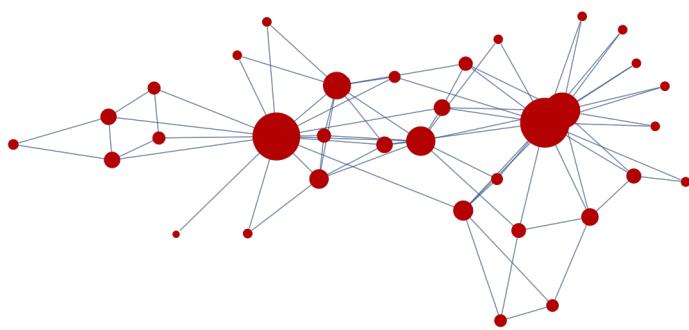
Out[4]=



Node / Local Properties

```
In[3]:= HighlightGraph[Karate, VertexList[Karate], VertexSize →
Thread[VertexList[Karate] → 0.3 + 2 * Rescale[PageRankCentrality[Karate], .85]]]
```

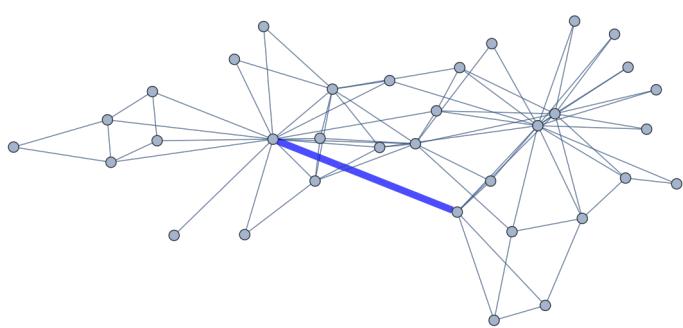
Out[3]=



Edge Properties

```
In[5]:= HighlightGraph[Karate,
Style[Take[Part[EdgeList[Karate], Ordering[EdgeBetweennessCentrality[Karate],
All, Greater]], 1], Blue, Thickness[.01]]]
```

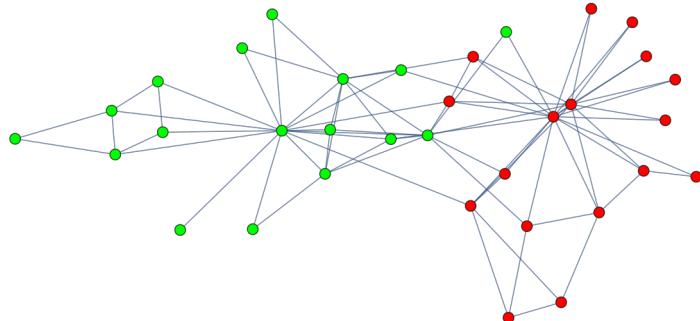
Out[5]=



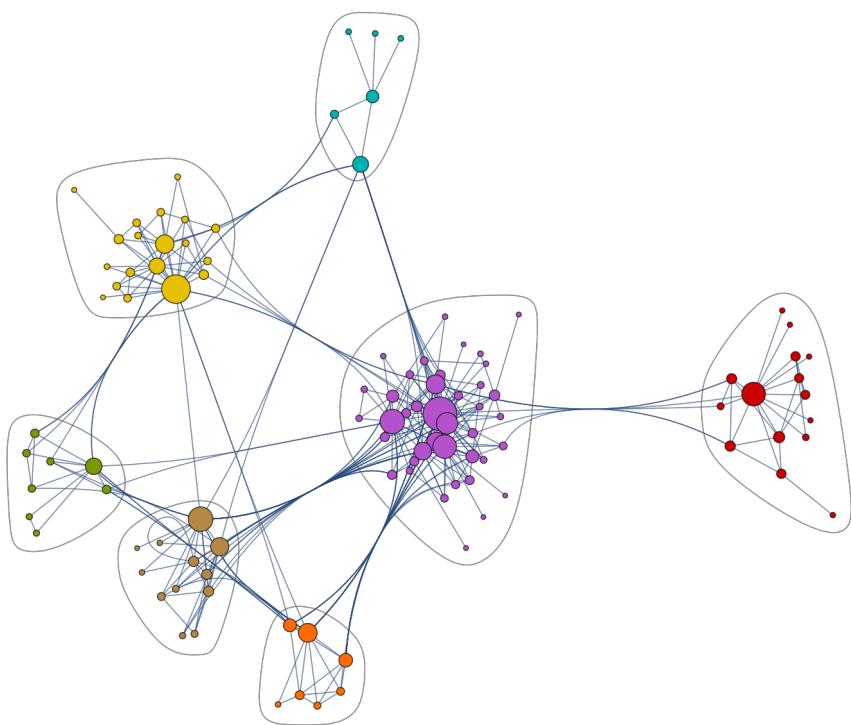
Global Properties

```
In[6]:= HighlightGraph[Karate, {Style[First[FindGraphPartition[Karate]], Green],  
Style[Last[FindGraphPartition[Karate]], Red]}]
```

Out[6]=

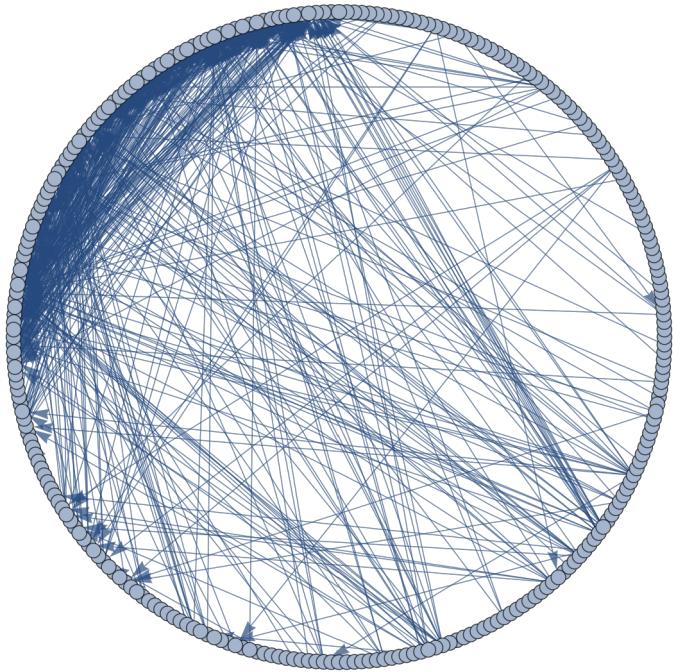


Game of Thrones



Political Blogs

```
In[7]:= Blog = ExampleData[{"NetworkGraph", "PoliticalBlogs"}];  
In[8]:= Subgraph[Blog, RandomChoice[VertexList[Blog], 300],  
GraphLayout → "CircularEmbedding"]  
Out[8]=
```



```
EdgeCount[Blog]
```

```
16718
```

```
VertexCount[Blog]
```

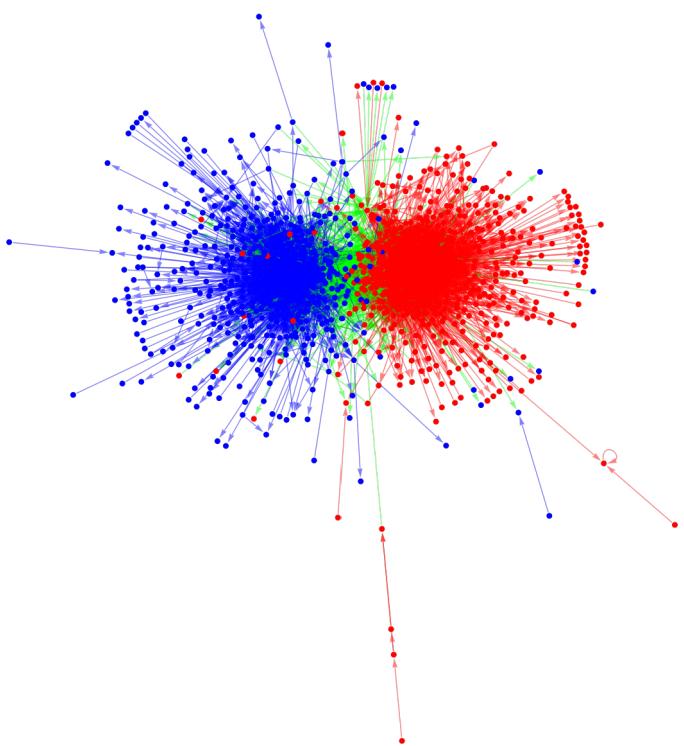
```
1490
```

- Every blog is either:

- “left or liberal”
- “right or conservative”

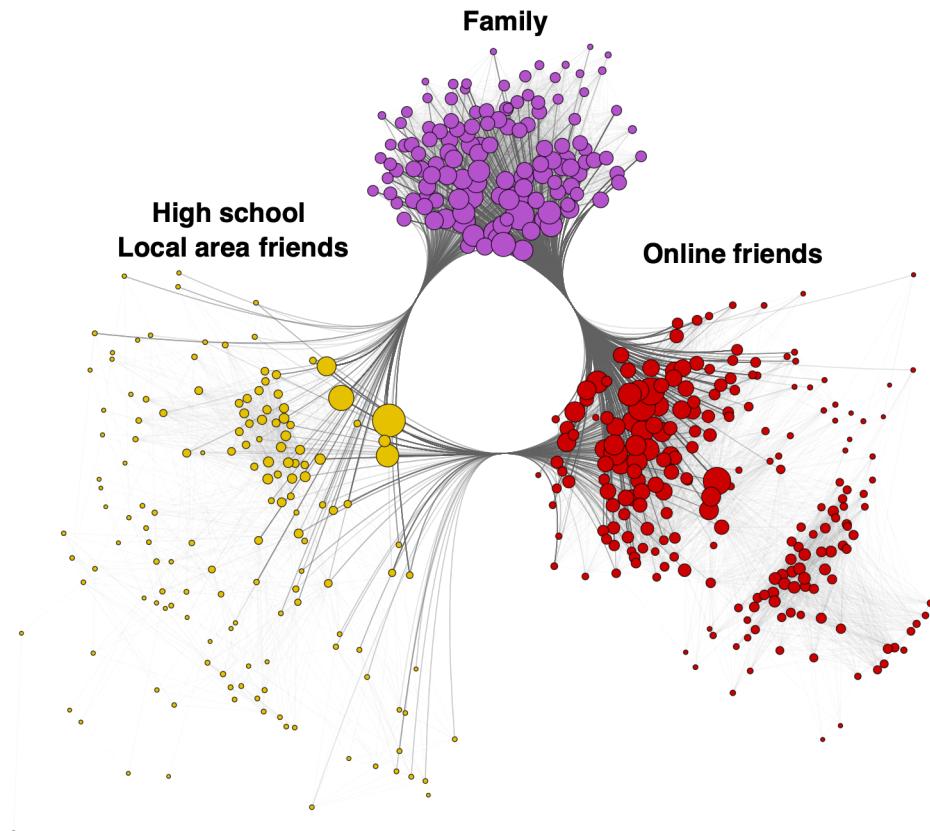
Nice Presentation

```
HighlightGraph[WLCC[Blog], {Style[left, Blue], Style[right, Red],
  Style[bothRight, Red], Style[bothLeft, Blue], Style[cross, Green]},
  VertexStyle → EdgeForm[Thick], VertexLabels → Placed["Name", Tooltip]]
```



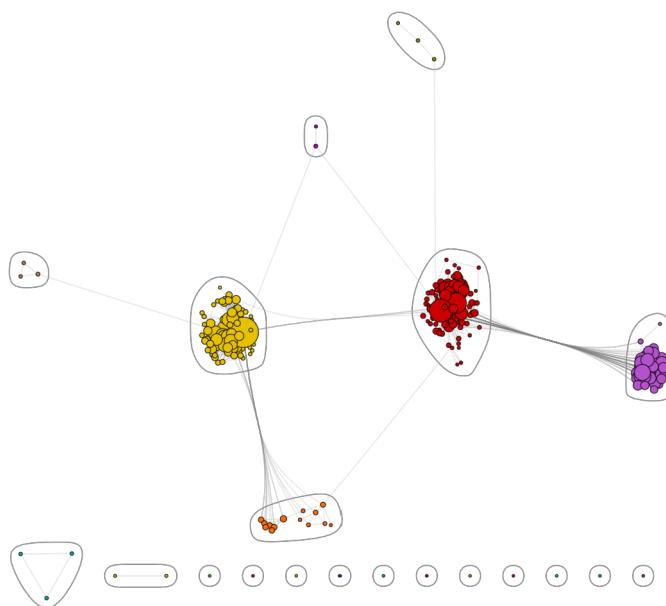
On-line Data

■ Facebook Friends Example



```
MyNet = SocialMediaData["Facebook", "FriendNetwork"]
```

```
CommunityGraphPlot[MyNet]
```



```
Take[VertexList[MyNet], 5]
{Ori Benhamou, Alok Nandan, David DaRose, Joseph Lee Nunn III, Anahita Shayesteh}

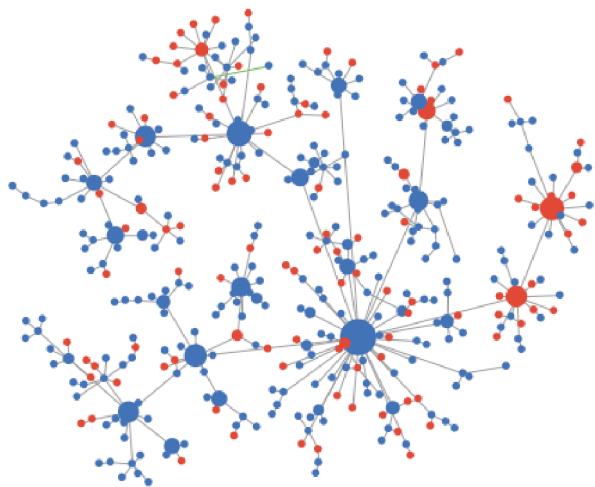
PropertyList[{MyNet, "Ori Benhamou"}]
{ID, Picture, VertexCoordinates, VertexLabels,
 VertexShape, VertexShapeFunction, VertexSize, VertexStyle}

Import[PropertyValue[{MyNet, "David DaRose"}, "Picture"]]
```



Network Evolution

- How networks emerge?
- This is a process
- How Nodes / Edges join? What are the rules?
- See example...



PageRank Game

- Networks Games???
- How to optimize your rank in the world

Tentative Syllabus

- Week 1: Introduction
- Week 2: Graph Background and Data sets
- Week 3: Strong and Weak Ties
- Week 4: Homophily , Assortativity Mixing, Modularity
- Week 5: Centrality
- Week 6: Core-Periphery
- Week 7: Community detection
- Week 8: Random Graph Models Erdos-Reny - Preferential Attachment
- Week 9: Power Law Distribution
- Week 10: Small World Networks & Search
- Week 11: Ego Networks (optional)
- Week 12: Diffusion (optional)

Grading & Assignment

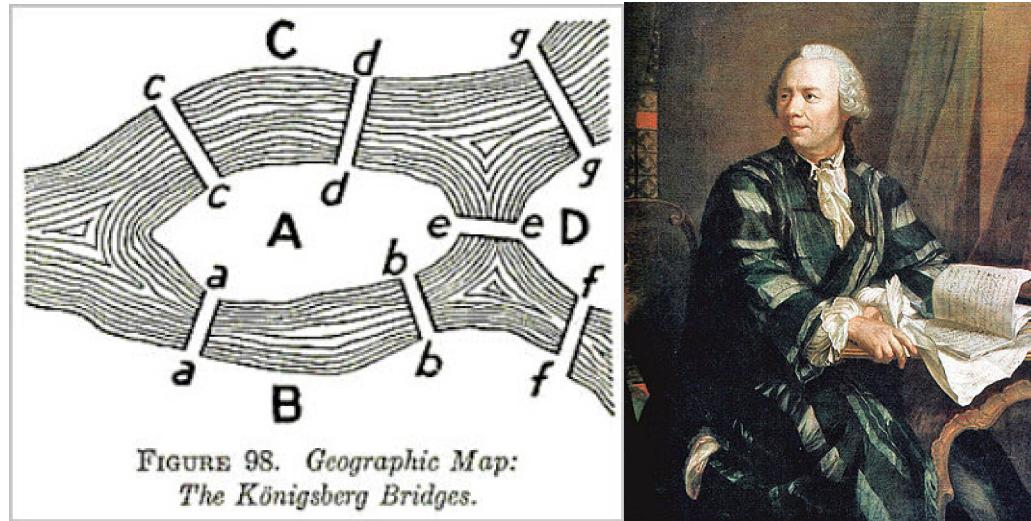
- “Small” programming assignments - *Mathematica* - 30%
 - In class questions and participation - 10% (Mandatory 70% in class)
 - Final Exam / Poster Session (must pass, 56) - 60%
 - **Short Class Challenges Bonus - 20%**
-

Administration

- Slack?- please be social....
- Moodle for assignments, announcements etc.
- Bring Laptops to class - Important

Graphs & Networks Basics

One of the most famous problems in the history of mathematics is the Königsberg Bridge Problem because it clearly marks the beginning of Graph Theory.



The Königsberg bridge problem asks if the seven bridges of the city of Konigsberg (*) over the river Preger can all be traversed in a single trip without doubling back, with the additional requirement that the trip ends in the same place it began. Euler proved in 1736 that there is no such traversal.

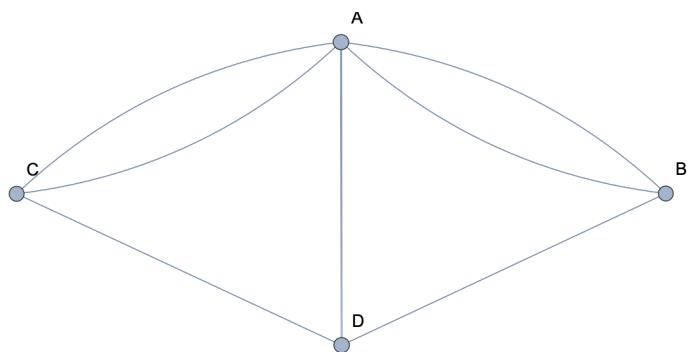
(*) Königsberg=Kaliningrad in the Russian enclave between Poland and Lithuania.

Using Graph Theory the problem is equivalent to asking if the multigraph on four nodes and seven edges (see figure) has an Eulerian cycle.

Using Mathematica we would model each bridge as an edge and the parts of the city as a vertex.

```
edges =
 {"A" → "B", "A" → "B", "A" → "C", "A" → "C", "C" → "D", "A" → "D", "D" → "B"};
```

```
bridges = Graph[edges, VertexLabels → "Name"]
```



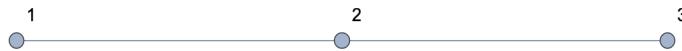
```
EulerianGraphQ[bridges]
```

```
False
```

Graphs Types

■ $G(V, E)$

```
G = Graph[Range[3], {1 ↔ 2, 2 ↔ 3}, VertexLabels → "Name"]
```



```
Vl = VertexList[G]
```

```
{1, 2, 3}
```

```
El = EdgeList[G]
```

```
{1 ↔ 2, 2 ↔ 3}
```

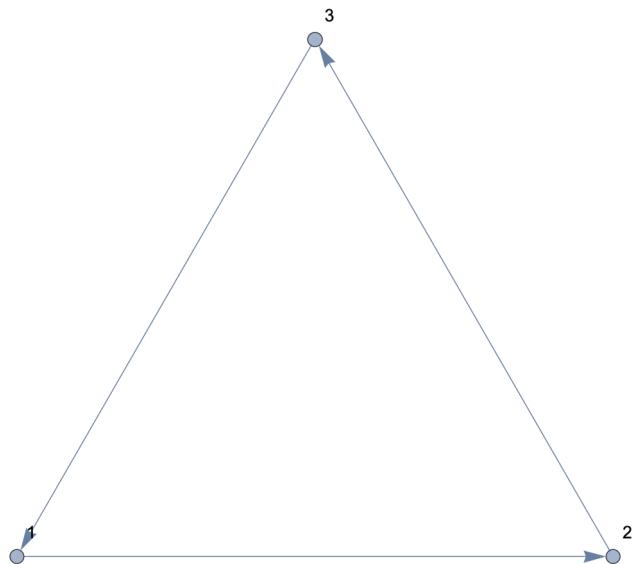
```
Last[El[[2]]]
```

```
3
```

Directed Graphs

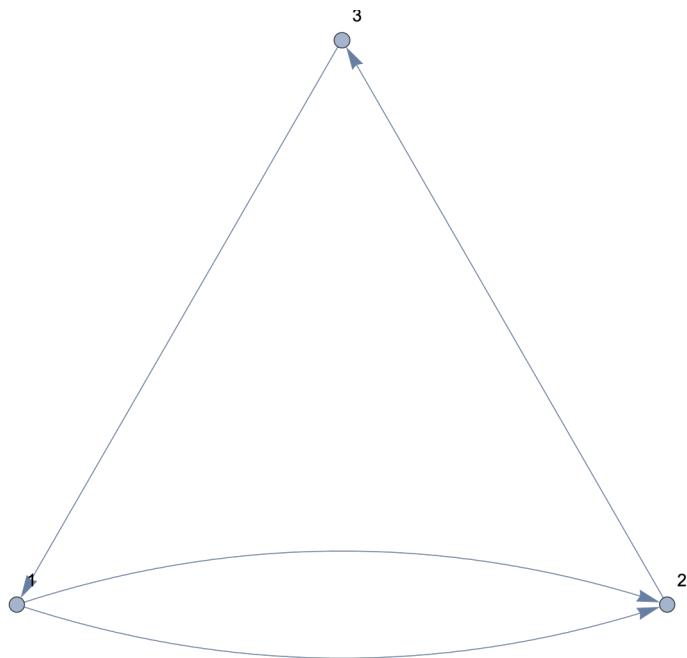
↔
→

```
Graph[{1 → 2, 2 → 3, 3 → 1}, VertexLabels → "Name"]
```



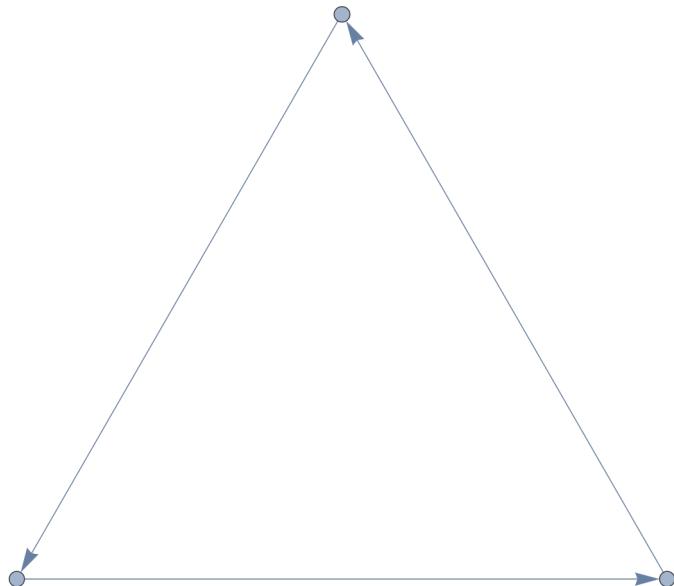
Multi-Graphs

```
G = Graph[{1 → 2, 1 → 2, 2 → 3, 3 → 1}, VertexLabels → "Name"]
```



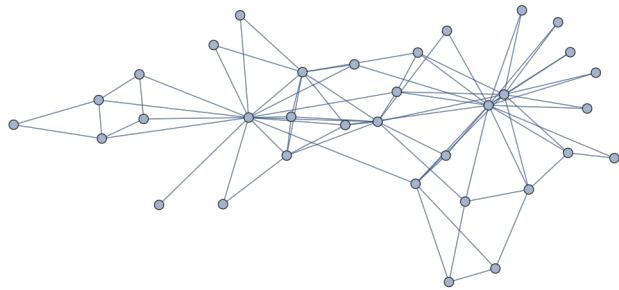
Simple Graphs

```
SimpleGraph[G]
```



Graph Representation

Karate



Edge List

EdgeList[Karate]

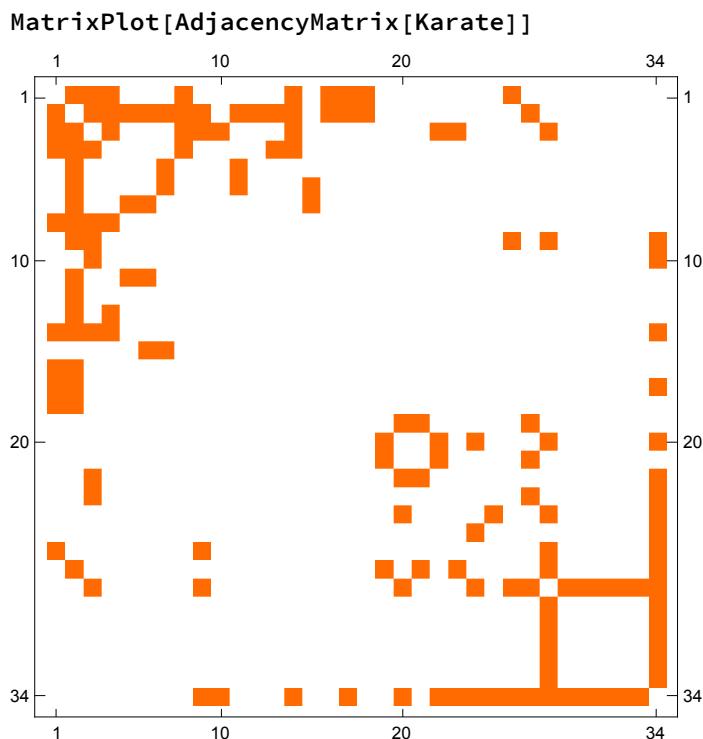
```
{2 → 1, 3 → 1, 3 → 2, 4 → 1, 4 → 2, 4 → 3, 5 → 1, 6 → 1, 7 → 1, 7 → 5, 7 → 6, 8 → 1,
 8 → 2, 8 → 3, 8 → 4, 9 → 1, 9 → 3, 10 → 3, 11 → 1, 11 → 5, 11 → 6, 12 → 1, 13 → 1,
 13 → 4, 14 → 1, 14 → 2, 14 → 3, 14 → 4, 17 → 6, 17 → 7, 18 → 1, 18 → 2, 20 → 1,
 20 → 2, 22 → 1, 22 → 2, 26 → 24, 26 → 25, 28 → 3, 28 → 24, 28 → 25, 29 → 3,
 30 → 24, 30 → 27, 31 → 2, 31 → 9, 32 → 1, 32 → 25, 32 → 26, 32 → 29, 33 → 3,
 33 → 9, 33 → 15, 33 → 16, 33 → 19, 33 → 21, 33 → 23, 33 → 24, 33 → 30, 33 → 31,
 33 → 32, 34 → 9, 34 → 10, 34 → 14, 34 → 15, 34 → 16, 34 → 19, 34 → 20, 34 → 21,
 34 → 23, 34 → 24, 34 → 27, 34 → 28, 34 → 29, 34 → 30, 34 → 31, 34 → 32, 34 → 33}
```

Adjacency matrix

```
AdjacencyMatrix[Karate] // MatrixForm
```

34 * 34

1156



Adjacency List (For sparse large graphs)

```
AdjacencyList[Karate, 1]
```

```
{2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 18, 20, 22, 32}
```

```
AdjacencyList[Karate, 12]
```

```
{1}
```

```
SparseArray[AdjacencyMatrix[Karate]]
```

```
SparseArray[  
  + Specified elements: 156  
  Dimensions: {34, 34}]
```

```

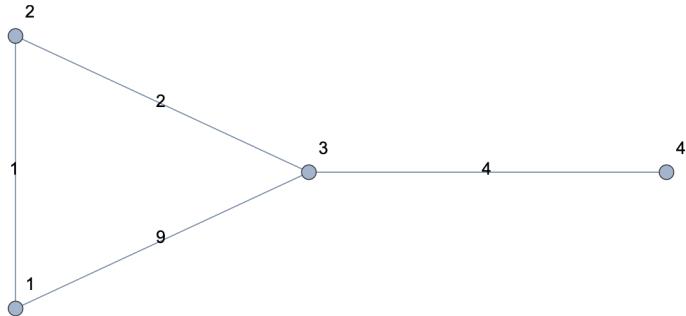
SparseArray[AdjacencyMatrix[Karate]] // ArrayRules
{{1, 2} \rightarrow 1, {1, 3} \rightarrow 1, {1, 4} \rightarrow 1, {1, 8} \rightarrow 1, {1, 14} \rightarrow 1, {1, 16} \rightarrow 1, {1, 17} \rightarrow 1,
{1, 18} \rightarrow 1, {1, 26} \rightarrow 1, {2, 1} \rightarrow 1, {2, 3} \rightarrow 1, {2, 4} \rightarrow 1, {2, 5} \rightarrow 1,
{2, 6} \rightarrow 1, {2, 7} \rightarrow 1, {2, 8} \rightarrow 1, {2, 9} \rightarrow 1, {2, 11} \rightarrow 1, {2, 12} \rightarrow 1,
{2, 13} \rightarrow 1, {2, 14} \rightarrow 1, {2, 16} \rightarrow 1, {2, 17} \rightarrow 1, {2, 18} \rightarrow 1, {2, 27} \rightarrow 1,
{3, 1} \rightarrow 1, {3, 2} \rightarrow 1, {3, 4} \rightarrow 1, {3, 8} \rightarrow 1, {3, 9} \rightarrow 1, {3, 10} \rightarrow 1,
{3, 14} \rightarrow 1, {3, 22} \rightarrow 1, {3, 23} \rightarrow 1, {3, 28} \rightarrow 1, {4, 1} \rightarrow 1, {4, 2} \rightarrow 1,
{4, 3} \rightarrow 1, {4, 8} \rightarrow 1, {4, 13} \rightarrow 1, {4, 14} \rightarrow 1, {5, 2} \rightarrow 1, {5, 7} \rightarrow 1,
{5, 11} \rightarrow 1, {6, 2} \rightarrow 1, {6, 7} \rightarrow 1, {6, 11} \rightarrow 1, {6, 15} \rightarrow 1, {7, 2} \rightarrow 1,
{7, 5} \rightarrow 1, {7, 6} \rightarrow 1, {7, 15} \rightarrow 1, {8, 1} \rightarrow 1, {8, 2} \rightarrow 1, {8, 3} \rightarrow 1,
{8, 4} \rightarrow 1, {9, 2} \rightarrow 1, {9, 3} \rightarrow 1, {9, 26} \rightarrow 1, {9, 28} \rightarrow 1, {9, 34} \rightarrow 1,
{10, 3} \rightarrow 1, {10, 34} \rightarrow 1, {11, 2} \rightarrow 1, {11, 5} \rightarrow 1, {11, 6} \rightarrow 1, {12, 2} \rightarrow 1,
{13, 2} \rightarrow 1, {13, 4} \rightarrow 1, {14, 1} \rightarrow 1, {14, 2} \rightarrow 1, {14, 3} \rightarrow 1, {14, 4} \rightarrow 1,
{14, 34} \rightarrow 1, {15, 6} \rightarrow 1, {15, 7} \rightarrow 1, {16, 1} \rightarrow 1, {16, 2} \rightarrow 1, {17, 1} \rightarrow 1,
{17, 2} \rightarrow 1, {17, 34} \rightarrow 1, {18, 1} \rightarrow 1, {18, 2} \rightarrow 1, {19, 20} \rightarrow 1, {19, 21} \rightarrow 1,
{19, 27} \rightarrow 1, {20, 19} \rightarrow 1, {20, 22} \rightarrow 1, {20, 24} \rightarrow 1, {20, 28} \rightarrow 1, {20, 34} \rightarrow 1,
{21, 19} \rightarrow 1, {21, 22} \rightarrow 1, {21, 27} \rightarrow 1, {22, 3} \rightarrow 1, {22, 20} \rightarrow 1, {22, 21} \rightarrow 1,
{22, 34} \rightarrow 1, {23, 3} \rightarrow 1, {23, 27} \rightarrow 1, {23, 34} \rightarrow 1, {24, 20} \rightarrow 1, {24, 25} \rightarrow 1,
{24, 28} \rightarrow 1, {24, 34} \rightarrow 1, {25, 24} \rightarrow 1, {25, 34} \rightarrow 1, {26, 1} \rightarrow 1, {26, 9} \rightarrow 1,
{26, 28} \rightarrow 1, {26, 34} \rightarrow 1, {27, 2} \rightarrow 1, {27, 19} \rightarrow 1, {27, 21} \rightarrow 1, {27, 23} \rightarrow 1,
{27, 28} \rightarrow 1, {27, 34} \rightarrow 1, {28, 3} \rightarrow 1, {28, 9} \rightarrow 1, {28, 20} \rightarrow 1, {28, 24} \rightarrow 1,
{28, 26} \rightarrow 1, {28, 27} \rightarrow 1, {28, 29} \rightarrow 1, {28, 30} \rightarrow 1, {28, 31} \rightarrow 1, {28, 32} \rightarrow 1,
{28, 33} \rightarrow 1, {28, 34} \rightarrow 1, {29, 28} \rightarrow 1, {29, 34} \rightarrow 1, {30, 28} \rightarrow 1, {30, 34} \rightarrow 1,
{31, 28} \rightarrow 1, {31, 34} \rightarrow 1, {32, 28} \rightarrow 1, {32, 34} \rightarrow 1, {33, 28} \rightarrow 1, {33, 34} \rightarrow 1,
{34, 9} \rightarrow 1, {34, 10} \rightarrow 1, {34, 14} \rightarrow 1, {34, 17} \rightarrow 1, {34, 20} \rightarrow 1, {34, 22} \rightarrow 1,
{34, 23} \rightarrow 1, {34, 24} \rightarrow 1, {34, 25} \rightarrow 1, {34, 26} \rightarrow 1, {34, 27} \rightarrow 1, {34, 28} \rightarrow 1,
{34, 29} \rightarrow 1, {34, 30} \rightarrow 1, {34, 31} \rightarrow 1, {34, 32} \rightarrow 1, {34, 33} \rightarrow 1, {_, _} \rightarrow 0}

```

Weighted Graph

```
weight = RandomInteger[{1, 10}, 4];
edges = {1 → 2, 2 → 3, 3 → 1, 3 → 4};

Graph[edges, EdgeWeight → weight,
VertexLabels → "Name", EdgeLabels → Thread[edges → weight]]
```



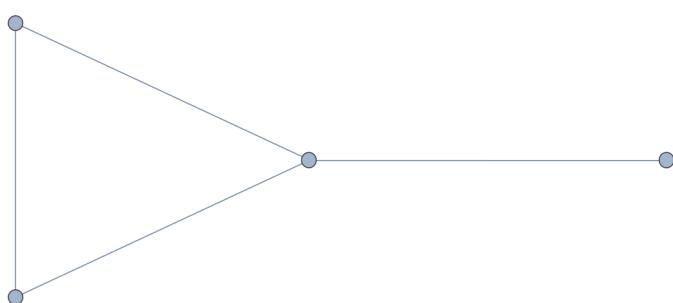
```
W = WeightedAdjacencyMatrix[%];
W // MatrixForm


$$\begin{pmatrix} 0 & 1 & 9 & 0 \\ 1 & 0 & 2 & 0 \\ 9 & 2 & 0 & 4 \\ 0 & 0 & 4 & 0 \end{pmatrix}$$


W2 = {{∞, 2, 2, ∞}, {2, ∞, 3, ∞}, {2, 3, ∞, 1}, {∞, ∞, 1, ∞}} ;
W2 // MatrixForm


$$\begin{pmatrix} \infty & 2 & 2 & \infty \\ 2 & \infty & 3 & \infty \\ 2 & 3 & \infty & 1 \\ \infty & \infty & 1 & \infty \end{pmatrix}$$


WeightedAdjacencyGraph[W2]
```

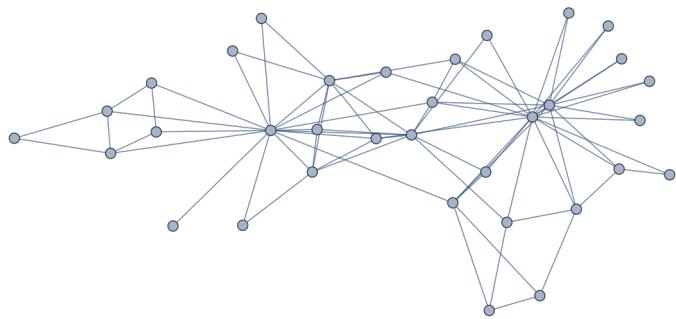


Vertex Properties

```
VertexDegree[Karate, 1]
```

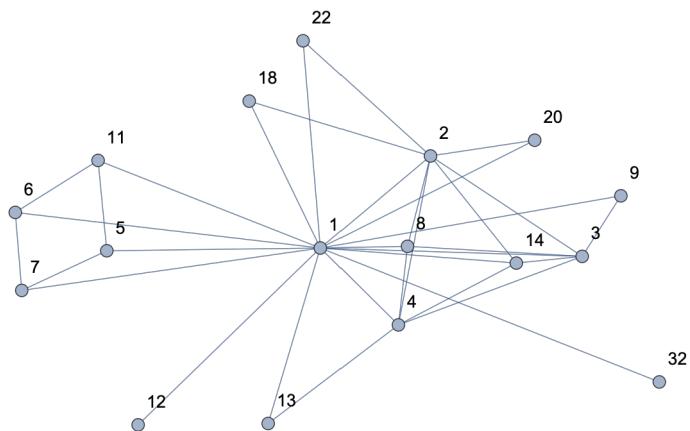
16

Karate



Neighborhood Graph / Ego Network

```
NeighborhoodGraph[Karate, 1, VertexLabels → "Name"]
```

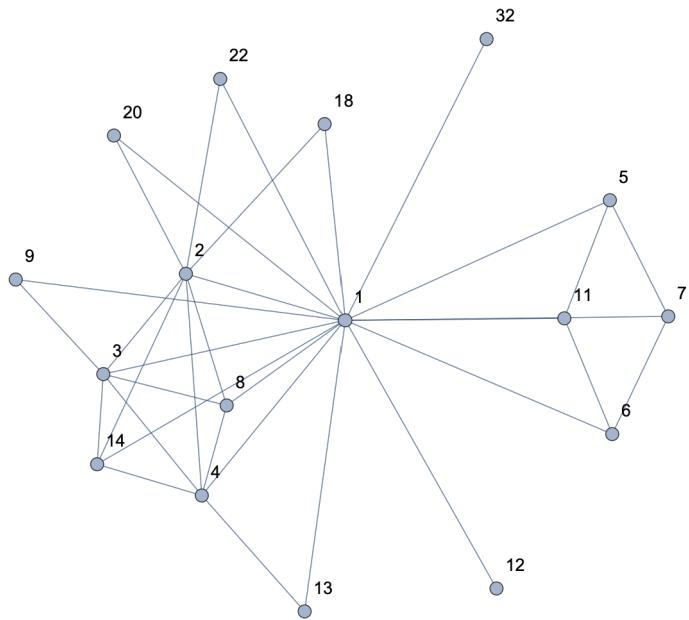


- Neighborhood: $N(v) := \{u \in V : (v, u) \in E\}$

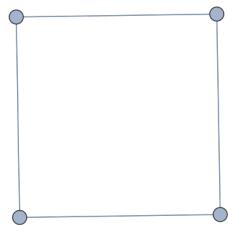
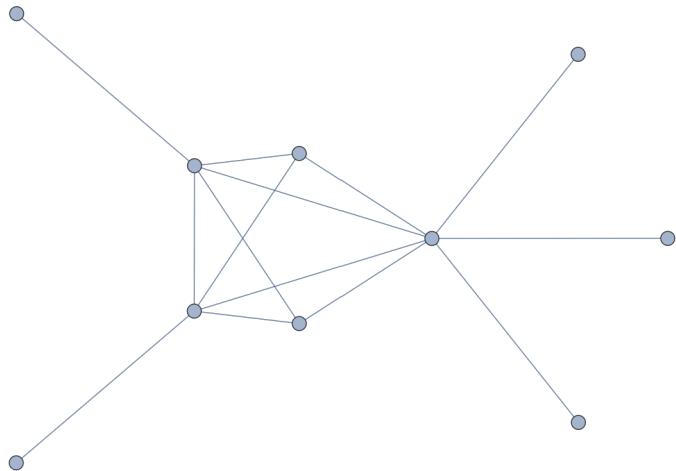
- Vertex Degree: $\delta(v) = |N(v)|$

```
Nb = AdjacencyList[Karate, 1];
```

```
Subgraph[Karate, Union[Nb, {1}], VertexLabels → "Name"]
```



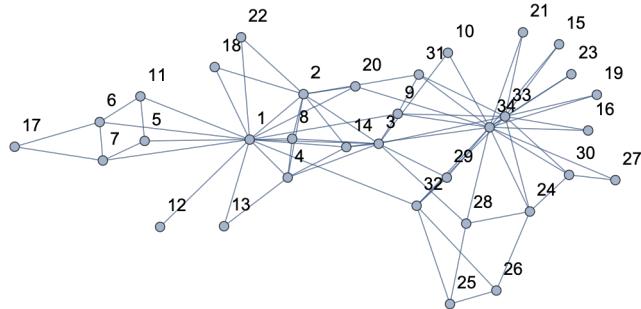
```
Subgraph[Karate, Nb]
```



Ranking of Nodes (later in the class)

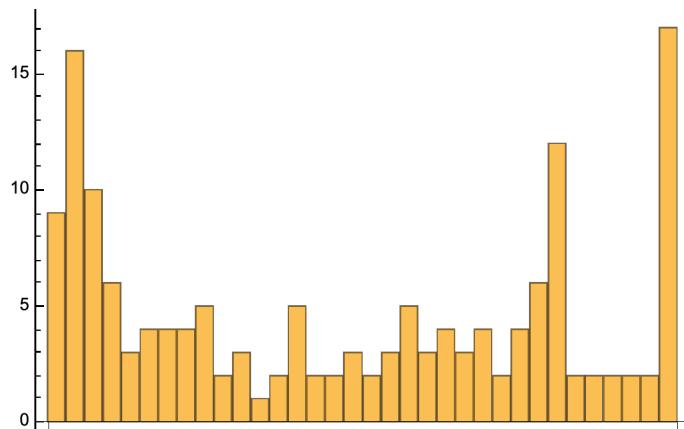
Degree Distribution

```
Graph[Karate, VertexLabels → "Name"]
```



Degree Sequence

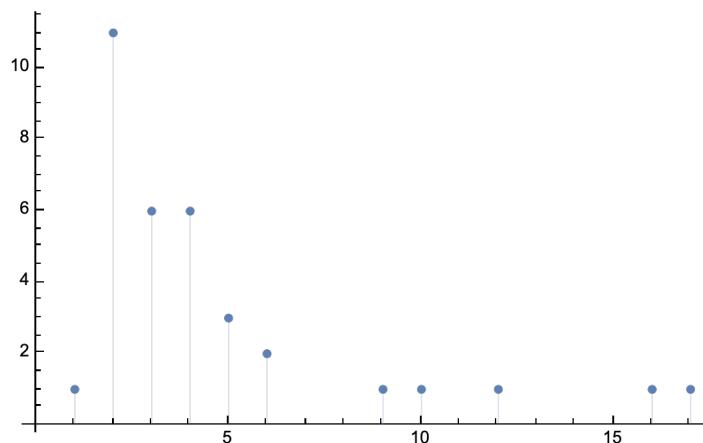
```
Deg = VertexDegree[Karate]
BarChart[Deg]
{9, 16, 10, 6, 3, 4, 4, 4, 5, 2, 3, 1, 2, 5, 2,
 2, 3, 2, 3, 5, 3, 4, 3, 4, 2, 4, 6, 12, 2, 2, 2, 2, 17}
```



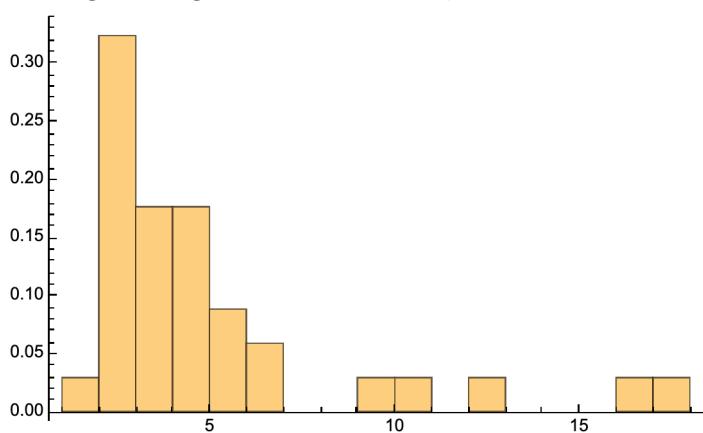
How much from each degree / Degree distribution

```
Tally[Deg]
{{9, 1}, {16, 1}, {10, 1}, {6, 2}, {3, 6},
 {4, 6}, {5, 3}, {2, 11}, {1, 1}, {12, 1}, {17, 1}}
```

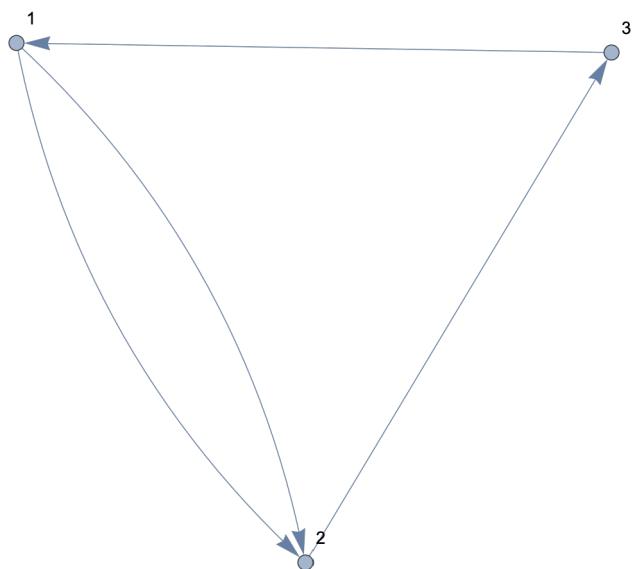
```
ListPlot[Tally[Deg], Filling -> Automatic]
```



```
Histogram[Deg, 20, "Probability"]
```



InDegree / OutDegree Sequence



```
VertexInDegree[G]
{1, 2, 1}

VertexOutDegree[G]
{2, 1, 1}

NF = Normal[AdjacencyMatrix[G]]
{{0, 2, 0}, {0, 0, 1}, {1, 0, 0}}

NF // MatrixForm

$$\begin{pmatrix} 0 & 2 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

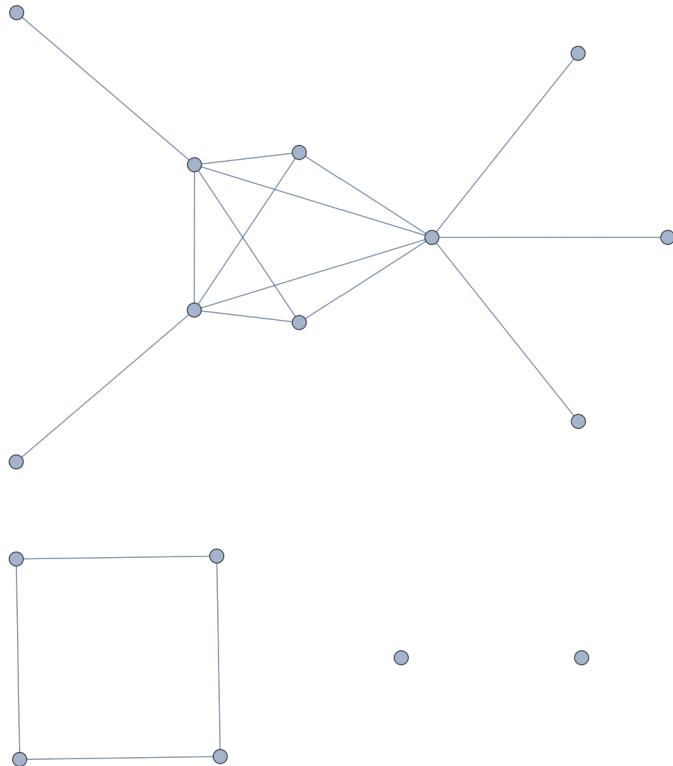

NF[[1]]
{0, 2, 0}

NF[[All, 1]]
{0, 0, 1}

Transpose[NF][[1]]
{0, 0, 1}
```

Connected Components

```
Subgraph[Karate, Nb]
```

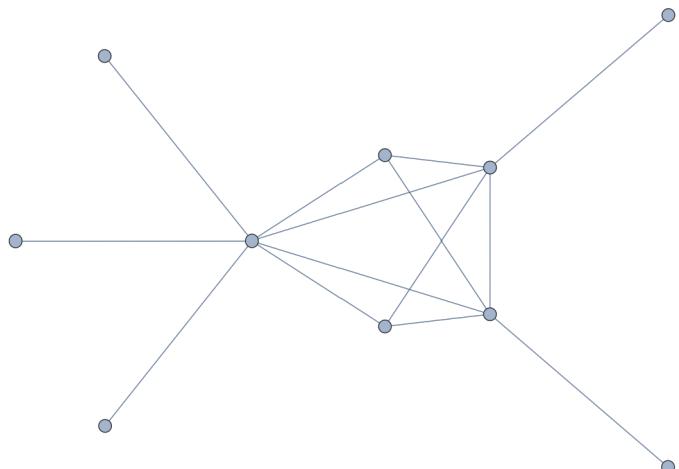


Strongly Connected Components

```
ConnectedComponents[Subgraph[Karate, Nb]]
```

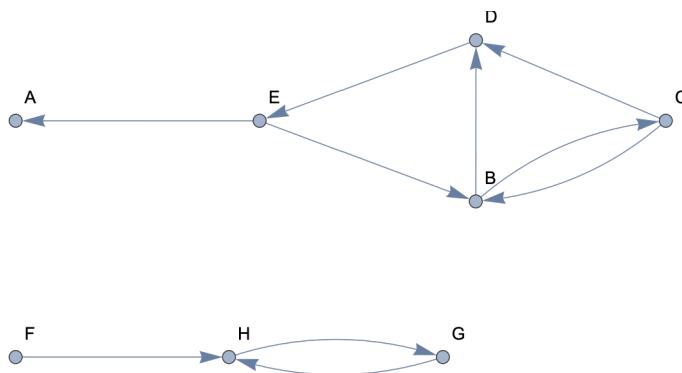
```
{ {2, 3, 4, 8, 14, 18, 20, 22, 9, 13}, {5, 7, 11, 6}, {32}, {12} }
```

```
Subgraph[Karate, First[ConnectedComponents[Subgraph[Karate, Nb]]]]
```



Ex =

```
Graph[{ "E" → "A", "E" → "B", "B" → "C", "B" → "D", "C" → "B", "C" → "D",
        "D" → "E", "F" → "H", "H" → "G", "G" → "H"}, VertexLabels → "Name"]
```



ConnectedComponents[Ex]

```
{ {A}, {E, B, C, D}, {H, G}, {F} }
```

Weakly Connected Components

WeaklyConnectedComponents[Ex]

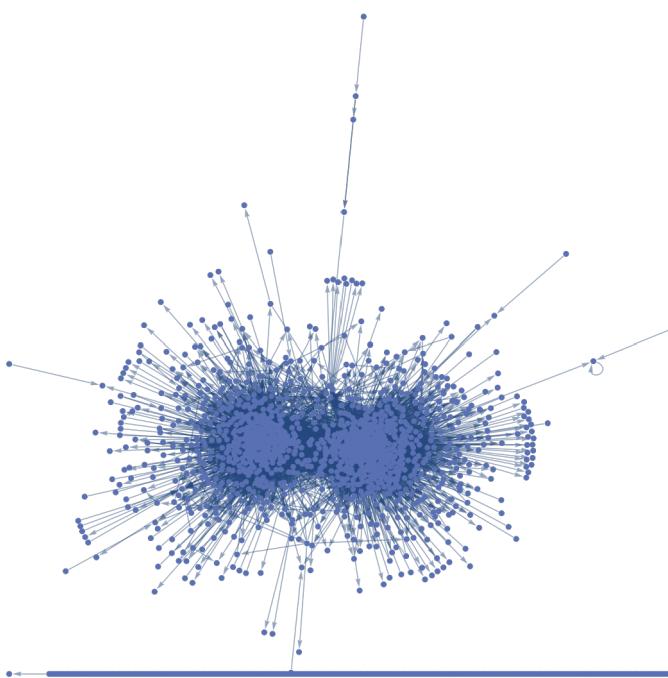
```
{ {D, B, C, E, A}, {F, H, G} }
```

ConnectedComponents[UndirectedGraph[Ex]]

```
{ {E, D, A, B, C}, {F, H, G} }
```

Largest Connected Component

Blog



`Length[WeaklyConnectedComponents[Blog]]`

268

■ Largest Connected Components

```
Length[First[WeaklyConnectedComponents[Blog]]]
```

1222

■ Fraction of Largest Connected Components

```
Length[First[WeaklyConnectedComponents[Blog]]] / VertexCount[Blog] // N
```

0.820134

```
Length[#] & /@ WeaklyConnectedComponents[Blog]
```

Special Graphs

Complete Graphs

Trees

Grids

Bipartite Graphs

Affiliation Network Example

```
Marvel = ExampleData[{"NetworkGraph", "MarvelUniverseSocialGraph"}];
```



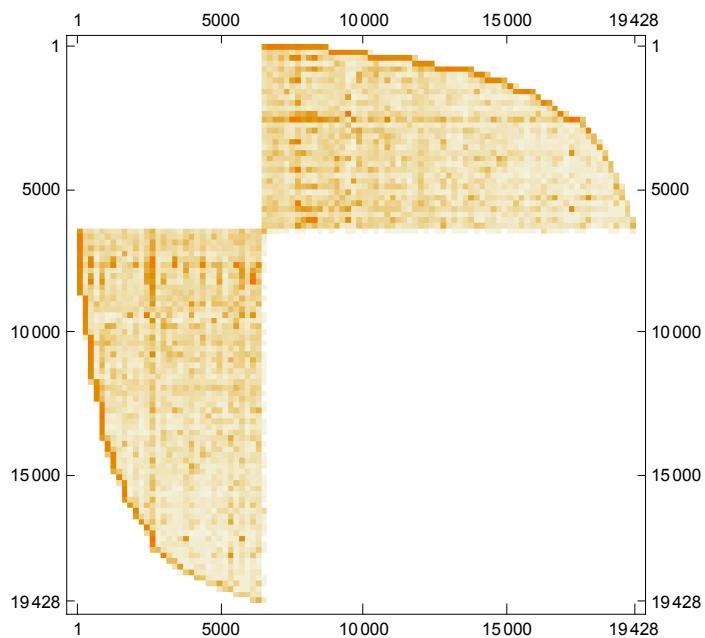
```
BipartiteGraphQ[Marvel]
```

```
True
```

```
Max[AdjacencyMatrix[Marvel]]
```

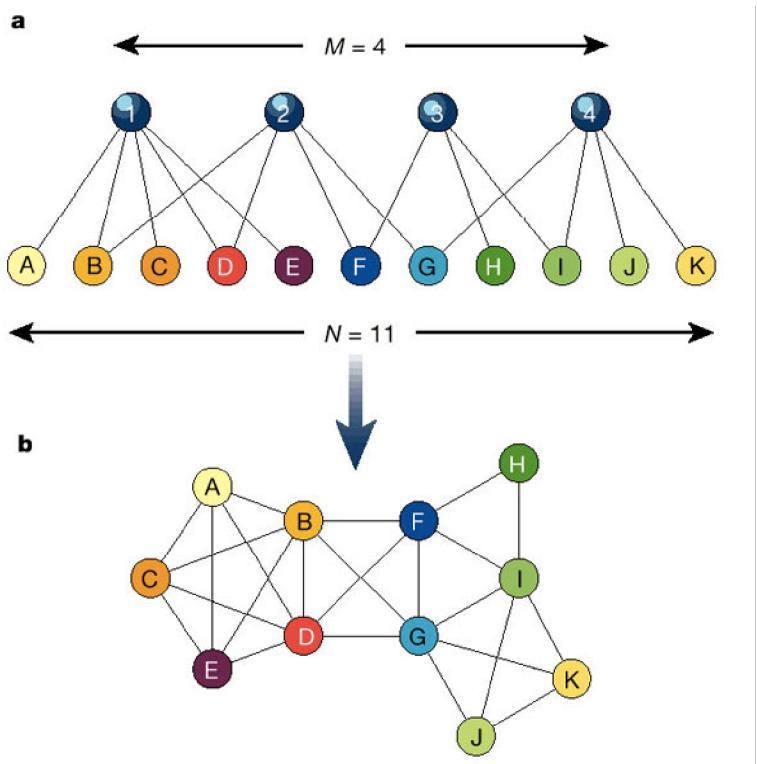
```
1
```

```
MatrixPlot[AdjacencyMatrix[Marvel]]
```



```
ExampleData[{"NetworkGraph", "MarvelUniverseSocialGraph"}, "VertexProperty"]
{Name, Type}
```

```
DeleteDuplicates[PropertyValue[{Marvel, #}, "Type"] & /@ VertexList[Marvel]]
{Hero, Comic}
```



```
Heros =
Select[VertexList[Marvel], PropertyValue[{Marvel, #}, "Type"] == "Hero" &];

Comics =
Select[VertexList[Marvel], PropertyValue[{Marvel, #}, "Type"] == "Comic" &];

PropertyValue[{Marvel, #}, "Name"] & /@
Take[Part[VertexList[Marvel], Ordering[VertexDegree[Marvel], All, Greater]], 3]
{SPIDER-MAN/PETER PAR, CAPTAIN AMERICA, IRON MAN/TONY STARK }

VertexDegree[Marvel] @@
Take[Part[VertexList[Marvel], Ordering[VertexDegree[Marvel], All, Greater]], 3]]
{1625, 1367, 1168}

PropertyValue[{Marvel, #}, "Name"] & /@ Take[Part[VertexList[Marvel][[Comics]],
Ordering[VertexDegree[Marvel][[Comics]], All, Greater]], 3]
{COC 1, IW 3, IW 1}

VertexDegree[Marvel][[Take[Part[VertexList[Marvel][[Comics]],
Ordering[VertexDegree[Marvel][[Comics]], All, Greater]], 3]]]
{111, 91, 90}
```

Homework Week 1

- Find your favorite (social) network in

```
ExampleData["NetworkGraph"];
```

- Pick the largest degree node in this network - call it **Adam**
- Calculate statistics for Adam's **Neighborhood Graph**
 - Number of nodes
 - Number of edges
 - Number Connected Components
 - Size of Largest connected component
 - Degree Distribution
- How many triangles Adam have in his Ego networks (Including Adam). How many triangles in the Neighborhood graph?
- What is the maximum number of triangles a network of Adam's network size could have (Including Adam)?

```
In[9]:= NetList = ExampleData["NetworkGraph"];
In[10]:= list = {ExampleData[{"NetworkGraph", #}, "StandardName"] ,
           ExampleData[{"NetworkGraph", #}, "Description"]} & /@ NetList[[All, 2]];
In[11]:= Grid[list, Frame -> All]
Out[*]=
```

AmericanCollegeFootball	Network of American football games
AskOpinionRecall	Members who you ask for an option (by recall)
AskOpinionRecognition	Members who you ask for an option (by recognition)
AstrophysicsCollaborations	Weighted network of coauthorships
BeAskedOpinionRecall	Members who ask you for opinion (by recall)
BeAskedOpinionRecognition	Members who ask you for opinion (by recognition)
BipartiteDiseasomeNetwork	A bipartite network of diseases linked by known disorder-gene associations
Brock2001	The Second DIMACS Implementation Challenge: 1992–1993
Brock2002	The Second DIMACS Implementation Challenge: 1992–1993
Brock2003	The Second DIMACS Implementation Challenge: 1992–1993
Brock2004	The Second DIMACS Implementation Challenge: 1992–1993
Brock4001	The Second DIMACS Implementation Challenge: 1992–1993
Brock4002	The Second DIMACS Implementation Challenge: 1992–1993
Brock4003	The Second DIMACS Implementation Challenge: 1992–1993
Brock4004	The Second DIMACS Implementation Challenge: 1992–1993
Brock8001	The Second DIMACS Implementation Challenge: 1992–1993
Brock8002	The Second DIMACS Implementation Challenge: 1992–1993
Brock8003	The Second DIMACS Implementation Challenge: 1992–1993
Brock8004	The Second DIMACS Implementation Challenge: 1992–1993

BuddingYeast	Protein-protein interaction network in budding yeast
CellOntology	Ontology network for cell types
CFat2001	The Second DIMACS Implementation Challenge: 1992–1993
CFat2002	The Second DIMACS Implementation Challenge: 1992–1993
CFat2005	The Second DIMACS Implementation Challenge: 1992–1993
CFat5001	The Second DIMACS Implementation Challenge: 1992–1993
CFat50010	The Second DIMACS Implementation Challenge: 1992–1993
CFat5002	The Second DIMACS Implementation Challenge: 1992–1993
CFat5005	The Second DIMACS Implementation Challenge: 1992–1993
CoauthorshipsInNetworkScience	Coauthorship network of scientists
CondensedMatterCollaborations	Weighted network of coauthorships
CondensedMatterCollaborations2003	Updated network of coauthorships
CondensedMatterCollaborations2005	Updated network of coauthorships
DavisSouthernWomen	The network of southern women social club
DiscussionRecall	Members who you discuss with (by recall)
DiscussionRecognition	Members who you discuss with (by recognition)
DiseaseGeneNetwork	A network of disease genes linked by known disorder–gene associations
DolphinSocialNetwork	An undirected social network of frequent associations
EastAfricaEmbassyAttacks	Terrorist network linked to the 1998 bombings of the US embassies in Kenya and Tanzania
EmailListMathGroup	Network of email sent to the MathGroup list in November 2011
EuclidElements	The network of theorems associated with Euclid's Elements
EurovisionVotes	Eurovision Song Contest voting network
ExpandedAbortion	WWW Graph of Abortion for Link Analysis Ranking Experiments
ExpandedComputationalComplexity	WWW Graph of Computational Complexity for Link Analysis Ranking Experiments

ExpandedComputationalGeometry	WWW Graph of Computational Geometry for Link Analysis Ranking Experiments
ExpandedDeathPenalty	WWW Graph of Death Penalty for Link Analysis Ranking Experiments
ExpandedGenetic	WWW Graph of Genetic for Link Analysis Ranking Experiments
ExpandedGunControl	WWW Graph of Gun Control for Link Analysis Ranking Experiments
ExpandedMovies	WWW Graph of Movies for Link Analysis Ranking Experiments
ExpandedNetCensorship	WWW Graph of Net Censorship for Link Analysis Ranking Experiments
FamilyGathering	A social network of close family ties among people at a family gathering
FlorentineFamilies	Florentine families network in the early 15th century
FreeAssociationNormsAppendixA	Free association norm
Friendship	Social network of friendship in a swimming team
Hamming102	The Second DIMACS Implementation Challenge: 1992–1993
Hamming104	The Second DIMACS Implementation Challenge: 1992–1993
Hamming62	The Second DIMACS Implementation Challenge: 1992–1993
Hamming64	The Second DIMACS Implementation Challenge: 1992–1993
Hamming82	The Second DIMACS Implementation Challenge: 1992–1993
Hamming84	The Second DIMACS Implementation Challenge: 1992–1993
HighEnergyPhysicsPhenomenology	Collaboration and citation network
HighEnergyPhysicsTheory	Collaboration and citation network
HighEnergyTheoryCollaborations	Weighted network of coauthorships
HumanDiseaseNetwork	A network of human diseases linked by known disorder–gene associations
Internet	A symmetrized snapshot of the structure of the Internet
JazzMusicians	List of edges of the network of Jazz musicians.
Johnson1624	The Second DIMACS Implementation Challenge: 1992–1993

Johnson3224	The Second DIMACS Implementation Challenge: 1992–1993
Johnson824	The Second DIMACS Implementation Challenge: 1992–1993
Johnson844	The Second DIMACS Implementation Challenge: 1992–1993
Keller4	The Second DIMACS Implementation Challenge: 1992–1993
Keller5	The Second DIMACS Implementation Challenge: 1992–1993
Keller6	The Second DIMACS Implementation Challenge: 1992–1993
LesMiserables	Coappearance network of characters
MannA27	The Second DIMACS Implementation Challenge: 1992–1993
MannA45	The Second DIMACS Implementation Challenge: 1992–1993
MannA81	The Second DIMACS Implementation Challenge: 1992–1993
MannA9	The Second DIMACS Implementation Challenge: 1992–1993
MarvelUniverseSocialGraph	A Marvel Comics character collaboration graph
MetabolicNetworkActinobacillusActinomycetemcomitans	Metabolic cellular network data
MetabolicNetworkAeropyrumPernix	Metabolic cellular network data
MetabolicNetworkAquifexAeolicus	Metabolic cellular network data
MetabolicNetworkArabidopsisThaliana	Metabolic cellular network data
MetabolicNetworkArchaeoglobusFulgidus	Metabolic cellular network data
MetabolicNetworkBacillusSubtilis	Metabolic cellular network data
MetabolicNetworkBorreliaBurgdorferi	Metabolic cellular network data
MetabolicNetworkCaenorhabditisElegans	Metabolic cellular network data
MetabolicNetworkCampylobacterJejuni	Metabolic cellular network data
MetabolicNetworkChlamydiaPneumoniae	Metabolic cellular network data
MetabolicNetworkChlamydiaTrachomatis	Metabolic cellular network data
MetabolicNetworkChlorobiumTepidum	Metabolic cellular network data
MetabolicNetworkClostridiumAcetobutylicum	Metabolic cellular network data
MetabolicNetworkDeinococcusRadiodurans	Metabolic cellular network data
MetabolicNetworkEmericellaNidulans	Metabolic cellular network data
MetabolicNetworkEnterococcusFaecalis	Metabolic cellular network data
MetabolicNetworkEscherichiaColi	Metabolic cellular network data
MetabolicNetworkHaemophilusInfluenzae	Metabolic cellular network data
MetabolicNetworkHelicobacterPylori	Metabolic cellular network data
MetabolicNetworkMethanobacteriumThermoaerotrophicum	Metabolic cellular network data

MetabolicNetworkMethanococcusJannaschii	Metabolic cellular network data
MetabolicNetworkMycobacteriumBovis	Metabolic cellular network data
MetabolicNetworkMycobacteriumLeprae	Metabolic cellular network data
MetabolicNetworkMycobacteriumTuberculosis	Metabolic cellular network data
MetabolicNetworkMycoplasmaGenitalium	Metabolic cellular network data
MetabolicNetworkMycoplasmaPneumoniae	Metabolic cellular network data
MetabolicNetworkNeisseriaGonorrhoeae	Metabolic cellular network data
MetabolicNetworkNeisseriaMeningitidis	Metabolic cellular network data
MetabolicNetworkOryzaSativa	Metabolic cellular network data
MetabolicNetworkPorphyromonasGingivalis	Metabolic cellular network data
MetabolicNetworkPseudomonasAeruginosa	Metabolic cellular network data
MetabolicNetworkPyrococcusFuriosus	Metabolic cellular network data
MetabolicNetworkPyrococcusHorikoshii	Metabolic cellular network data
MetabolicNetworkRhodobacterCapsulatus	Metabolic cellular network data
MetabolicNetworkRickettsiaProwazekii	Metabolic cellular network data
MetabolicNetworkSaccharomycesCerevisiae	Metabolic cellular network data
MetabolicNetworkSalmonellaTyphi	Metabolic cellular network data
MetabolicNetworkStreptococcusPneumoniae	Metabolic cellular network data
MetabolicNetworkStreptococcusPyogenes	Metabolic cellular network data
MetabolicNetworkSynechocystisSp	Metabolic cellular network data
MetabolicNetworkThermotogaMaritima	Metabolic cellular network data
MetabolicNetworkTreponemaPallidum	Metabolic cellular network data
MetabolicNetworkYersiniaPestis	Metabolic cellular network data
NationalHockeyLeague	Weighted network of wins in the National Hockey League during regular season 2010–2011
OnlineSocialNetwork	Social network of an online community.
PerlModuleAuthors	Network of CPAN module authors
PGPNetwork	The network of users of the Pretty-Good-Privacy algorithm
PHat10001	The Second DIMACS Implementation Challenge: 1992–1993
PHat10002	The Second DIMACS Implementation Challenge: 1992–1993
PHat10003	The Second DIMACS Implementation Challenge: 1992–1993
PHat15001	The Second DIMACS Implementation Challenge: 1992–1993
PHat15002	The Second DIMACS Implementation Challenge: 1992–1993
PHat15003	The Second DIMACS Implementation Challenge: 1992–1993

PHat3001	The Second DIMACS Implementation Challenge: 1992-1993
PHat3002	The Second DIMACS Implementation Challenge: 1992-1993
PHat3003	The Second DIMACS Implementation Challenge: 1992-1993
PHat5001	The Second DIMACS Implementation Challenge: 1992-1993
PHat5002	The Second DIMACS Implementation Challenge: 1992-1993
PHat5003	The Second DIMACS Implementation Challenge: 1992-1993
PHat7001	The Second DIMACS Implementation Challenge: 1992-1993
PHat7002	The Second DIMACS Implementation Challenge: 1992-1993
PHat7003	The Second DIMACS Implementation Challenge: 1992-1993
PoliticalBlogs	A directed network of hyperlinks
PowerGrid	An undirected, unweighted network representing the topology
ProteinInteraction	Protein interaction network
RefinedAbortion	WWW Graph of Abortion for Link Analysis Ranking Experiments
RefinedComputationalComplexity	WWW Graph of Computational Complexity for Link Analysis Ranking Experiments
RefinedComputationalGeometry	WWW Graph of Computational Geometry for Link Analysis Ranking Experiments
RefinedDeathPenalty	WWW Graph of Death Penalty for Link Analysis Ranking Experiments
RefinedGenetic	WWW Graph of Genetic for Link Analysis Ranking Experiments
RefinedGunControl	WWW Graph of Gun Control for Link Analysis Ranking Experiments
RefinedMovies	WWW Graph of Movies for Link Analysis Ranking Experiments
RefinedNetCensorship	WWW Graph of Net Censorship for Link Analysis Ranking Experiments
RegularAbortion	WWW Graph of Abortion for Link Analysis Ranking Experiments

RegularComputationalComplexity	WWW Graph of Computational Complexity for Link Analysis Ranking Experiments
RegularComputationalGeometry	WWW Graph of Computational Geometry for Link Analysis Ranking Experiments
RegularDeathPenalty	WWW Graph of Death Penalty for Link Analysis Ranking Experiments
RegularGenetic	WWW Graph of Genetic for Link Analysis Ranking Experiments
RegularGunControl	WWW Graph of Gun Control for Link Analysis Ranking Experiments
RegularMovies	WWW Graph of Movies for Link Analysis Ranking Experiments
RegularNetCensorship	WWW Graph of Net Censorship for Link Analysis Ranking Experiments
San1000	The Second DIMACS Implementation Challenge: 1992–1993
San200071	The Second DIMACS Implementation Challenge: 1992–1993
San200072	The Second DIMACS Implementation Challenge: 1992–1993
San200091	The Second DIMACS Implementation Challenge: 1992–1993
San200092	The Second DIMACS Implementation Challenge: 1992–1993
San200093	The Second DIMACS Implementation Challenge: 1992–1993
San400051	The Second DIMACS Implementation Challenge: 1992–1993
San400071	The Second DIMACS Implementation Challenge: 1992–1993
San400072	The Second DIMACS Implementation Challenge: 1992–1993
San400073	The Second DIMACS Implementation Challenge: 1992–1993
San400091	The Second DIMACS Implementation Challenge: 1992–1993
Sanr20007	The Second DIMACS Implementation Challenge: 1992–1993
Sanr20009	The Second DIMACS Implementation Challenge: 1992–1993
Sanr40005	The Second DIMACS Implementation Challenge: 1992–1993

Sanr40007	The Second DIMACS Implementation Challenge: 1992-1993
September11Terrorists	Terrorist network linked to the tragic events of September 11, 2001
SimpleFoodWeb	A simple food web
SloveneParliamentaryParties	Relations between Slovene parliamentary political parties
TaggedTestImages	Bipartite network of tags and images
URVEmailNetwork	The email network between members of the University Rovira i Virgili
USPoliticsBooks	A network of books about US politics
WholeNetworkActinobacillusActinomycetemcomitans	Whole cellular network data
WholeNetworkAeropyrumPernix	Whole cellular network data
WholeNetworkAequifexAeolicus	Whole cellular network data
WholeNetworkArabidopsisThaliana	Whole cellular network data
WholeNetworkArchaeoglobusFulgidus	Whole cellular network data
WholeNetworkBacillusSubtilis	Whole cellular network data
WholeNetworkBorreliaBurgdorferi	Whole cellular network data
WholeNetworkCaenorhabditisElegans	Whole cellular network data
WholeNetworkCampylobacterJejuni	Whole cellular network data
WholeNetworkChlamydiaPneumoniae	Whole cellular network data
WholeNetworkChlamydiaTrachomatis	Whole cellular network data
WholeNetworkChlorobiumTepidum	Whole cellular network data
WholeNetworkClostridiumAcetobutylicum	Whole cellular network data
WholeNetworkDeinococcusRadiodurans	Whole cellular network data
WholeNetworkEnterococcusFaecalis	Whole cellular network data
WholeNetworkEscherichiaColi	Whole cellular network data
WholeNetworkHaemophilusInfluenzae	Whole cellular network data
WholeNetworkHelicobacterPylori	Whole cellular network data
WholeNetworkMethanobacteriumThermoautotrophicum	Whole cellular network data
WholeNetworkMethanococcusJannaschii	Whole cellular network data
WholeNetworkMycobacteriumBovis	Whole cellular network data
WholeNetworkMycobacteriumLeprae	Whole cellular network data
WholeNetworkMycobacteriumTuberculosis	Whole cellular network data
WholeNetworkMycoplasmaGenitalium	Whole cellular network data
WholeNetworkMycoplasmaPneumoniae	Whole cellular network data
WholeNetworkNeisseriaGonorrhoeae	Whole cellular network data
WholeNetworkNeisseriaMeningitidis	Whole cellular network data
WholeNetworkOryzaSativa	Whole cellular network data
WholeNetworkPorphyromonasGingivalis	Whole cellular network data
WholeNetworkPseudomonasAeruginosa	Whole cellular network data
WholeNetworkPyrococcusFuriosus	Whole cellular network data
WholeNetworkPyrococcusHorikoshii	Whole cellular network data
WholeNetworkRhodobacterCapsulatus	Whole cellular network data
WholeNetworkRickettsiaProwazekii	Whole cellular network data
WholeNetworkSaccharomycesCerevisiae	Whole cellular network data

WholeNetworkSalmonellaTyphi	Whole cellular network data
WholeNetworkStreptococcusPneumoniae	Whole cellular network data
WholeNetworkStreptococcusPyogenes	Whole cellular network data
WholeNetworkSynechocystisSp	Whole cellular network data
WholeNetworkThermotogaMaritima	Whole cellular network data
WholeNetworkTreponemaPallidum	Whole cellular network data
WholeNetworkYersiniaPestis	Whole cellular network data
WikiVote	Wikipedia who-votes-on-whom network
WordAdjacencies	Adjacency network of common adjectives and nouns
WorldCup1988	Describe the 22 soccer teams which participated in the World Cup in Paris, 1998.
WorldWideWeb	The World-Wide-Web graph of web pages
ZacharyKarateClub	Social network of friendships