Heidelberg University
Institute of Computer Science
Database Systems Research Group

Lecture: Complex Network Analysis

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Assignment 1

Graph Theory and Networks in Python

`https://github.com/nilskre/CNA_assignments`

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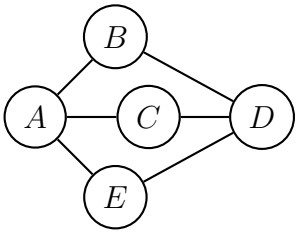
1 Problem 1-1 Adjacency Matrix

1. Is the corresponding graph G directed or undirected? Justify your answer.

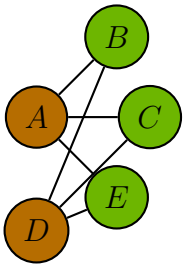
   Undirected, because the adjacency matrix is symmetric.

2. Draw the graph described by the adjacency matrix A_G. Use labels to indicate the correspondence of nodes to rows or columns of the adjacency matrix.



3. Is the graph bipartite? Explain your answer by giving 2-3 sentences.

   Yes, the graph is bipartite. It can be divided into the two disjoint sets $U = A, D$ and $V = B, C, E$. The nodes connect these two sets, but never connect two nodes in one set.



4. Give the adjacency list and the edge list representation of the graph G.

   adjacency list:

node	linked to
A	B, C, E
B	A, D
C	A, D
D	B, C, E
E	A, D

   edge list:

pair of edges
(A, B)
(A, E)
(A, C)
(B, D)
(E, D)
(C, D)

2 Problem 1-2 Average Degree of a Growing Network

Consider the following properties of the network at time t = T .

1. What is the total number of nodes N?

   In each time step one node is added to the network. That is why $N = T$

2. What is the total number of links L?

   For t=1 no links exist. For every node also a link is added. That is why $L = T - 1$

3. What is the average degree <k>?

   The average degree is defined for an undirected graph as $< k >= \frac{2L}{N}$
   After inserting the values from above: $< k >= \frac{2*(T-1)}{T} = \frac{2T-2}{T} = T - \frac{2}{T}$

4. What is the average degree in the limit T -> infinity?

   When inserting infinity in the formula above, the second term $(\frac{2}{T})$ becomes irrelevant. The remaining term T is going to infinity. Consequently the average degree also goes to infinity.

3 Problem 1-3 Difficulty of an Exhaustive Search

4 Problem 1-4 Introduction to Network Processing with Python