Exercise 2

Introduction to Complex Network Analysis

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Edge list
Advantages:
Uses less memory for storing the graph. It is easy to iterate over all the edges.

Disadvantages:
It is hard to tell if an edge exists from A to B and to compute the degree of a node. It is usually not suitable for isolated nodes.

Adjacency matrix
Advantages:
We can check if two nodes have an edge in constant time. It is easier to compute the degrees of the nodes.

Disadvantages:
Large memory complexity. It has redundant information for undirected graphs.

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If all of the 14 friends are also friends with each other, then this is the case of a complete graph - where between every pair of nodes there is an edge.
The number of edges can be calculated with the following formula: $N(N-1)/2$ where N is the number of nodes.

In this case, the number of nodes is N = 15 (me and my 14 friends), so the total number of edges is: 15*14 / 2 = 105.

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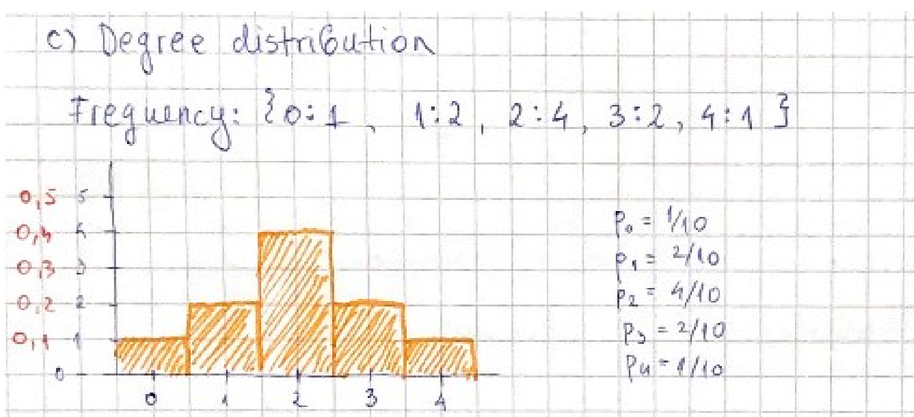
a) Adjacency matrix:

0,1,0,0,0,0,0,0,0,0
1,0,1,1,1,0,0,0,0,0
0,1,0,0,0,1,0,0,0,0
0,1,0,0,0,0,0,0,0,0
0,1,0,0,0,1,1,0,0,0
0,0,1,0,1,0,0,0,0,0
0,0,0,0,1,0,0,1,1,0
0,0,0,0,0,0,1,0,1,0
0,0,0,0,0,0,1,1,0,0
0,0,0,0,0,0,0,0,0,0

b) Edge list:

(1, 2)
(2, 3)
(2, 4)
(2, 5)
(3, 6)
(5, 6)
(5, 7)
(7, 8)
(7, 9)
(8, 9)



e) Number of d=3 paths between 2 and 3: 1

f) The node pair 1 and 6 has 2 d=3 paths (there are also more node pairs that satisfy this).

d)

Clustering coefficient

$C_i = \frac{e_i}{[k_i(k_i-1)/2]}$

$C_1 = \frac{0}{[1(1-1)/2]} = 0$

$C_2 = \frac{0}{[4(4-1)/2]} = 0$

$C_3 = \frac{0}{[2(2-1)/2]} = 0$

$C_4 = \frac{0}{[1(1-1)/2]} = 0$

$C_5 = \frac{0}{[3(3-1)/2]} = 0$

$C_6 = \frac{0}{[2(2-1)/2]} = 0$

$C_7 = \frac{1}{[3(3-1)/2]} = 1/3$

$C_8 = \frac{1}{[2(2-1)/2]} = 1$

$C_9 = \frac{1}{[2(2-1)/2]} = 1$

$C_{10} = \frac{0}{[0(0-1)/2]} = 0$

$\langle C \rangle = \frac{1}{10}\left(\frac{1}{3}+1+1\right) = \frac{1}{10} \cdot \frac{7}{3} = \boxed{0,2333}$

Diameter

$d_{1,2} = 1$, $d_{1,3} = 2$, $d_{1,4} = 2$, $d_{1,5} = 2$, $d_{1,6} = 3$, $d_{1,7} = 3$, $d_{1,8} = 4$, $d_{1,9} = 4$

$d_{2,3} = 1$, $d_{2,4} = 1$, $d_{2,5} = 1$, $d_{2,6} = 2$, $d_{2,7} = 2$, $d_{2,8} = 3$, $d_{2,9} = 3$

$d_{3,4} = 2$, $d_{3,5} = 2$, $d_{3,6} = 1$, $d_{3,7} = 3$, $d_{3,8} = 4$, $d_{3,9} = 4$

$d_{4,5} = 2$, $d_{4,6} = 3$, $d_{4,7} = 3$, $d_{4,8} = 4$, $d_{4,9} = 4$

$d_{5,6} = 1$, $d_{5,7} = 1$, $d_{5,8} = 2$, $d_{5,9} = 2$

$d_{6,7} = 2$, $d_{6,8} = 3$, $d_{6,9} = 3$

$d_{7,8} = 1$, $d_{7,9} = 1$

$d_{8,9} = 1$

$\boxed{\text{diameter} = 4}$

density:

$D = \frac{2L}{N(N-1)} = \frac{2 \cdot 10}{10(10-9)} = \frac{2}{9} = \boxed{0,222}$

The computations by computer are made and presented in Tutorial2.

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A bipartite network with N1 and N2 nodes in the two sets.
a) Maximum number of edges: N1 * N2.
b) The total number of edges in a nonbipartite graph is: $N(N-1)/2$, which is $(N1+N2)(N1+N2-1)/2$. The maximal number of edges in a bipartite graph is: $N1 * N2$, so the differences between these two numbers is: $(N1^2 + N2^2 - N1 - N2)/2$.