BL40A2010 Introduction to IoT-Based Systems

Assignment 3, 01.02.2023

Author: Kush Patel

(1) Compute the following for a ring topology of $N=5$ and $N=6$ nodes considering that the network in unweighted and the links are directed. The result will give these number as a function of N. *Fig. 1 Example when $N=6$.*

Answer:

(a) Degree of nodes: if ring topology is 6 which means there is only one incoming and out going node of each components so, the degree of node for 6 topology is sum of incoming and outgoing degree which means the degree of nodes is 2. This is also same if the topology is 5.
(b) Adjacent matrix: for N = 6 0 1 0 0 0 1 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 0 0 0 1 0 1 1 0 0 0 1 0

for N = 5 0 1 0 0 1 1 0 1 0 0 0 1 0 1 0 0 0 1 0 1 1 0 0 1 0

(c) Diameter: N-1 = 6-1 = 5(All nodes are connected)

(d) Clustering coefficient of the nodes: Each clustering has 2 neighbours and they are connected to each other. So clustering coefficient of of the nodes for a ring is 1 because they are interconnected.

(2) Use NetworkX to draw and analyze a ring topology with 5 nodes. Verify if the results previously obtained are valid.

In [13]:
```
pip install -r requirements.txt
```

```
Requirement already satisfied: matplotlib in /srv/conda/envs/notebook/lib/pytho
n3.7/site-packages (from -r requirements.txt (line 7)) (3.5.3)
Requirement already satisfied: numpy in /srv/conda/envs/notebook/lib/python3.7/
site-packages (from -r requirements.txt (line 8)) (1.21.6)
Requirement already satisfied: pandas in /srv/conda/envs/notebook/lib/python3.
7/site-packages (from -r requirements.txt (line 9)) (1.3.5)
Requirement already satisfied: kiwisolver>=1.0.1 in /srv/conda/envs/notebook/li
b/python3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (1.4.
4)
Requirement already satisfied: cycler>=0.10 in /srv/conda/envs/notebook/lib/pyt
hon3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (0.11.0)
Requirement already satisfied: packaging>=20.0 in /srv/conda/envs/notebook/lib/
python3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (22.0)
Requirement already satisfied: fonttools>=4.22.0 in /srv/conda/envs/notebook/li
b/python3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (4.3
8.0)
Requirement already satisfied: pyparsing>=2.2.1 in /srv/conda/envs/notebook/li
b/python3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (3.0.
9)
Requirement already satisfied: python-dateutil>=2.7 in /srv/conda/envs/noteboo
k/lib/python3.7/site-packages (from matplotlib->-r requirements.txt (line 7))
(2.8.2)
Requirement already satisfied: pillow>=6.2.0 in /srv/conda/envs/notebook/lib/py
thon3.7/site-packages (from matplotlib->-r requirements.txt (line 7)) (9.4.0)
Requirement already satisfied: pytz>=2017.3 in /srv/conda/envs/notebook/lib/pyt
hon3.7/site-packages (from pandas->-r requirements.txt (line 9)) (2022.7)
Requirement already satisfied: typing-extensions in /srv/conda/envs/notebook/li
b/python3.7/site-packages (from kiwisolver>=1.0.1->matplotlib->-r requirements.
txt (line 7)) (4.4.0)
Requirement already satisfied: six>=1.5 in /srv/conda/envs/notebook/lib/python
3.7/site-packages (from python-dateutil>=2.7->matplotlib->-r requirements.txt
(line 7)) (1.16.0)
Note: you may need to restart the kernel to use updated packages.
```

In [14]:
```
! pip install --upgrade networkx
```

```
Requirement already satisfied: networkx in /srv/conda/envs/notebook/lib/python
3.7/site-packages (2.6.3)
```

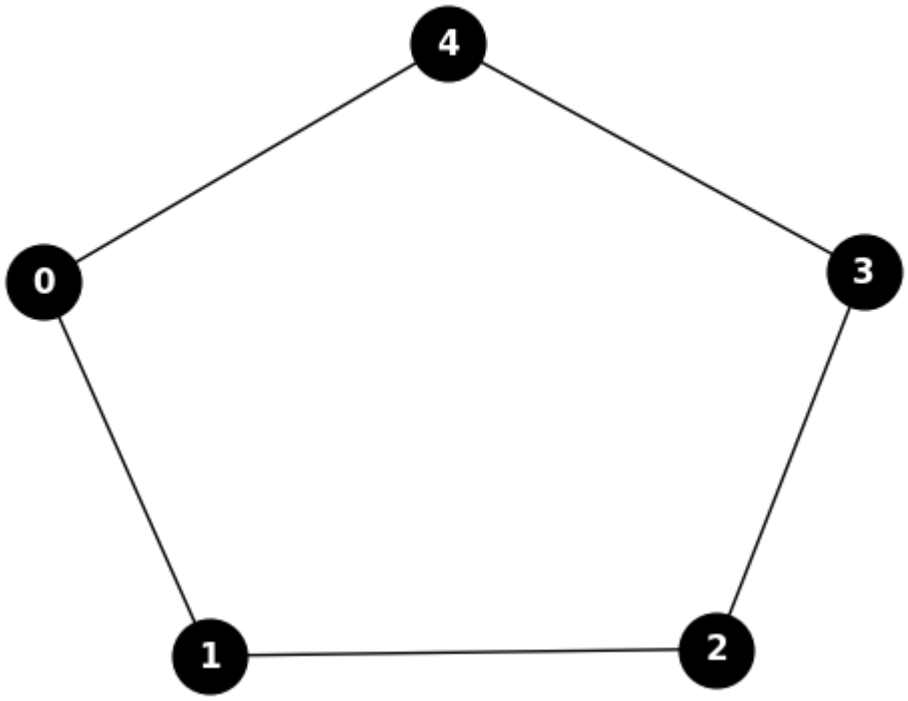
In [18]:
```
pip install scipy
```

```
Collecting scipy
  Downloading scipy-1.7.3-cp37-cp37m-manylinux_2_12_x86_64.manylinux2010_x86_6
4.whl (38.1 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 38.1/38.1 MB 13.4 MB/s eta 0:00:0
000:0100:01
Requirement already satisfied: numpy<1.23.0,>=1.16.5 in /srv/conda/envs/noteboo
k/lib/python3.7/site-packages (from scipy) (1.21.6)
Installing collected packages: scipy
Successfully installed scipy-1.7.3
Note: you may need to restart the kernel to use updated packages.
```

In [19]:
```
import networkx as nx #https://networkx.github.io/
import matplotlib.pyplot as plt #https://matplotlib.org/
import scipy as sp
import numpy as np
```

In [52]:
```
G = nx.Graph()
G.add_nodes_from(range(5))
edges = [(0, 1), (1, 2), (2, 3), (3, 4), (4, 0)]
```

```
G.add_edges_from(edges)
nx.draw_networkx(G, node_color='black', font_color='white', edge_color='black',
plt.axis('off')
plt.show()
G.degree(2)
diameter = nx.diameter(G)
print(diameter)
```




```
2
```

In [39]:
```
matrix = np.array([[0, 1, 0, 0, 1],
                   [1, 0, 1, 0, 0],
                   [0, 1, 0, 1, 0],
                   [0, 0, 1, 0, 1],
                   [1, 0, 0, 1, 0]])
print(matrix)
```

```
[[0 1 0 0 1]
 [1 0 1 0 0]
 [0 1 0 1 0]
 [0 0 1 0 1]
 [1 0 0 1 0]]
```

In [53]:
```
nx.clustering(G)
```

Out[53]:
```
{0: 0, 1: 0, 2: 0, 3: 0, 4: 0}
```

(3) Analyze the ring topology with size 15 ($N=15$) as a communication network (i.e. how data travel to a point to another in the network) based on the node degree, the network diameter and the cluster coefficient.

Answer: in this ring topology, every components connect to 2 components which means the degree is 2. the diameter of that perticular ring topology is 7 which means one component has to travel through 7 nodes in order to reach it's destination. in ring topology there cluster coefficient is 0 because they are no any triangle and degree.

(4) Consider the ring network from the previous question. The network performance depends on its diameter. As a designer, you can add one new node in the network (and an unlimited number of links that this node is part) . Justify your decision and evaluate how much better the network is. Generalize this finding as a function of N.

Hint: Follow Exercise 1 approach to generalize the finding.

Answer: The diameter of a ring network is the number of nodes that separate the two most distant nodes in the network. Adding a new node to the network would increase the number of possible paths between any two nodes and therefore decrease the diameter of the network, making it more efficient.the diameter of the network would be N/2. If we add a new node, the diameter would be reduced to (N+1)/2, which is a decrease of 1. This means that, for every additional node added to the network, the diameter of the network would decrease by 1. This can be generalized as follows: if we have N nodes in a ring network, adding a new node would result in a decrease of 1 in the diameter, so the new diameter would be (N+1)/2.