Lab4, 70

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Variant: *70*
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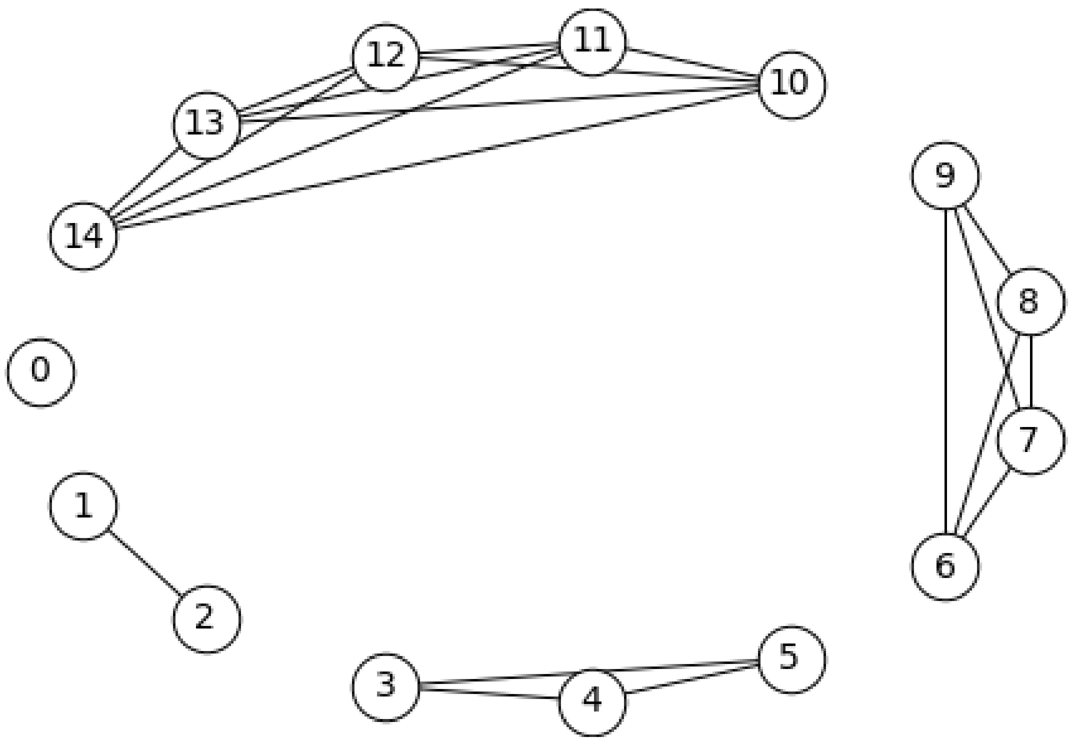
[1]:
```
import numpy as np
import networkx as nx
import matplotlib.pyplot as plt

from queue import Queue
```

[2]:
```
FILE_PATH = "./graph.txt"

N = 15
V = 20
K = 5

SIZES = {'node_size': 2000, 'font_size': 25, 'width': 3}
BASE_COLORS = {'font_color': 'black', 'node_color': 'white',  'with_labels':␣
 ↪True}
BLACK = {'edgecolors': 'black', 'edge_color': 'black'} | BASE_COLORS
```

[3]:
```
g = nx.read_adjlist(FILE_PATH, nodetype=int, create_using=nx.Graph)
```

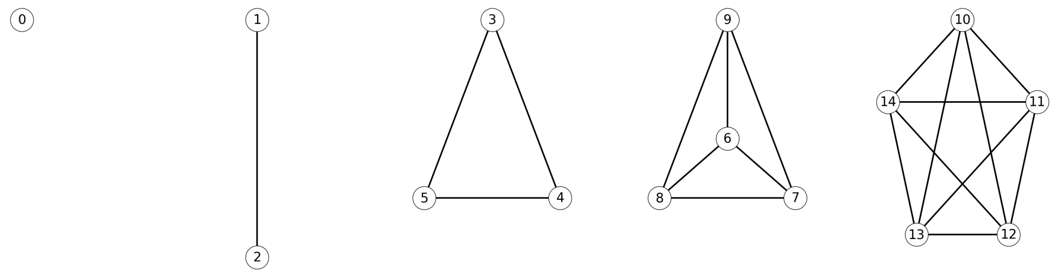
[4]:
```
nx.draw_shell(g, **BLACK, node_size=700, font_size=14)
```



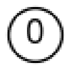
```
[5]: def complete_pos(n, start_index=0, radius=1, x_shift=0, y_shift=0):
         """
         Build circle positions for graph

         Parameters
         n : int
             Number of nodes

         start_index : int
             Number of first numerical label

         radius : float
             Circle radius

         x_shift : float
             Shift the figure along the x coordinate

         y_shift : float
             Shift the figure along the y coordinate

         Returns
         dict
```

```
        Dictionary with labels as keys and pairs of x and y coordinates as␣
↪values
    """
    positions = {}
    first_in_circle = 0

    if n == 4:
        positions[start_index] = np.array((x_shift, y_shift)) * radius
        first_in_circle += 1


    fi = 2 * np.pi / (n - first_in_circle)
    start_rad = np.pi*0.5

    return positions | {
        start_index+i : np.array((
            np.cos(-i*fi + start_rad) + x_shift,
            np.sin(-i*fi + start_rad) + y_shift
        )) * radius
        for i in range(first_in_circle, n)
    }

def completed_components_pos(k, compontnts_distance, radius=1):
    """
    Create circle nodes positions for graph

    Parameters
    k : int
        Number of components

    compontnts_distance : float
        Distance between two neighboring components

    radius : float
        Radius of circles

    Returns
    dict
        Dictionary with labels as keys and pairs of x and y coordinates as␣
↪values
    """
    res_pos = dict()
    for i in range(k):
        v_in_comp = i+1
        x_shift = (radius*2+compontnts_distance)*i

        res_pos |= complete_pos(i+1, start_index=v_in_comp*(v_in_comp-1) // 2,
                                    radius=radius, x_shift=x_shift)
    return res_pos
```

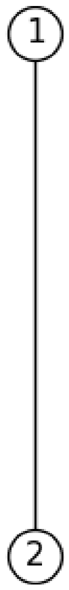
[6]:
```
plt.figure(figsize=(30, 7), dpi=100)
nx.draw(g, pos=completed_components_pos(K, 1), **(BLACK|SIZES))
```



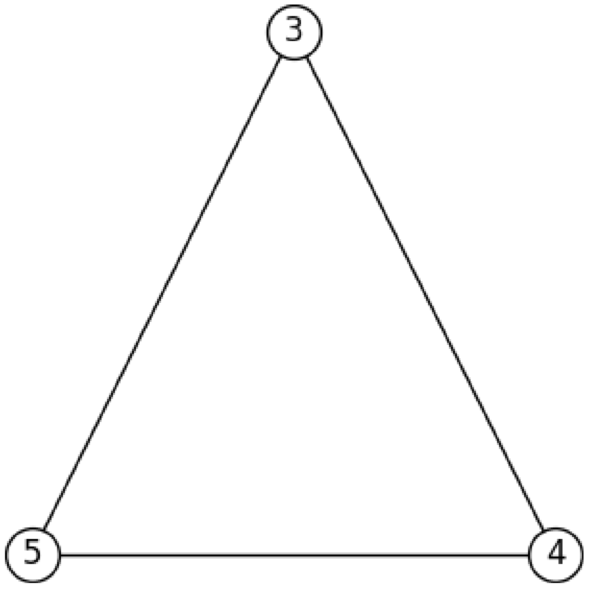
[7]:
```
for component_nodes in nx.connected_components(g):
    subgraph = g.subgraph(component_nodes)
    eccentricities = nx.eccentricity(subgraph)
    n_nodes = subgraph.number_of_nodes()
    start_index = n_nodes * (n_nodes-1) // 2

    plt.figure(figsize=(3, 3), dpi=100)
    nx.draw(subgraph, pos=complete_pos(n_nodes, start_index=start_index),␣
 ↪**BLACK, node_size=400, font_size=12)
    plt.show()

    print("Count of nodes:", subgraph.number_of_nodes())
    print("Count of edges:", subgraph.number_of_edges())
    print("Node", "Degree", "Eccentricity", sep="\t")

    for node in component_nodes:
        print(node, end="\t")
        print(g.degree(node), end="\t")
        print(eccentricities[node])

    print()
    print()
```



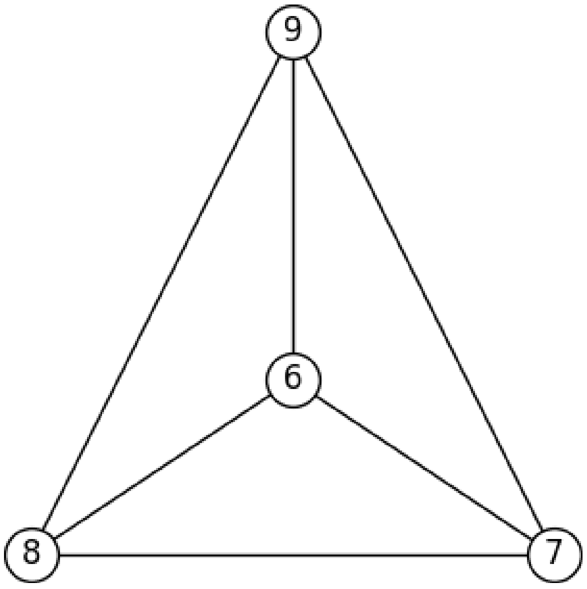
```
Count of nodes: 1
Count of edges: 0
Node    Degree  Eccentricity
0       0       0
```



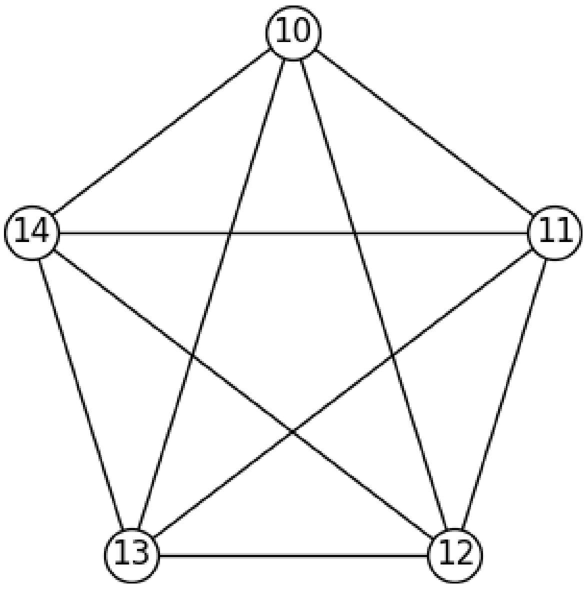
```
Count of nodes: 2
Count of edges: 1
Node    Degree  Eccentricity
1       1       1
2       1       1
```



```
Count of nodes: 3
Count of edges: 3
Node    Degree  Eccentricity
3       2       1
4       2       1
5       2       1
```



```
Count of nodes: 4
Count of edges: 6
Node    Degree  Eccentricity
8       3       1
9       3       1
6       3       1
7       3       1
```

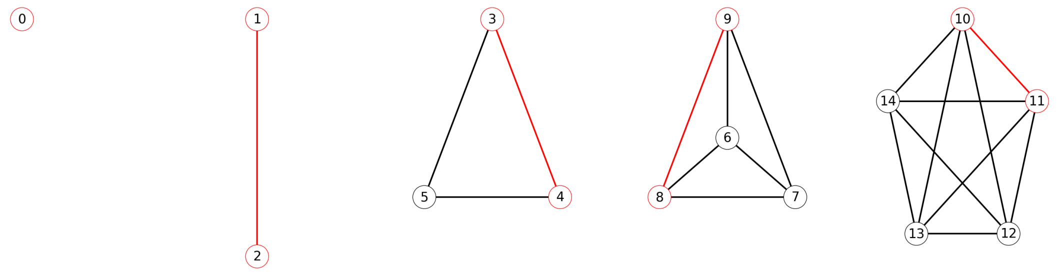


```
Count of nodes: 5
Count of edges: 10
Node    Degree  Eccentricity
10      4       1
11      4       1
12      4       1
13      4       1
14      4       1
```

[8]:
```python
def _get_key_by_best_result(dictionary, estimator=lambda x: x):
    keys = list(dictionary.keys())

    best_key = keys[0]
    best_res = estimator(dictionary[best_key])

    for i in range(1, len(keys)):
        key = keys[i]

        if estimator(dictionary[key]) > best_res:
            best_key = key
            best_res = estimator(dictionary)
    return best_key

def bfs(graph, start_node):
    """
    Find paths from selected vertex to all other

    Parameters
    graph : networkx.Graph
        Connected graph in which the search will be performed.

    start_node : int
        Label of starting node

    Returns
    dict
        Dictionary with vertex labels as keys and chain of vertexes as path␣
 ↪from start node to other
    """

    nodes = dict.fromkeys(graph.nodes, None)
    nodes[start_node] = [start_node]
    queue = Queue()
    visited = []

    queue.put(start_node)
    visited.append(start_node)

    while not queue.empty():
        curr_node = queue.get()
        for neighbor_node in graph.neighbors(curr_node):
            if neighbor_node not in visited:
                nodes[neighbor_node] = nodes[curr_node] + [neighbor_node]
                visited.append(neighbor_node)
                queue.put(neighbor_node)
    return nodes


def diameter(graph):
    """
    Find the diameter of connected graph

    Parameters
    graph : networkx.Graph
        Connected graph in which the search will be performed.

    Returns:
    list
        Chain of connected nodes.
    """
    eccentricities = nx.eccentricity(graph)
    start_node = _get_key_by_best_result(eccentricities, lambda x: x)
    paths = bfs(graph, start_node)
    path_key = _get_key_by_best_result(paths, lambda x: len(x))
    return paths[path_key]

def nodes_to_chain_edges(nodes):
    """
    Convert list of connected nodes to list of edges

    Parameters
    nodes : list
        List of connected nodes

    Returns
    list
        List of edges
    """
    edges = []
    for i in range(len(nodes)-1):
        edges.append((nodes[i], nodes[i+1]))
    return edges
```

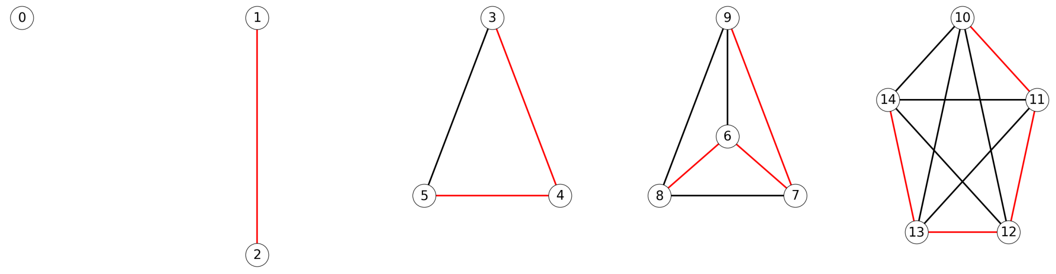
[9]:
```
diameter_nodes = []
diameter_edges = []

for component_nodes in nx.connected_components(g):
    subgraph = g.subgraph(component_nodes)
    current_diamter_nodes = diameter(subgraph)
    diameter_nodes += current_diamter_nodes
    diameter_edges += nodes_to_chain_edges(current_diamter_nodes)

diam_border_colors = ["red" if node in diameter_nodes else "black" for node in␣
 ↪g.nodes]
diam_edge_colors = ["red" if (u, v) in diameter_edges or (v, u) in␣
 ↪diameter_edges else "black"
                    for u, v in g.edges]
```

[10]:
```
plt.figure(figsize=(30, 7), dpi=100)
nx.draw(g, pos=completed_components_pos(K, 1), **(BASE_COLORS|SIZES),
        edgecolors=diam_border_colors, edge_color=diam_edge_colors)
```



[11]:
```
tree_edges = set()

for component_nodes in nx.connected_components(g):
    subgraph = g.subgraph(component_nodes)
    start_node = list(subgraph.nodes)[0]
    current_tree = nx.dfs_tree(subgraph, source=start_node)
    current_tree_edges = current_tree.edges()
    tree_edges.update(current_tree_edges)

tree_edge_colors = ["red" if (u, v) in tree_edges or (v, u) in tree_edges else␣
 ↪"black"
                    for u, v in g.edges]
```

[12]:
```
plt.figure(figsize=(30, 7), dpi=100)
nx.draw(g, pos=completed_components_pos(K, 1), **(BASE_COLORS|SIZES),
        edgecolors="black", edge_color=tree_edge_colors)
```


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14