Homework Assignment 4

The Art of Analyzing Big Data - The Data Scientist’s Toolbox

Reddit Networks

Using the Movie Dynamics Networks dataset (https://www.kaggle.com/datasets/michaelfire/movie-dynamics-over-15000-movie-social-networks) select the subreddit of your favorite movie show. Using the data of the selected movie, answer the following questions:

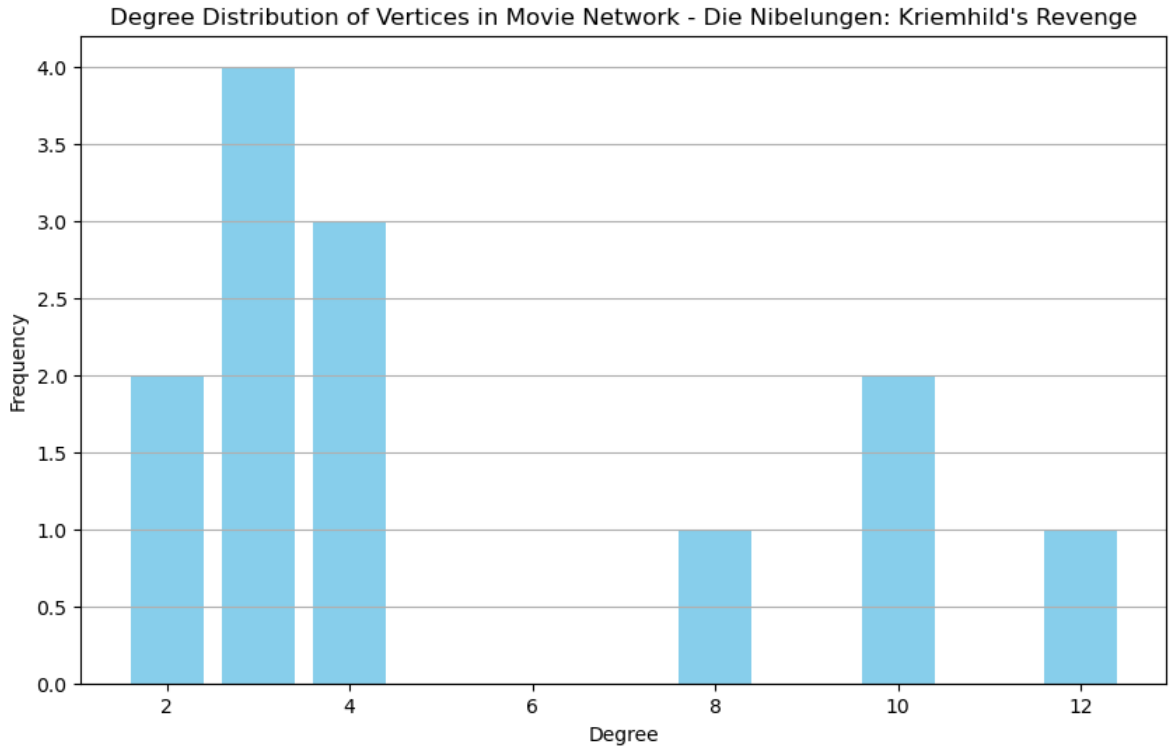
Task 1: Calculate and visualize the degree distribution of the vertices in the network (15pt)

In [1]:

```python
# Import necessary libraries
import json
import os
import networkx as nx
import numpy as np
import matplotlib.pyplot as plt

# Set the path to the dataset folder
dataset_folder = "moviedynamics"

# Function to read and parse a movie file
def read_movie_file(file_path):
    with open(file_path, "r") as file:
        data = json.load(file)
    return data

# Function to create a graph from movie data
def create_movie_graph(movie_data):
    G = nx.Graph()

    # Add nodes with roles as attributes
    for node_info in movie_data['nodes']:
        G.add_node(node_info['id'], role=node_info['role'])

    # Add edges with weights
    for link_info in movie_data['links']:
        G.add_edge(link_info['source'], link_info['target'], weight=link_info['weight'])

    return G

# Function to calculate and visualize degree distribution
def calculate_and_visualize_degree_distribution(movie_data, filename):
    # Create a graph for the movie
    movie_graph = create_movie_graph(movie_data)

    # Calculate degree distribution
    degrees = dict(movie_graph.degree())
    degree_values = list(degrees.values())

    unique_degrees = np.unique(degree_values)
    degree_distribution = [list(degree_values).count(degree) for degree in unique_degrees]

    # Get movie name
    movie_name = movie_data['graph']['movie_name']

    # Print filename
    print(f"\nMovie: {movie_name} ({filename})")

    # Visualize degree distribution
    plt.figure(figsize=(10, 6))
    plt.bar(unique_degrees, degree_distribution, color='skyblue')
    plt.title(f'Degree Distribution of Vertices in Movie Network - {movie_name}')
    plt.xlabel('Degree')
    plt.ylabel('Frequency')
    plt.grid(axis='y')
    plt.show()

# Specify the movie file name
target_movie_filename = "1924_Die_Nibelungen_Kriemhild_s_Revenge.json"

# Load the target movie from the dataset
target_movie_path = os.path.join(dataset_folder, target_movie_filename)
target_movie_data = read_movie_file(target_movie_path)

# Calculate and visualize degree distribution for the target movie
```

```
calculate_and_visualize_degree_distribution(target_movie_data, target_movie_filename)
```

```
Movie: Die Nibelungen: Kriemhild's Revenge (1924_Die_Nibelungen_Kriemhild_s_Revenge.json)
```

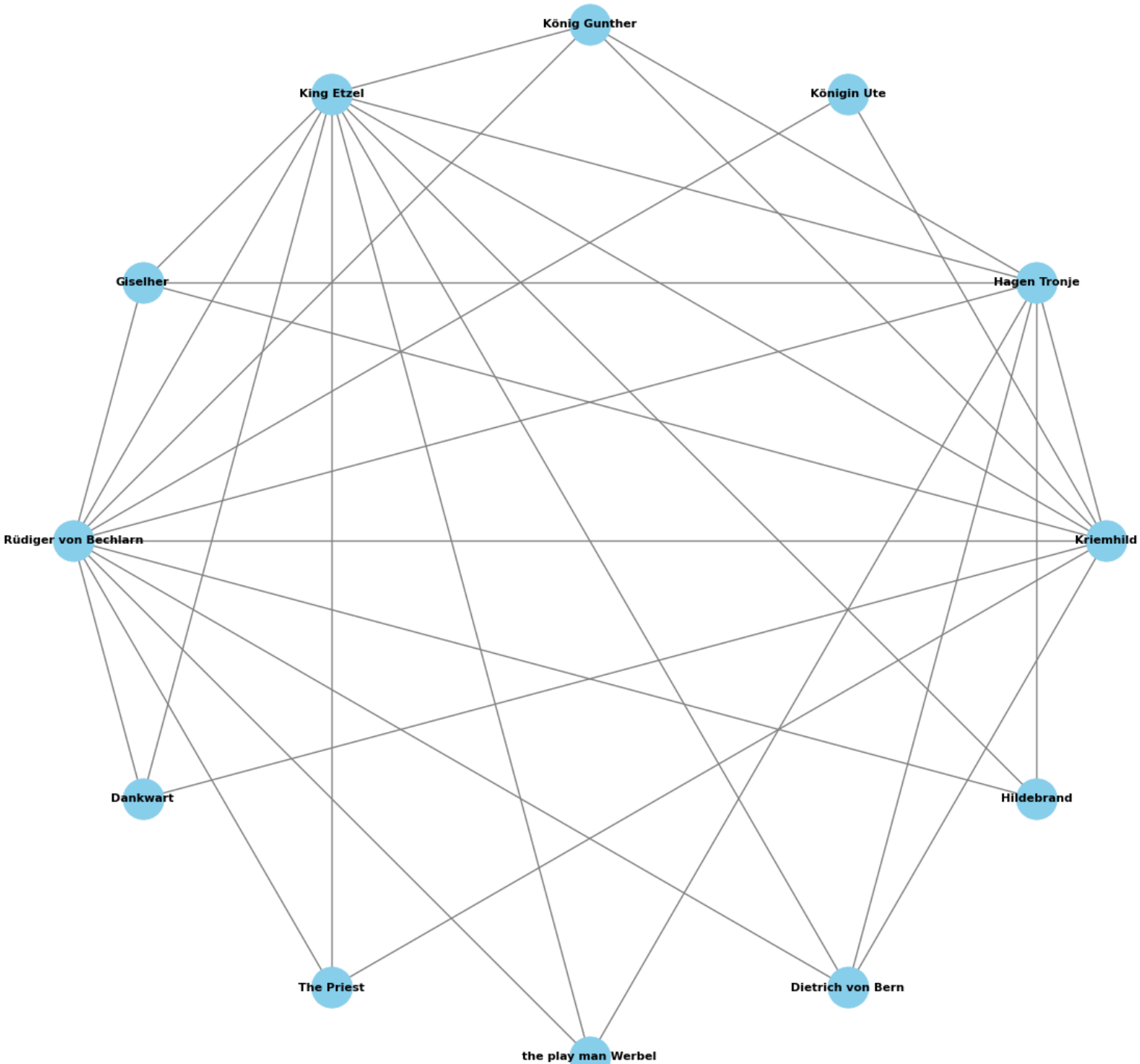


Task 2: Create a subgraph of the top-12 movie characters according to a selected centrality algorithm. Draw the subgraph using circlular layout (15pt)

In [2]:

```
import operator

# Create a graph for the target movie
movie_graph = create_movie_graph(target_movie_data)

# Calculate Closeness Centrality for each node
closeness_centrality = nx.closeness_centrality(movie_graph)

# Identify the most central hero based on Closeness Centrality
most_central_hero = max(closeness_centrality.items(), key=operator.itemgetter(1))[0]

# Print the most central hero
print(f"The most central hero according to Closeness Centrality is: {most_central_hero}")

# Identify the top-12 characters based on Closeness Centrality
top_characters = sorted(closeness_centrality, key=closeness_centrality.get, reverse=True)[:12]

# Create a subgraph with the top-12 characters
subgraph = movie_graph.subgraph(top_characters)

# Visualize the subgraph using circular layout
plt.figure(figsize=(12, 12))
pos = nx.circular_layout(subgraph)
nx.draw(subgraph, pos, with_labels=True, font_size=8, font_color='black', node_size=800, node_color='skyblue', font_weight='bold', edge_color='gray', linewidths=0.5)
plt.title('Subgraph of Top-12 Characters Using Circular Layout (Closeness Centrality)')
plt.show()
```

```
The most central hero according to Closeness Centrality is: Rüdiger von Bechlarn
```


Subgraph of Top-12 Characters Using Circular Layout (Closeness Centrality)
König Gunther
King Etzel
Königin Ute
Giselher
Hagen Tronje
Rüdiger von Bechlarn
Kriemhild
Dankwart
Hildebrand
The Priest
Dietrich von Bern
the play man Werbel

Task 3: Calculate the PageRank, triangles, and average shortest path of each vertex in the graph (15pt)

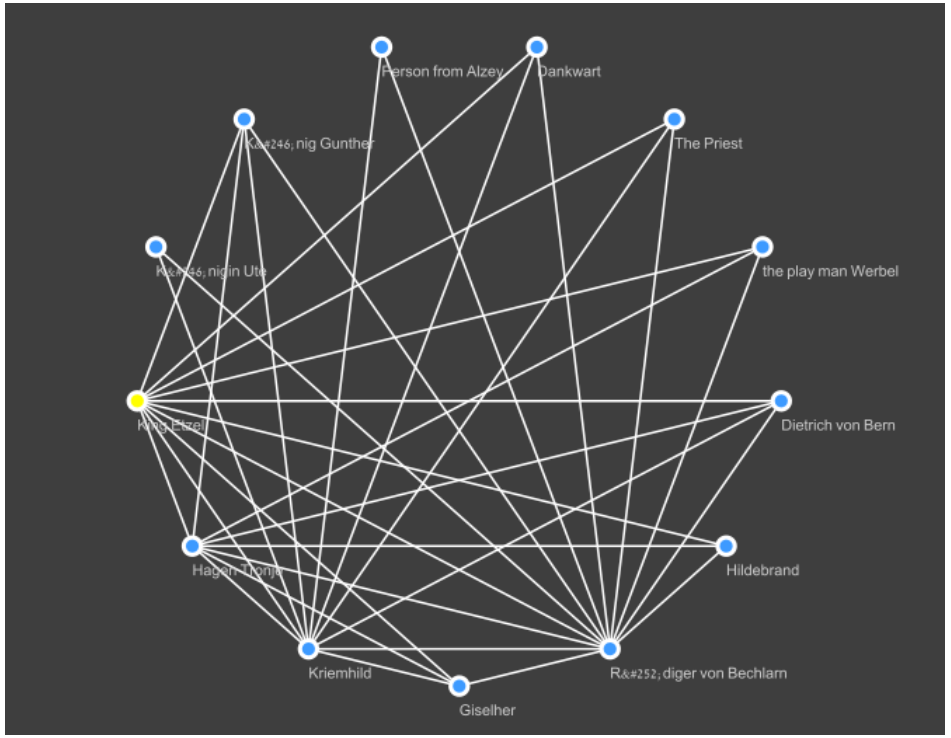
In [3]:
```python
# Calculate PageRank for each node
pagerank = nx.pagerank(movie_graph)

# Identify the most central hero based on PageRank
most_central_hero_pagerank = max(pagerank.items(), key=operator.itemgetter(1))[0]

# Print the most central hero according to PageRank
print(f"The most central hero according to PageRank is: {most_central_hero_pagerank}")

# Calculate triangles count for each node
triangles = nx.triangles(movie_graph)

# Print triangles count for each node
print("\nTriangles count for each character:")
for node, triangle_count in triangles.items():
    print(f"{node}: {triangle_count}")

# Calculate average shortest path for each node
average_shortest_path = nx.shortest_path_length(movie_graph)

# Print average shortest path for each node
print("\nAverage Shortest Path for each character:")
for node, shortest_path_dict in average_shortest_path:
    avg_shortest_path = sum(shortest_path_dict.values()) / len(shortest_path_dict)
    print(f"{node}: {avg_shortest_path}")
```

```
The most central hero according to PageRank is: Rüdiger von Bechlarn

Triangles count for each character:
Kriemhild: 18
Hagen Tronje: 16
Königin Ute: 1
König Gunther: 6
King Etzel: 20
Giselher: 6
Rüdiger von Bechlarn: 22
Person from Alzey: 1
Dankwart: 3
The Priest: 3
the play man Werbel: 3
Dietrich von Bern: 6
Hildebrand: 3

Average Shortest Path for each character:
Kriemhild: 1.0769230769230769
Hagen Tronje: 1.2307692307692308
Königin Ute: 1.6923076923076923
König Gunther: 1.5384615384615385
King Etzel: 1.0769230769230769
Giselher: 1.5384615384615385
Rüdiger von Bechlarn: 0.9230769230769231
Person from Alzey: 1.6923076923076923
Dankwart: 1.6153846153846154
The Priest: 1.6153846153846154
the play man Werbel: 1.6153846153846154
Dietrich von Bern: 1.5384615384615385
Hildebrand: 1.6153846153846154
```

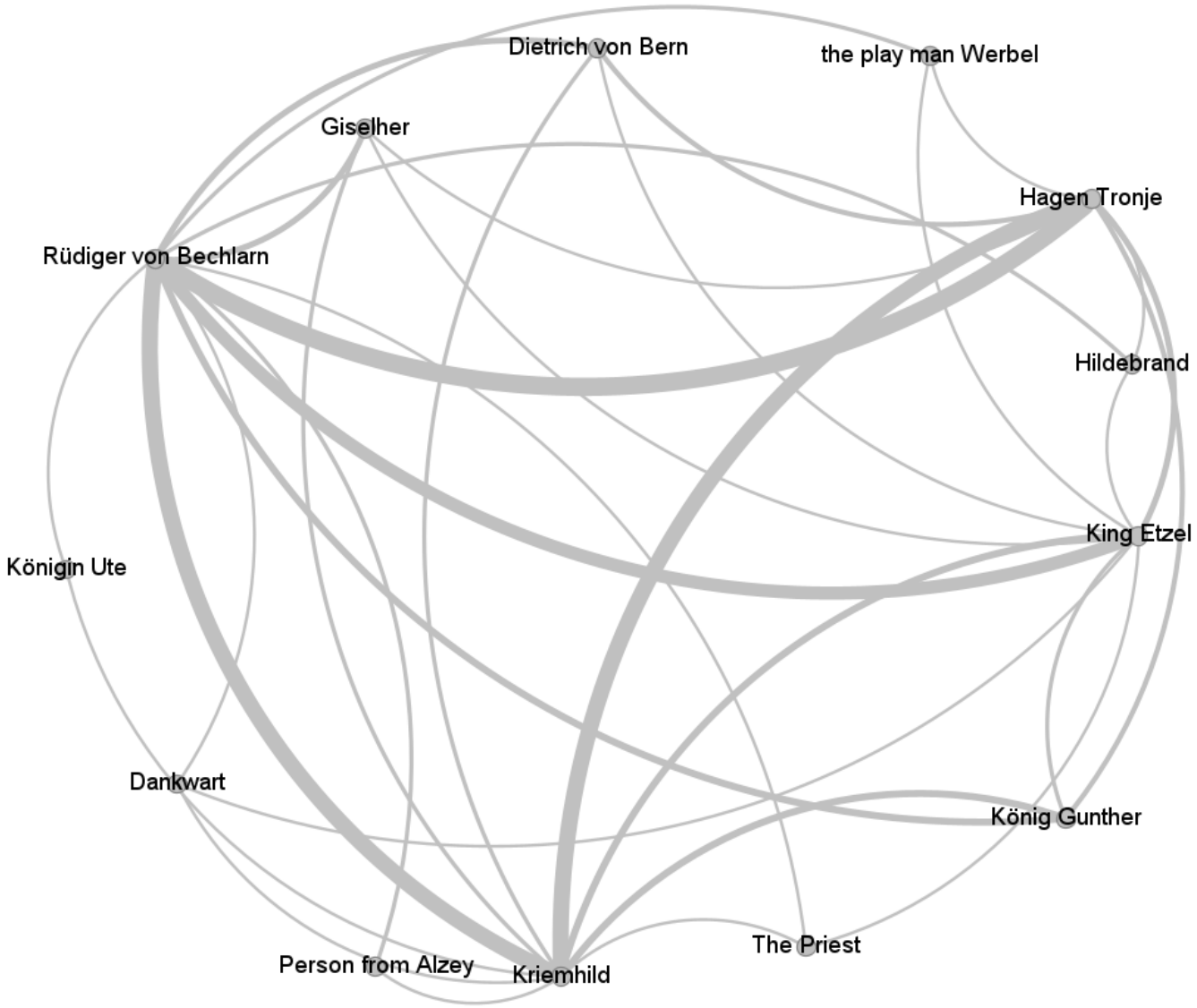
Task 4: Use Cytoscape and Gephi to visualize the network, where each vertex size is correlates to its degree (15pt)

In [4]:
```
nx.write_gexf(movie_graph, "lotr_network_full.gexf")
nx.write_gml(movie_graph, "lotr_network_full.gml")
```

Cytoscape Layout

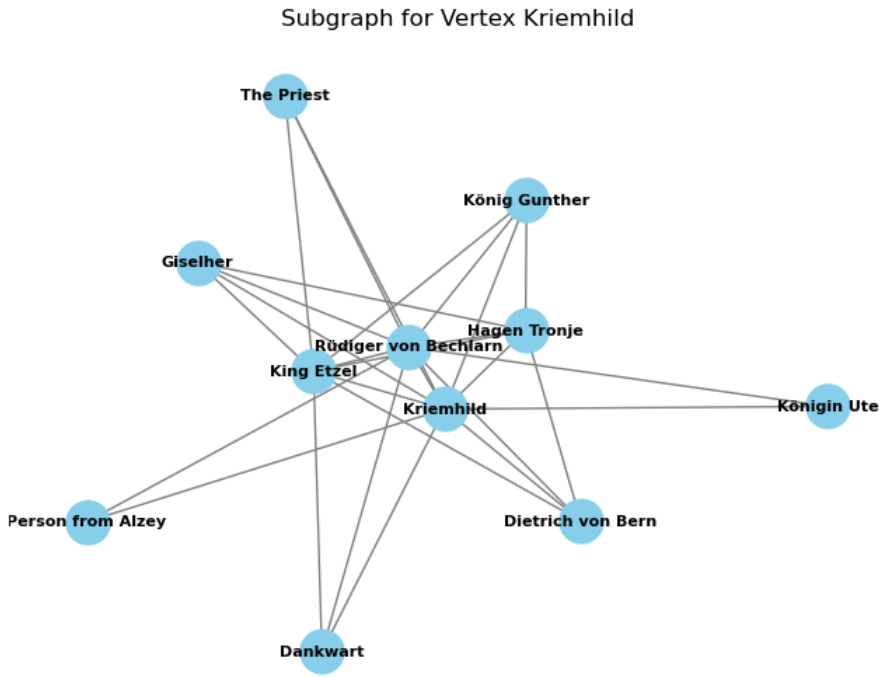


Gephi Layout



Task 5: Write a function that for a given vertex creates a subgraph of the selected vertex and all the vertex's in/out friends (10pt). Draw the subgraph (5pt). Calculate the number of verticies and edges in the subgraph (5pt)

In [5]:
```python
def create_and_visualize_subgraph(graph, selected_vertex):
    # Create subgraph with selected vertex and its in/out neighbors
    subgraph_nodes = set([selected_vertex] + list(graph.neighbors(selected_vertex)))
    subgraph = graph.subgraph(subgraph_nodes)

    # Draw the subgraph
    pos = nx.spring_layout(subgraph)  # You can choose a different layout if needed
    nx.draw(subgraph, pos, with_labels=True, node_size=500, node_color='skyblue', font_size=8, font_color='black', font_weight='bold', edge_color='gray')
    plt.title(f"Subgraph for Vertex {selected_vertex}")
    plt.show()

    # Calculate the number of vertices and edges in the subgraph
    num_vertices = len(subgraph.nodes)
    num_edges = len(subgraph.edges)

    return num_vertices, num_edges

# Choose a valid node from the graph (e.g., use the first node)
selected_vertex = list(movie_graph.nodes)[0]

# Call the function to create and visualize the subgraph
num_vertices, num_edges = create_and_visualize_subgraph(movie_graph, selected_vertex)

# Print the number of vertices and edges in the subgraph
print(f"Number of vertices: {num_vertices}")
print(f"Number of edges: {num_edges}")
```




```
Number of vertices: 11
Number of edges: 28
```

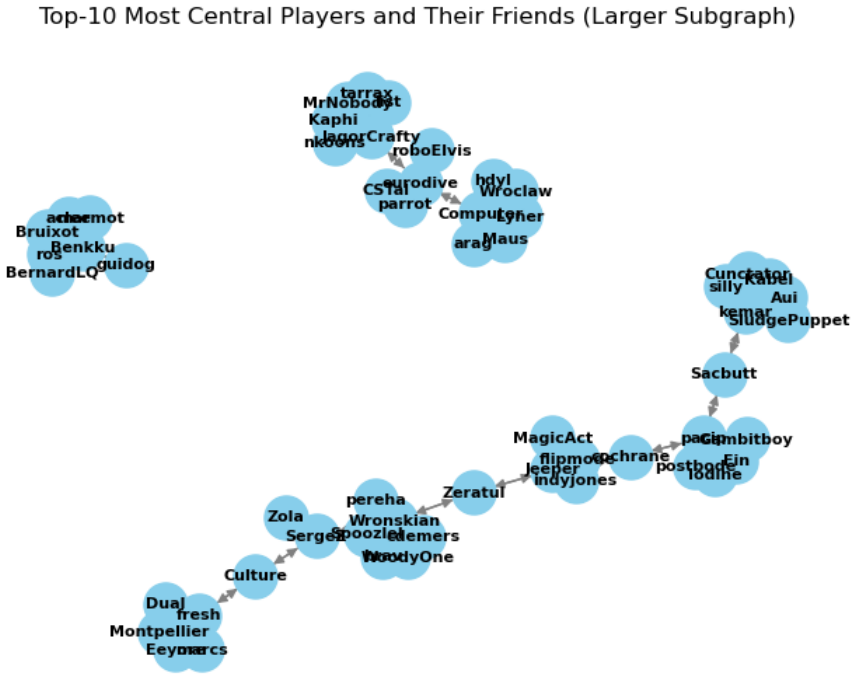
Task 6: Find the top-10 most centeral players at The Free Internet Chess Sever (http://dynamics.cs.washington.edu/nobackup/chess/fcis.tar.gz) (15 pt). Visualize part of the network (5pt).

Note: The network has 429,747,476 edges (Tip: use SGraph)

In [6]:

```python
import networkx as nx
import matplotlib.pyplot as plt
import pandas as pd

# Example: Read graph from CSV files
def read_graph_data(vertices_file, interactions_file):
    # Read vertices and interactions data from CSV files
    vertices_df = pd.read_csv(vertices_file, nrows=3000)
    interactions_df = pd.read_csv(interactions_file, nrows=3000)

    # Create a directed graph from the interactions DataFrame
    G = nx.DiGraph()

    # Add nodes from vertices
    G.add_nodes_from(vertices_df['v_id'])

    # Add edges from interactions
    for _, row in interactions_df.iterrows():
        datetime = row['datetime']
        source = row['src_id']
        target = row['dst_id']

        G.add_edge(source, target, datetime=datetime)

    return G

# Replace 'fcis_chess.vertices.csv' and 'fcis_chess.interactions.csv' with your actual file paths
fics_graph = read_graph_data('fcis_chess.vertices.csv', 'fcis_chess.interactions.csv')

# Calculate centrality measures
degree_centrality = nx.degree_centrality(fics_graph)
closeness_centrality = nx.closeness_centrality(fics_graph)
betweenness_centrality = nx.betweenness_centrality(fics_graph)

combined_centrality = {player: degree_centrality[player] + closeness_centrality[player] + betweenness_centrality[player]
                       for player in fics_graph.nodes()}

# Find the top-10 most central players
top_10_players = sorted(combined_centrality, key=combined_centrality.get, reverse=True)[:10]

# Print the top-10 most central players
print("Top-10 Most Central Players:")
for player in top_10_players:
    print(player)

# Add friends of the top-10 players
friends_of_top_10 = set(top_10_players)
for player in top_10_players:
    friends_of_top_10.update(fics_graph.neighbors(player))

# Visualize a larger part of the network (top-10 players and their friends)
larger_subgraph = fics_graph.subgraph(friends_of_top_10)
pos = nx.spring_layout(larger_subgraph)
nx.draw(larger_subgraph, pos, with_labels=True, node_size=500, node_color='skyblue', font_size=8, font_color='black', font_weight='bold', edge_color='gray')
plt.title("Top-10 Most Central Players and Their Friends (Larger Subgraph)")
plt.show()
```

```
Top-10 Most Central Players:
Wronskian
fresh
pacip
Jeeper
Computer
Benkku
JagorCrafty
kemar
eurodive
SergeZ
```



Task 7: Use Cytoscape to draw the Lord of the Rings Couples network (see Lecture 2). Fill the network's vertices in a different color according to the gender. Select each vertex shape to be according to the vertex race. (7pt)

In [7]:

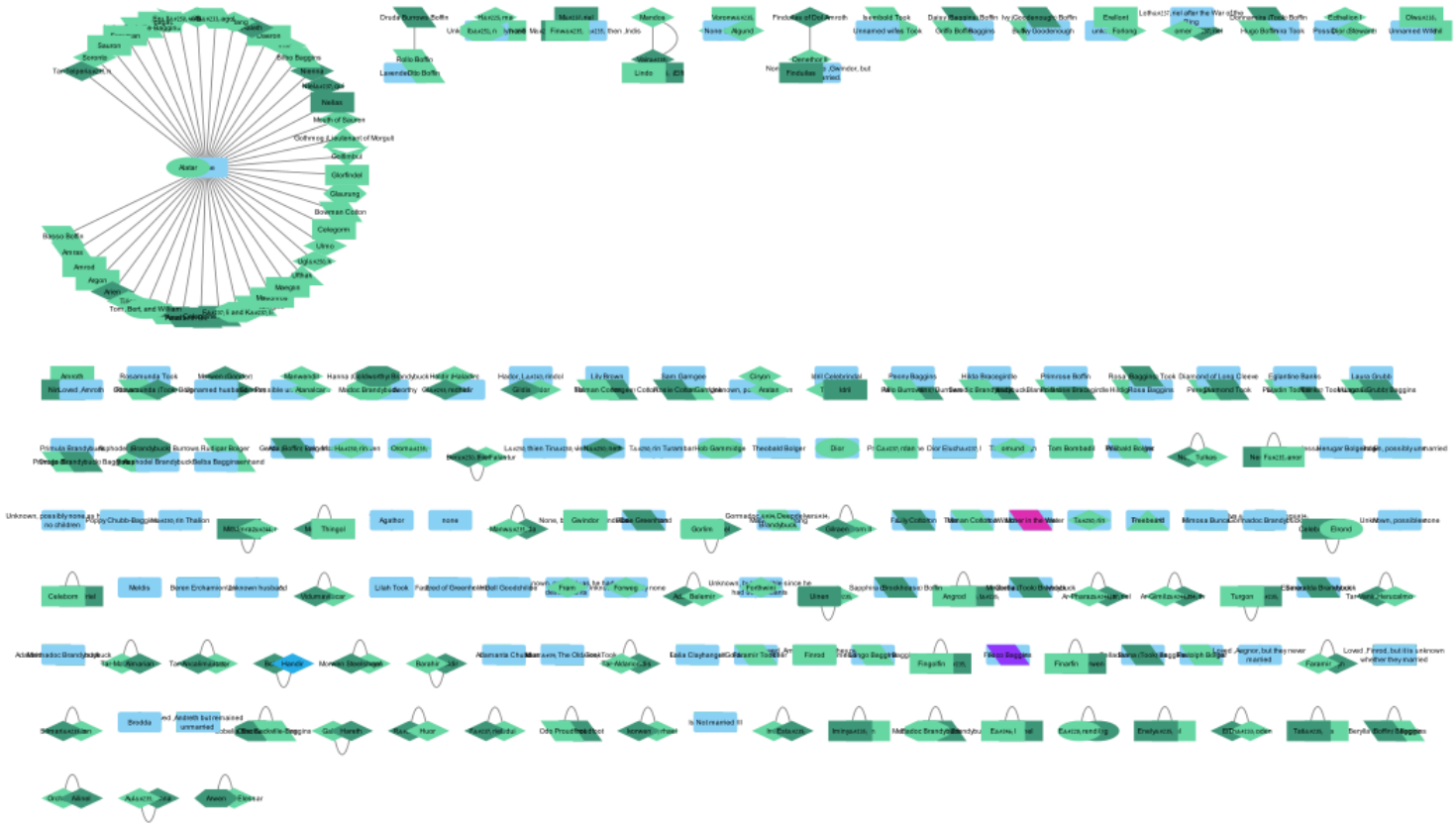
```python
import networkx as nx
import pandas as pd

# Assuming your CSV file is named 'lotr_characters.csv'
csv_file = 'lotr_characters.csv'

# Read the CSV file into a DataFrame
df = pd.read_csv(csv_file)
df = df[['name', 'gender', 'race', 'realm', 'spouse']]
df = df.fillna('')
df = df[df['spouse'] != 'Unnamed wife']
df = df[df['spouse'] != '']

# Create a directed graph using NetworkX
G = nx.DiGraph()

# Add nodes with attributes
for _, row in df.iterrows():
    # Ensure 'gender' is a string (convert NaN to an empty string)
    gender = str(row['gender']) if pd.notna(row['gender']) else ''
    G.add_node(row['name'], gender=gender, race=row['race'])

# Add edges (assuming there's a 'spouse' column representing relationships)
for _, row in df.iterrows():
    if pd.notna(row['spouse']):
        G.add_edge(row['name'], row['spouse'])

# Export the graph to a GML file
gml_file = 'lotr_characters_network.gml'
nx.write_gml(G, gml_file)
```

In [8]:

```python
set(df['gender'])
```

Out[8]:

```
{'', 'Female', 'Male', 'Most likely male', 'male'}
```



Additional Questions for Practice

Task 1: Visualize the distribution of the network's strongly and weakly connected components.

In [ ]:

Task 2: Using Cytoscape, visualize the network's maximal strongly connected component (or part of it)

In [ ]:

Task 3: Draw a subgraph of all the vertices that have at least one reciprocal link, i.e., all the vertices where there is at least one vertex *u* so that both links (u,v) and (v,u) exists

In [ ]:

Task 4: Split the network into communities, and find the second most central vertex in each community

In [ ]:

Task 5: Find the top-10 most central players at [The Free Internet Chess Server (http://dynamics.cs.washington.edu/nobackup/chess/fcis.tar.gz)](http://dynamics.cs.washington.edu/nobackup/chess/fcis.tar.gz). Visualize part of the network.

Note: The network has 429,747,476 edges

In [ ]: