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Course Name: ECGR-3180-091-Data Struct and Algorithms C++

Semester: Fall 2024

Instructor Name: Dr. Arun Ravindran

Report 1: Adjacency List

1. **Problem description**

   The goal is to create a graph structure where each actor is represented as a vertex, and an edge connects two actors if they have co-acted in a movie. This adjacency list will serve as the foundation for subsequent milestones.

2. **Solution description**

   The solution involves iterating through a dataset containing movie titles and their associated cast lists. For each movie, the list of actors is extracted. All pairs of actors within the same movie are considered co-actors, and an edge is created between them.

   The approach was to parse the dataset to retrieve cast data for each movie. Then I used a hashmap where keys are actor names, and values are sets of their co-actors. For each movie, add edges between every pair of actors using nested loops.

   Key Data Structures:

   A hashmap (unordered_map) for the adjacency list.

   A set (unordered_set) to store connections, ensuring no duplicate edges.

   Time Complexity:

   $O(m \cdot k^2)$, where m is the number of movies and k is the average cast size per movie.

   Space Complexity:

   O(n + e), where n is the number of actors and e is the number of edges.

3. **Initial non-AI attempt to code the solution**

The initial approach involved parsing the dataset to extract actor names and creating a nested loop for all pairs of actors in a movie. This implementation was straightforward but required debugging for cases with missing or malformed data.

4. **AI prompts used**

Throughout the making of this code my group used online resources and peers for help to understand and solve the problem. No AI was used for the creation of the adjacency list, however we did various websites to learn about an adjacency list and how to apply it to the code.

5. **Code testing description**

Test with a small dataset where the cast list is well-defined, such as a dataset containing two movies with known casts. Verify that all co-acting pairs are correctly added.

Example input:

Movie 1: ["Actor A", "Actor B"]

Movie 2: ["Actor B", "Actor C"]

Expected output adjacency list:

Actor A: Actor B

Actor B: Actor A, Actor C

Actor C: Actor B.

Edge Cases:

No cast data: Ensure the program can handle movies with an empty or missing cast list without errors.

Duplicate entries: If an actor appears multiple times in the same movie, ensure no duplicate edges are added.

Malformed data: Handle cases where the dataset has improperly formatted JSON or missing fields.

6. **Code including tests**

```cpp
    ofstream output_file("adjacency_list.txt");
    if (!output_file.is_open()) {
        cerr << "Failed to open output file." << endl;
        return 1;
    }

    for (const auto& pair : adj_list) {
        output_file << pair.first << ": ";
        for (const auto& neighbor : pair.second) {
            output_file << neighbor << " ";
        }
        output_file << endl;
    }

    output_file.close();

    return 0;
}
```

```
Chris Colfer: Titus Makin Jr. Curt Mega Riker Lynch Dianna Agron Naya Rivera Ashley Fink Lea Michele Jenna Ushkowitz Harry Shum Jr. Gwyneth Paltrow Darren Criss Mark Salling Cory Monteith
Kevin McHale: Titus Makin Jr. Curt Mega Riker Lynch Dianna Agron Naya Rivera Ashley Fink Lea Michele Jenna Ushkowitz Harry Shum Jr. Gwyneth Paltrow Darren Criss Chris Colfer Mark Salling C
Riker Lynch: Titus Makin Jr. Curt Mega Dianna Agron Naya Rivera Ashley Fink Lea Michele Jenna Ushkowitz Harry Shum Jr. Gwyneth Paltrow Darren Criss Chris Colfer Amber Riley Jane Lynch Mar
Emily Alyn Lind: Lotta Losten Alexander DiPersia Gabriel Bateman Lauren Pennington Abigail Spencer Chad Michael Murray Gattlin Griffith Michael Rooker Julie McNiven Christina Linhardt Mar
M.L. Piyapas Bhirombhakdi: Sinjai Plengpanit Mai Charoenpura Chatchai Plengpanich Johnny Anfone Sarunyu Wongkrachang
Chatchai Plengpanich: Sinjai Plengpanit Mai Charoenpura Johnny Anfone Sarunyu Wongkrachang M.L. Piyapas Bhirombhakdi
Mai Charoenpura: Sinjai Plengpanit Chatchai Plengpanich Johnny Anfone Sarunyu Wongkrachang M.L. Piyapas Bhirombhakdi
Niamh Cusack: Patrice Juiff Lyndsey Marshal Mathew Baynton Derek Sakakura Charlie Creed-Miles Tim Fitzhigham Jessica Griffiths Jay Mohr Marthe Keller Cyndi Mayo Davis Frankie McLaren Thie
Riley Paton: Hiroshi Kasuga Callum Gallagher Christian Fane Jackson Hengombe Gadaffi Davsab Ferdinand Hengombe Whiley Toll Hunter Stratton Boland Maycn Van Borssum Ripley Voeten Albert Le
Ramy Zada: Tom Savini Jeff Howell Anthony Dileo Jr. Christine Forrest Harvey Keitel E.G. Marshall Madeleine Potter Kim Hunter Bingo O'Malley John Amos Chuck Aber Jeff Monahan Peggy McInta
Holter Graham: Amanda LaPergola Al Roffe Jessica Kaye Victor Steinbach Nicolette Hart Jill Marie Lawrence Rafael Sardina Meg Gibson Ward Horton Gregory Marcel Stuart Rudin Lisette Bross R
Tao Wu: Yu Li Glen Murphy Cai Hongxiang Shu Chen Biao Wang Constantine Gregory Hideo Takamatsu Henry O Daxing Zhang John Lone Lisa Lu Ric Young Richard Vuu Tsou Tijger Basil Pao Joan Chen
Jeff Monahan: Clifton James Vanessa Martinez Chandra Wilson Ron Canada Richard Coca Eddie Robinson Eleese Lester Martin Balsam Gordon Tootoosis Sally Kirkland Adrienne Barbeau Holter Grah
Mac McDonald: Andrius Paulavičius Larisa Kalpokaitė Tyler Labine Tim Pigott-Smith Yui Ruth Bradley Roberto Bryce Kenneth Colley Philip Winchester Tom Egeland Todd Boyce Tiffany L. Kurtz K
Guillaume de Tonquédec: Stéphane De Groodt Lysiane Meis Antoine Blanquefort Marc Fayet Lionel Abelanski Sophie Duez Valérie Crouzet Jérôme Commandeur Florence Foresti Franck Dubosc Nabiha
Lysiane Meis: Stéphane De Groodt Antoine Blanquefort Marc Fayet Lionel Abelanski Sophie Duez Valérie Crouzet Jérôme Commandeur Guillaume de Tonquédec Florence Foresti Franck Dubosc Nabiha
Diveen Henry: Leo Bill Daniel Ryan Alan Williams Maxine Peake Di Botcher Tracy O'Flaherty Robert Wilfort Georgia Fitch Edna Doré Dorothy Atkinson James Corden Mark Benton Helen Coker Miche
Ion Sapdaru: Constantin Bojog Adina Cristescu Mădălina Ghițescu Geo Dobre Georgeta Paduraru Burdujan Sanziana Tarta Anamaria Marinca Luminița Gheorghiu Vlad Ivanov Adi Carauleanu Liliana
David Newton: Vincent Selhorst-Jones Jeff DePaoli Maggie Beal Johnny Dinu Miles Aubrey Danielle Souza Jacqueline Mazarella Aria Pullman Michael Butler Murray Phil Abrams Troy Grant Derek
Georgia Fitch: Leo Bill Daniel Ryan Alan Williams Maxine Peake Robert Wilfort Di Botcher Tracy O'Flaherty Diveen Henry Edna Doré Dorothy Atkinson James Corden Mark Benton Helen Coker Miche
Mayte Sánchez: Patricia Keefer Sharon Devlin Dianna Casale Femi Gardiner Odette Benatar Leslie French Heinz Winter Richard Cubison Bill Weston Glyn Baker Barbara Broccoli Frederick Warder
Will Stone: Benjamin Wood Shirley Tregre LaQuita S-Kay Anthony Ramsey Robert Pekel Mike R. Moreau Mark R. Miscione Nathan Marchena Tracy B. Mann Justin Lebrun Mark Kubr John C. Klein Steve
Michele Austin: Ralph Ineson Imelda Staunton Martin Savage David Bradley Daniel Mays Ben Crompton Alex Kelly Alison Garland Kathryn Hunter Timothy Bateson Sally Hawkins Paul Jesson Gary M
Mille Lehfeldt: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Simona Vcalová Lars Mikkelsen Flemming Enevold C
Flemming Enevold: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Christian Berkel Simona Vcalová Lars Mikkelsen
Claus Riis Østergaard: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona V
Malene Schwartz: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Roman Horn Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Si
Brian Protheroe: Noel Neill Burnell Tucker Bill Bailey William Russell Robert MacLeod David Yorston Graham McPherson Paul Tuerpe Larry Hagman Lawrence Trimble Jayne Tottman Rex Everhart O
Sheila Hancock: Stephanie Leonidas Charlie Baker Vera Farmiga Harvey Atkin Cara Horgan Béla Fesztbaum Joan Allen Richard Johnson David Hayman Rupert Friend Jim Norton Jack Scanlon Zac Mat
Brian Tahash: Gary Sievers Inna Swann Tim Pilleri Rock Anthony Basilina Butler Chris Cleveland Robert W. Arbogast Sam Menning Ricky Jay Rebecca Hall Michael Caine Piper Perabo William Mor
Martin Hestbæk: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona Vcalová
Rasmus Bjerg: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona Vcalová L
Tony Hatton: Kim Borrell Sibusiso Mamba Olivia Grant Caroline Smart Michael Richard Ian Roberts Sindisiswe Nxumalo Gabriel Byrne John Matshikiza Julie Walters Zac Fox Julian Wadham Sid Mi
Charlotte Rathnov: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona Vcal
Henrik Jandorf: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona Vcalová
Baxter Harris: Martin Sheen Codie Scott Chuck Kelley Alan Donnes Marie Del Marco Jeffrey Bornstein Kevin Beard Ron Rifkin Maria Mason Jacquelyn Twodat Jackson John Larroquette Victor Kemp
Hans Henrik Clemensen: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Flemming Enevold Christian Berkel Simona
Jocko Sims: Dennis Haysbert Dendrie Taylor Katherine Randolph Craig Coyne Riad Galayini Kevin Foster Brian Geraghty Chris Cooper Enrique Murciano Scott Lang Matthew James Deneen Tyler Al
Mai Holm Laureng: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Jan Zuska Flemming Enevold Christian Berkel Si
Marie Christensen-Dalsgaard: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Jan Zuska Flemming Enevold Christian
Klaus Tange: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Jan Zuska Flemming Enevold Christian Berkel Simona Vcalová Lars
William Atkinson: Logan Marshall-Green Chris McGarry Saycon Sengbloh Cicily Daniels Destan Owens Bono Christopher Tierney Erin Elliott Robert Clohessy Salma Hayek Angela Mounsey Nicholas
Roman Horn: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Jan Zuska Flemming Enevold Christian Berkel Simona V
Genevieve Guilbault: Agnieshka Wnorowska Marc Trottier Darren Shahlavi Deke Richards Devin Delorme Manny Cortez Tuazon Sabrina-Jasmine Guilbault Atif Y. Siddiqi Chanelle Lamothe Stephania
Kim Basinger: Akon Nathin Butler Awuese Awunde Christina Alex Ibrahim Aba-Gana Wyclef Jean Anne Heche Razaaq Adoti Joseph Maher Tony Jay Ann Prentiss Harry Shearer Seth Green Jon Lovitz F
Marika Blossfeldt: David Hyde Pierce Susan Traylor Maria Pitillo Kelly Lynch Jessica Lundy Bernard Zette Michael J. Fox Annabelle Gurwitch Peter Boyden Kiefer Sutherland Phoebe Cates Sam
Thomas Bendixen: Per Löwberg Nikola Navrátil Caspar Phillipson Oliver Hvidtfeldt Robert Reinhold Martin Vasquez Klaus Tange Jan Zuska Flemming Enevold Christian Berkel Simona Vcalová Lars
Oliver Robins: Noel Conlon Lou Perryman JoBeth Williams Beatrice Straight Michael McManus Richard Lawson Craig T. Nelson Dominique Dunne Heather O'Rourke Martin Casella Zelda Rubinstein J
Nikola Navrátil: Per Löwberg Caspar Phillipson Oliver Hvidtfeldt Thomas Bendixen Robert Reinhold Martin Vasquez Klaus Tange Jan Zuska Flemming Enevold Christian Berkel Simona Vcalová Lars
Zeta Graff: Roger Wright Gito Santana Anita Koh Renee Montemayor François Guillaume Alex Georgijev Roy Garcia Patrick Nicholls C. Keith Martin Leon Dekker Scott Woods Cecil Cheng Mia Frye
Ashlee Simpson: Mann Alfonso Carrie Fisher Shannyn Sossamon Pell James Steven Strait Stephen Moyer Fisher Stevens Perrey Reeves Peter Weller Melissa Lawner Cameron Thor Kip Pardue Ewan Ch
Michael Gover: Noel Neill Burnell Tucker Bill Bailey William Russell Robert MacLeod David Yorston Graham McPherson Paul Tuerpe Larry Hagman Lawrence Trimble Jayne Tottman Rex Everhart Oz
Anthony Flanagan: Sean Bean Sean Harris Rebecca Hall Gerard Kearns Peter Mullan Mary Jo Randle Ian Mercer Graham Walker Robert Sheehan John Henshaw Rachel Jane Allen Shaun Dooley David Mo
Allen Fiuzat: Christopher Connelly Edgar Buchanan Deborah Walley Tom Lester Terry Carter Frances Bavier Peter Breck Cynthia Smith Patsy Garrett
Jennifer Hennessy: Steven Robertson Sean Bean Sean Harris Rebecca Hall Gerard Kearns Peter Mullan Mary Jo Randle Ian Mercer Graham Walker John Henshaw Rachel Jane Allen Robert Sheehan Ant
Rita May: Sean Bean Sean Harris Rebecca Hall Gerard Kearns Peter Mullan Mary Jo Randle Ian Mercer Graham Walker John Henshaw Rachel Jane Allen Robert Sheehan Anthony Flanagan Cara Seymour
Gerard Kearns: Sean Bean Sean Harris Rebecca Hall Cara Seymour Daniel Mays Andrew Garfield Peter Mullan Mary Jo Randle Ian Mercer Graham Walker John Henshaw Rachel Jane Allen Robert Sheeha
Michy Gustavia: Rob Hall Roman Podhora Larissa Gomes Jo Chim Sharon Moore Dan Ellery Janessa Crimi Dionne Renee Peter C. Wylde Garry Geddes Joan Moore Torquil Colbo Gene Pyrz Eric Morgan
Jérémie Quaegebeur: Ronit Elkabetz Mathieu Demy Nicolas Duvauchelle Émilie Dequenne Catherine Deneuve Michel Blanc
Florencia Lozano: Christy Bella Joiner Michael Harkins Tania Santiago Holter Graham Sarah Michelle Gellar Erica Gimpel Nicolette Hart Waleed Zuaiter Melissa Leo Meg Gibson Adrian Martinez
Rafael Sardina: Laura Harrier Cassandra Inman Nic Novicki Alan Simpson Bettina Bresnan Natalie Knepp Jeremy Jordan Anna Kendrick Allison Macri Christy Bella Joiner Michael Harkins Tania Sa
```

Report 2: Top 5 Actors by Degree Centrality

1. **Problem description**

   Identify the five actors who have co-acted with the largest number of other actors, indicating their centrality in the graph.

2. **Solution description**

   The solution requires determining the degree (number of neighbors) for each vertex in the graph. We traversed the adjacency list to calculate the size of each actor's neighbor set (degree). Then stored results in a list of (actor, degree) pairs. Sort this list by degree in descending order and select the top 5.

   Key Data Structures:

   Vector for storing actor-degree pairs.

   Time Complexity:

   O(n+nlogn), where n is the number of actors.

   Space Complexity:

   O(n).

3. **Initial non-AI attempt to code the solution**

   Initially, we tried manually iterating through the adjacency list to compute degrees and then sorting the results using basic sorting techniques. But that proved to be impossible as the adjacency list is far too long. Debugging focused on ensuring accurate degree calculation.

4. **AI prompts used**

My group consulted ChatGPT about how to determine the actors with the most number of other actors by using the adjacency list. I then asked the AI to who the top 5 actors with the highest degree centrality was to ensure accuracy.

5. **Code testing description**

Use a small dataset where the degree centrality is easy to calculate manually. Verify that the top 5 actors are identified correctly.

Example:

Actor A: Actor B, Actor C

Actor B: Actor A, Actor C, Actor D

Actor C: Actor A, Actor B

Actor D: Actor B

Expected result: Actor B (3 connections), Actor A (2 connections), Actor C (2 connections), and Actor D (1 connection).

Edge Cases:

Ties in degree centrality: If multiple actors have the same degree, ensure consistent sorting behavior (e.g., alphabetical order).

Less than 5 actors: If there are fewer than 5 actors in the graph, ensure the program handles this gracefully without crashing.

6. Code including tests

```cpp
    cout << "__________________________________________________________________________" << endl << "\nTop 5 actors with the most connections:\n" << endl;
    for (size_t i = 0; i < 5 && i < actor_degrees.size(); ++i) {
        cout << actor_degrees[i].first << " with " << actor_degrees[i].second << " connections.\n";
    }

    unordered_set<string> visited;
    int connected_components = 0;

    for (const auto& pair : adj_list) {
        if (!visited.count(pair.first)) {
            ++connected_components;
            dfs(pair.first, adj_list, visited);
        }
    }
```

```
__________________________________________________________________________

Top 5 actors with the most connections:

Samuel L. Jackson with 1899 connections.
Morgan Freeman with 1596 connections.
Stan Lee with 1511 connections.
Anne Fletcher with 1501 connections.
Robert De Niro with 1467 connections.
__________________________________________________________________________
```

Report 3: Checking Graph Connectivity

1. **Problem description**

   Determine whether the graph is connected, i.e., whether there is a path between every pair of actors. If not, we need to count the number of connected components (subgraphs where all vertices are reachable from one another).

2. **Solution description**

   To check connectivity, we perform a graph traversal using Depth-First Search (DFS). By initiating a new DFS from any unvisited actor, we identify all actors in the same connected component. The code maintains a set to track visited actors.

   For each actor in the adjacency list:

   > If the actor is not visited, perform a DFS starting from that actor.
   >
   > Increment the connected component count.

   If only one component exists, the graph is connected. Otherwise, it is not.

   Key Data Structures:

   Set: Tracks visited actors during DFS.

   Adjacency list: Guides the DFS traversal.

Time Complexity:

O(n+e), where n is the number of actors and e is the number of edges. DFS processes every vertex and edge once.

Space Complexity:

O(n), for the visited set and the recursion stack.

3. **Initial non-AI attempt to code the solution**

   The group implemented a recursive DFS function but encountered stack overflow for large connected components. Switching to an iterative DFS using an explicit stack resolved this issue. Debugging also revealed errors when handling isolated vertices, which we corrected by adding explicit checks for disconnected nodes.

4. **AI prompts used**

   We did not use any AI to complete this problem.

5. **Code testing description**

   Test with a small dataset where the number of connected components is easy to verify.

   Example:

   Component 1: Actor A - Actor B - Actor C

   Component 2: Actor D - Actor E

   Expected output: "Graph is not connected. It has 2 connected components."

   Edge Cases:

Fully connected graph: All actors are part of one connected component.

Disconnected graph: All actors are isolated (no edges).

Single node: A graph with one actor and no edges.

6. **Code including tests**

```cpp
cout << "____________________________________________________________________" << endl << "\nGraph Connectivity:\n" << endl;
if (connected_components == 1) {
    cout << "The graph is connected.\n";
} else {
    cout << "The graph is not connected. It has " << connected_components << " connected components.\n";
}
```

```
____________________________________________________________________

Graph Connectivity:

The graph is not connected. It has 82 connected components.
____________________________________________________________________
```

Report 4: Shortest Degree of Separation

1. **Problem description**

   The task is to compute the shortest degree of separation between any two given actors. The degree of separation is defined as the minimum number of edges connecting the two actors.

2. **Solution description**

   This problem is solved using Breadth-First Search (BFS), which is ideal for finding shortest paths in unweighted graphs. The code initializes a queue with the starting actor and an initial distance of 0. Performs BFS, exploring all neighbors of the current actor and marking them as visited. Stops the search as soon as the target actor is reached, and return the distance. If the target actor is not reachable, returns an indication of disconnection.

   Key Data Structures:

   Queue: Tracks the current actor and its distance during BFS.

   Set: Ensures each actor is visited only once.

   Time Complexity:

   O(n+e), as BFS visits each vertex and edge once.

   Space Complexity:

   O(n), for the queue and visited set.

3. **Initial non-AI attempt to code the solution**

   My first BFS implementation correctly handled connected graphs but struggled with disconnected components. Refinements included additional checks for unreachable target actors.

4. **AI prompts used**

   My group asked ChatGPT to solve the disconnected components issue. The AI showed how to check and connect the actors so that the code ran properly.

5. **Code testing description**

   Test simple cases where the shortest degree of separation is easy to calculate manually.

   Example:

   Actor A - Actor B - Actor C

   Actor C - Actor D

   Test cases:

   Shortest degree of separation between Actor A and Actor C: 2.

   Shortest degree of separation between Actor A and Actor D: 3.

   Edge Cases:

   Direct connection: Two actors are co-actors.

   Disconnected nodes: Actors belong to different connected components.

   Self-query: When the same actor is queried.

6. Code including tests

```cpp
cout << "____________________________________________________________________________" << endl << "\nShortest Degrees of Separation with Path:\n" << endl;
for (const auto& pair : example_pairs) {
    const auto& actor1 = pair.first;
    const auto& actor2 = pair.second;

    vector<string> path = shortestDistance(actor1, actor2, adj_list);
    if (!path.empty()) {
        cout << actor1 << " and " << actor2 << " have a degree of separation: " << path.size() - 2 << "." << endl << "Path: ";
        for (const auto& actor : path) {
            cout << actor;
            if (&actor != &path.back()) {
                cout << " -> ";
            }
        }
        cout << endl << endl;
    } else {
        cout << actor1 << " and " << actor2 << " are not connected.\n";
    }
}
```

```
____________________________________________________________________________

Shortest Degrees of Separation with Path:

Emma Watson and Robert Pattinson have a degree of separation: 0.
Path: Emma Watson -> Robert Pattinson

Ewan McGregor and Daniel Radcliffe have a degree of separation: 1.
Path: Ewan McGregor -> Janet McTeer -> Daniel Radcliffe

Tom Hanks and Adam West have a degree of separation: 1.
Path: Tom Hanks -> Garry Marshall -> Adam West
```

Report 5: Shortest Path Between Two Actors

1. **Problem description**

   Determine the actor chain (path) that constitutes the shortest connection between two given actors. The path should explicitly list all intermediate actors.

2. **Solution description**

   BFS is extended to track the path from the starting actor to the target. At each step, the current actor's path is updated and propagated to its neighbors. The code initializes a queue containing pairs of the current actor and the path taken to reach them. Then explores all neighbors, updating the path dynamically. Stops when the target actor is reached and return the path. If the target actor is not reachable, returns an empty path.

   Key Data Structures:

   Queue: Stores the current actor and its path.

   Vector: Tracks the path for each actor.

   Time Complexity:

   O(n+e).

   Space Complexity:

   O(n+p), where p is the path length.

3. **Initial non-AI attempt to code the solution**

   Initially, we struggled with maintaining correct path tracking due to overwriting shared paths. Introducing unique path updates for each actor in the queue resolved this issue.

4. **AI prompts used**

   This problem was similar to that of milestone 4, so no AI was needed for here.

5. **Code testing description**

   Use small graphs with known paths to verify that the shortest path is correctly identified.

   Example:

   Actor A - Actor B - Actor C

   Actor C - Actor D

   Test cases:

   Path between Actor A and Actor D: Actor A -> Actor B -> Actor C -> Actor D.

   Edge Cases:

   Direct path: Actors are directly connected.

   Disconnected nodes: Actors are in different components.

   Multiple shortest paths: If there are multiple shortest paths, ensure any valid path is returned.

6. Code including tests

```cpp
cout << "___________________________________________________________________" << endl << "\nShortest Degrees of Separation with Path:\n" << endl;
for (const auto& pair : example_pairs) {
    const auto& actor1 = pair.first;
    const auto& actor2 = pair.second;

    vector<string> path = shortestDistance(actor1, actor2, adj_list);
    if (!path.empty()) {
        cout << actor1 << " and " << actor2 << " have a degree of separation: " << path.size() - 2 << "." << endl << "Path: ";
        for (const auto& actor : path) {
            cout << actor;
            if (&actor != &path.back()) {
                cout << " -> ";
            }
        }
        cout << endl << endl;
    } else {
        cout << actor1 << " and " << actor2 << " are not connected.\n";
    }
}
```

```
____________________________________________________________________

Shortest Degrees of Separation with Path:

Emma Watson and Robert Pattinson have a degree of separation: 0.
Path: Emma Watson -> Robert Pattinson

Ewan McGregor and Daniel Radcliffe have a degree of separation: 1.
Path: Ewan McGregor -> Janet McTeer -> Daniel Radcliffe

Tom Hanks and Adam West have a degree of separation: 1.
Path: Tom Hanks -> Garry Marshall -> Adam West
```

Cole Bennett, Carlo Garay

Student signatures

12-01-2024

Date