The question I am answering is: How does a user's closeness centrality relate to their ability to influence other users within a limited number of steps? What is the relationship between closeness centrality and reach of a node in a social network graph?

https://snap.stanford.edu/data/feather-lastfm-social.html

I loaded the data using my read_graph function in main.rs, using the petgraph library in Rust.

Code Structure

Main.rs has my main function that runs the methods and functions of centrality.rs and graph.rs. It loads the graph, calculates connected components, calculates closeness centrality, and compares the reach of users based on their centrality.

graph.rs contains the Graphs struct and it's impl block which contains the methods of graph algorithms of BFS, closeness centrality, connected components, and finding the number of users a user can reach. It also has the read_graph function to load an undirected graph given a CSV file.

centrality.rs contains functions for computing centrality-related analysis. It has functions to find the most and least central user of a component, to find the largest component, and to find the most and least central users of multiple components.

Key Functions & Types (Structs, Enums, Traits, etc)

For each non-trivial item, restate its purpose, inputs and outputs, and **Core logic and key components**

How do modules/functions interact to produce your results?

Central_finder finds the most central user in each connected component. Input is a list of connected components (a list of node numbers) and a HashMap that contains (user, closeness centrality score.) pairs. Output is a vector containing the most central nodes from each component. For each component in the list of components, the user with the highest closeness score is found and added to a vector containing all found users at the end of the loop.

least_central_finder finds the least central user in each connected component. Input is a list of connected components (a list of node numbers) and a HashMap that contains (user, closeness centrality score) pairs. Output is a vector containing the least central nodes from each component. For each component, the user with the lowest closeness score is found and added to a vector that stores all such users.

most_central_user finds the most central user in a single connected component. Input is a vector of node numbers (a single component) and a HashMap of (user, closeness centrality score) pairs. Output is the user with the highest closeness score. The function loops through the users in the component and keeps track of the one with the highest score.

least_central_user finds the least central user in a single connected component. Input is a vector of node numbers (a single component) and a HashMap of (user, closeness centrality score) pairs. Output is the user with the lowest closeness score. The function loops through the users in the component and keeps track of the one with the lowest score.

largest_component returns the largest component from a list of connected components. Input is a list of components (each a vector of node numbers). Output is the component with the most users. The function compares the size of each component and returns the one with the largest length.

Graphs::new creates a new Graphs object from a Petgraph graph. Input is a Graph<u32, (), Undirected> and output is a Graphs struct containing the graph. The function returns a struct where the graph is stored as a field.

Graphs::bfs performs BFS from a starting node for a given number of steps. Input is the starting node number and a step limit. Output is a vector of visited node numbers. The function uses a queue to explore the graph from the starting node and stops when the step count is reached.

Graphs::closeness_centrality calculates the closeness centrality for every node in the graph. The input is the graph (self). Output is a HashMap with (node number, closeness score) pairs. The function runs a BFS from each node, calculates the total distance to all other nodes, and applies the closeness formula.

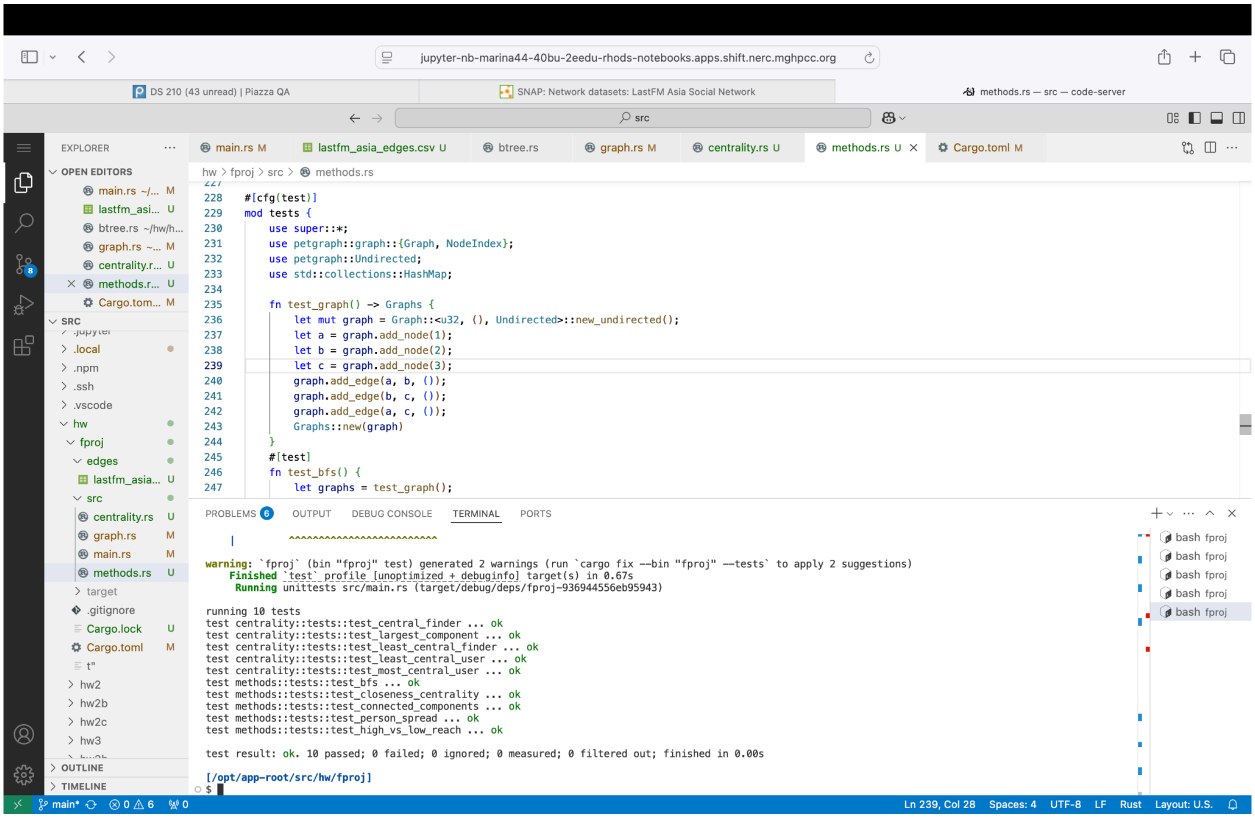
Graphs::connected_components finds all connected components in the graph. Input is the graph (self). Output is a vector of components, and each component is a list of node numbers. The function runs BFS from every unvisited node and grouped the reached nodes into components.

Graphs::person_spread finds how many people a given user can reach in a certain number of steps. Input is a user's node number and a number of steps. Output is the number of unique nodes reached. The function uses a limited-depth BFS to find the number of reachable nodes within the step limit.

Graphs::high_vs_low_reach compares the reach of the most central users and the least central users within each component. Input is a list of components, a HashMap of (node, closeness score) pairs, and a number of steps. Output prints the average number of users reached by the most and least central users. The function uses central_finder and least_central_finder to find the target users and then calls person_spread to calculate how many users they can reach.

read_graph loads a graph from a CSV file. Input is a file path. Output is a Petgraph Graph<u32, (), Undirected>with the nodes and edges from the file. The function reads each line, parses the node numbers, creates the graph using a HashMap to track existing nodes, and connects them with edges.

Tests



test_central_finder
Makes sure that the most central user found in each connected component is accurate, and has a component [1,2,3] with node 2 having the highest closeness score.

test_least_central_finder
Makes sure that the least central user found in each connected component is accurate, and has a component [1,2,3] with node 3 having the lowest closeness score.

Test_most_central_user
Makes sure that the most central user found within a single component is correct.

test_least_central_user
Makes sure that the least central user found within a single component is correct.

test_largest_component
Makes sure that the component with the most nodes is correctly identified from a list of components.

test_graph creates a new graph.

test_bfs
Makes sure that BFS visits all reachable nodes from a given starting point in 1 step.

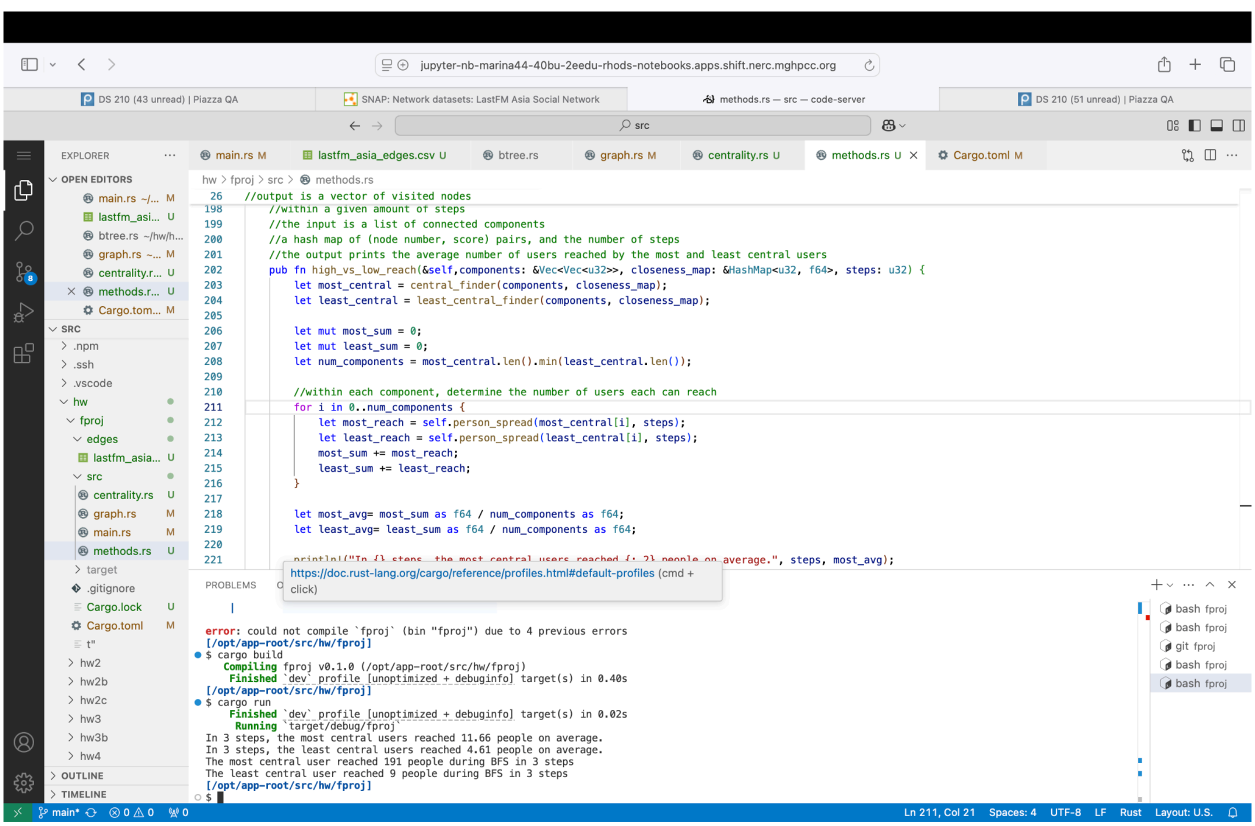
test_closeness_centrality
Makes sure that closeness centrality is calculated correctly.

test_connected_components
Makes sure that a graph is correctly classified as one connected component.

test_person_spread
Makes sure that the number of users a person can reach in a given number of steps found is accurate, using a node 1 in a graph which can reach nodes 2 and 3 in 1 step.

test_high_vs_low_reach
Makes sure that the high_vs_low_reach function works properly.

Results



reached 191 people and the least central user reached 9 people during BFS given 3 steps, showing that centrality plays a very significant role in the reach of a node within a graph.

To build and run the code: Cargo build, cargo run

The runtime should be near instant. I took a sample of the first 1000 rows of the dataset, which cut down on run time.

AI-Assistance Disclosure and Other Citations

I used chatgpt for assistance on syncing Github with Rust. I learned how to set up an ssh key by writing the following code in the terminal

ssh-keygen -t ed25519 -C "your_email@example.com"

git remote set-url origin git@github.com:your-username/your-repo-name.git

cat ~/.ssh/id_ed25519.pub. And pasting the output of this pasted into the terminal into “New SSH key” on Github in Settings.

Out of class resources I used:

https://john-cd.com/rust_howto/categories/data-structures/graph.html
https://docs.rs/petgraph/latest/petgraph/graph/struct.Graph.html
https://depth-first.com/articles/2020/02/03/graphs-in-rust-an-introduction-to-petgraph
https://crates.io/crates/petgraph