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DS210 Final Project Paper

This Rust project looks at social network analysis through graph data structures. It's main functionalities can be summarized like this:

The Chosen Dataset:

The project features a function (`load_social_data` in `main.rs`) designed to load data from a compressed file, representing a social network. The data is structured as edges connecting nodes, corresponding to users in the network. This Dataset was perfect because the 'friendship' relationship between users and the friendship or 'relationship' aspect of my function can directly be used.

<https://snap.stanford.edu/data/ego-Facebook.html>

Initially I didn't intend to use this dataset as I wanted a greater challenge and data cleaning aspect of my project but I found that process to be more time consuming than fulfilling the project requirements. Therefore, I went with a more straightforward dataset that would help further both my understanding of the project and my understanding of the information being given.

Graphing:

Processed data is used to construct a graph representation utilizing a `HashMap`. In this representation, each node (user) is linked to a list of its neighbors.

Graph Analysis:

The `graph_analysis` module provides functions for analyzing the social graph.

Average Distance Function:

The `calculate_avg_distance` function computes the mean distance between nodes in the social graph, likely leveraging breadth-first search (`bfs_distances`) to determine distances.

Six Degrees of Separation Function:

The `six_degrees_of_separation` function double checks if two nodes are connected within a specified number of degrees of separation in the social graph.

Relationship Strength Function:

The `compute_relationship_strength` function computes the strength of relationships between nodes based on mutual connections or friends in a literal and computational way. Specifically, it keeps track of the number of mutual friends between connected node pairs.

Main Function:

The main function in `main.rs` serves as the starting point for the application. It loads the social network data, conducts various graph analyses using the functions from `graph_analysis`, and outputs the results.

Testing:

The project incorporates test cases (tests module) to verify the accuracy of the graph analysis functions.

Modules:

Main.rs

What does it do?

The main.rs file within a Rust project commonly serves as the program's starting point, housing the main function that acts as the initial execution trigger. Here's an analysis of the main function's typical functionalities in main.rs:

A.) Import Statements:

The initiation of the main.rs file often features a set of import statements (use). These statements are employed to incorporate external libraries or modules, enabling the utilization of functionalities provided by these external sources.

B.) Module Declarations:

In scenarios where the project adopts a multi-file and module structure, main.rs may declare and utilize other modules. This is achieved through the mod keyword, facilitating the importation of functionalities from additional files (e.g., mod graph_analysis;).

C.) Function Definitions:

The main function has the capacity to define supplementary helper functions or invoke functions from alternative modules. These additional functions play a role in enhancing the overall functionality of the program.

D.) Entry Point:

Functioning as the program's entry point, the main function holds the distinction of being the initial function invoked upon program execution.

E.) Command-Line Arguments:

The main function is designed to accept command-line arguments as parameters. This functionality provides the program with the capability to receive input from the command line, offering a degree of flexibility and customization.

F.) Error Handling:

Integral to the main function is the inclusion of error-handling mechanisms. Rust employs the Result type to signify success or failure, and the main function typically returns a Result to effectively manage potential errors that may arise during program execution.

G.) Execution Logic:

The primary body of the main function encapsulates the logic steering the program. This involves orchestrating the execution flow, invoking functions, managing errors, and executing any necessary computations or actions.

H.) Output:

The main function may utilize the println! macro or other methods to produce output on the console. This output serves various purposes, including displaying results, tracking progress, or presenting debugging information.

I.) Result Return:

As a common practice, the main function frequently concludes by returning a `Result<(), Error>`, where `()` represents the unit type. In instances of successful program execution, `Ok()` is typically returned, while errors encountered during execution result in `Err(Error)`.

LOADING MY DATA:

```
// function made to load compressed csv file
fn load_social_data(file_path: &str) -> io::Result<HashMap<u32, Vec<u32>>> {
    let file: File = File::open(file_path)?; // open the specified file
    let decoder: GzDecoder<File> = GzDecoder::new(file); // create a GzDecoder to decompress the file

    let mut social_graph: HashMap<u32, Vec<u32>> = HashMap::new(); // initialize an empty graph

    // iterate through each line in the decompressed file
    for line: Result<String, Error> in io::BufReader::new(inner: decoder).lines() {
        let connection: Vec<u32> = line? String // split the line into u32 values
            .split_whitespace() SplitWhitespace' '
            .map(|s: &str| s.parse().unwrap()) impl Iterator<Item = u32>
            .collect();

        // edges added to the graph
        social_graph HashMap<u32, Vec<u32>>
            .entry(key: connection[0]) Entry<_, u32, Vec<u32>>
            .or_insert_with(default: Vec::new) &mut Vec<u32>
            .push(connection[1]);

        social_graph HashMap<u32, Vec<u32>>
            .entry(key: connection[1]) Entry<_, u32, Vec<u32>>
            .or_insert_with(default: Vec::new) &mut Vec<u32>
            .push(connection[0]);
    }

    Ok(social_graph) // return graph
} fn load_social_data
```

I loaded the facebook data by uncompressing the facebook data and importing:::

Note: Uncompressing

I used `GzDecoder` to decompress data, you use a `GzDecoder`, which is provided by the `flate2` crate. It wraps around a `Read` implementor, allowing you to read decompressed data from it.

Top Relationship Strengths:

It identifies and displays the top 10 strongest relationships in the graph.

The output is a list of pairs of individuals along with the strength of their relationship.

The results of these analyses provide a deeper understanding of the relationships within the social network graph, highlighting strong relationship, the average closeness of the network, and whether specific individuals are connected within a certain degree of separation.

```

// main funct
► Run | Debug
fn main() -> io::Result<()> {
    let file_path: &str = "data/facebook_combined.txt.gz"; // path to the social data file

    match load_social_data(file_path) {
        Ok(social_graph: HashMap<u32, Vec<u32>>=> {
            // calc and print relationship strength
            let relationship_strength: HashMap<(u32, u32), usize> = graph_analysis::compute_relationship_strength(&social_graph);

            // print all relationship strengths
            println!("All Relationship Strengths:");
            for ((node1: &u32, node2: &u32), strength: &usize) in &relationship_strength {
                println!("Nodes {} and {}: Relationship Strength {}", node1, node2, strength);
            }

            // calc and print the avg dist
            let avg_distance: f64 = graph_analysis::calculate_average_distance(&social_graph);
            println!("Average Distance: {:.2}", avg_distance);

            // see if nodes 1 and 100 are within six degrees of separation
            let source_node: u32 = 1;
            let target_node: u32 = 100;
            let max_degrees: u32 = 6;
            let are_connected: bool =
                graph_analysis::six_degrees_of_separation(&social_graph, start_node: source_node, end_node: target_node, max_degrees);

            if are_connected {
                println!(
                    "NODES {} AND {} ARE WITHIN {} DEGREE OF SEPARATION.",
                    source_node, target_node, max_degrees
                );
            } else {
                println!(
                    "NODES {} AND {} ARE NOT WITHIN {} DEGREES OF SEPARATION.",
                    source_node, target_node, max_degrees
                );
            }

            // print the top 10 relationship strengths
            println!("TOP TEN RELATIONSHIP STRENGTHS:");
            let num_top_relationships: usize = 10;
            let sorted_relationships: Vec<_> = relationship_strength.iter().collect();
            let top_relationships: &[(u32, u32), &usize] = &sorted_relationships[..num_top_relationships];
        }
    }
}

```

etc.....

Graph_Analysis.rs

What does it do?

Relationship Strength:

It calculates the strength of relationship between pairs of individuals in the graph.

The output is a map where each pair of individuals is associated with a numerical value representing the strength of their friendship.

Average Distance:

It calculates the average distance between individuals in the graph, indicating how closely connected the network is on average.

The output is a single numerical value representing the average distance.

```
// graph_analysis.rs
use std::collections::{HashMap, VecDeque};

pub fn calculate_average_distance(graph: &HashMap<u32, Vec<u32>>) -> f64 {
    let mut total_distance: u32 = 0;
    let mut total_pairs: usize = 0;

    for (source_node: &u32, _) in graph {
        let distances: HashMap<u32, u32> = bfs_distances(&graph, start_node: *source_node);

        // exclude unreachable nodes
        let reachable_distances: Vec<u32> = distances HashMap<u32, u32>
            .iter() Iter<_, u32, u32>
            .filter(|(&_, distance: &&u32)| *distance < &u32::MAX) impl Iterator<Item = (&u32, ...) >
            .map(|(&_, distance: &u32)| *distance) impl Iterator<Item = u32>
            .collect();

        // accumulate distances
        total_distance += reachable_distances.iter().sum:::<u32>();
        total_pairs += reachable_distances.len();
    }

    // calc avg dist
    if total_pairs > 0 {
        total_distance as f64 / total_pairs as f64
    } else {
        0.0
    }
} fn calculate_average_distance
```

Breadth-First Search (BFS)

This is a graph traversal algorithm that explores a graph level by level, visiting all the neighbors of a node before moving on to the next level. It is often used for searching, shortest path finding, and connected component determination in graphs.

```
fn bfs_distances(graph: &HashMap<u32, Vec<u32>>, start_node: u32) -> HashMap<u32, u32> {  
    let mut distances: HashMap<u32, u32> = graph.keys().map(|&node: u32| (node, std::u32::MAX)).collect();  
    let mut queue: VecDeque<u32> = VecDeque::new();  
  
    // initialize beginning node  
    distances.insert(k: start_node, v: 0);  
    queue.push_back(start_node);  
  
    while let Some(current_node: u32) = queue.pop_front() {  
        for &neighbor: u32 in &graph[&current_node] {  
            if distances[&neighbor] == u32::MAX {  
                distances.insert(k: neighbor, v: distances[&current_node] + 1);  
                queue.push_back(neighbor);  
            }  
        }  
    }  
  
    distances  
}
```

Six Degrees of Separation:

It checks whether two specified individuals in the graph are within a certain number of degrees of separation (a common concept in social networks).

The output is a boolean (true or false) indicating whether the individuals are connected within the specified degrees.

```
pub fn six_degrees_of_separation(graph: &HashMap<u32, Vec<u32>>, start_node: u32, end_node: u32, max_degrees: u32) -> bool {
    let mut visited_nodes: HashMap<u32, u32> = HashMap::new();
    visited_nodes.insert(k: start_node, v: 0);

    let mut queue: VecDeque<u32> = VecDeque::new();
    queue.push_back(start_node);

    while let Some(current_node: u32) = queue.pop_front() {
        for &neighbor: u32 in &graph[&current_node] {
            if !visited_nodes.contains_key(&neighbor) {
                visited_nodes.insert(k: neighbor, v: visited_nodes[&current_node] + 1);

                if neighbor == end_node {
                    return visited_nodes[&neighbor] <= max_degrees;
                }

                if visited_nodes[&neighbor] < max_degrees {
                    queue.push_back(neighbor);
                }
            }
        }
    }

    false
} fn six_degrees_of_separation
```

Compute Relationship Strength:

The "compute relationship strength" function, as implied by its name, likely calculates the strength of relationships or connections between individuals in a social network graph. The exact details of how this computation is performed would depend on the implementation of the function, but I can provide a general understanding. In a social network context, relationship strength could be quantified based on various factors, such as the frequency of interactions, the number of mutual connections, or the types of interactions. The goal is to assign a numerical value to represent the strength or closeness of the relationship between two individuals.

```
pub fn compute_relationship_strength(graph: &HashMap<u32, Vec<u32>>) -> HashMap<(u32, u32), usize> {
    let mut relationship_strength: HashMap<(u32, u32), usize> = HashMap::new();

    for (&node: u32, neighbors: &Vec<u32>) in graph {
        for &friend: u32 in neighbors {
            // see if there is a mutual connection
            if let Some(mutual_friends: &Vec<u32>) = graph.get(&friend) {
                let mutual_friends_count: usize = mutual_friends &Vec<u32>
                    .iter()
                    .filter(|&f: &u32| graph[&node].contains(f))
                    .count();
                relationship_strength.insert(k: (node, friend), v: mutual_friends_count);
            }
        }
    }

    relationship_strength
}
```

Tests:

What do they do?

Average Distance Calculation Test:

Test Function Name: test_calculate_avg_distance

Objective: Verify the correctness of the calculate_avg_distance function in graph_analysis.

Graph Setup: Manually create a small graph with predetermined nodes and edges.

Expected Result: The test computes the average distance within the graph and compares it to a predefined value (expected_value). Success is declared if the computed result matches expectations.

Six Degrees of Separation Test:

```
// test module
#[cfg(test)]
mod tests {
    use super::*;
    use std::collections::HashMap;

    // test case for calculating average distance in the graph
    #[test]
    fn test_calculate_avg_distance() {
        let mut social_graph: HashMap<u32, Vec<u32>> = HashMap::new();
        social_graph.insert(k: 1, v: vec![2, 3]);
        social_graph.insert(k: 2, v: vec![1, 4]);
        social_graph.insert(k: 3, v: vec![1, 4]);
        social_graph.insert(k: 4, v: vec![2, 3]);

        let avg_distance: f64 = graph_analysis::calculate_average_distance(&social_graph);
        let expected_value: f64 = 1.0; // updated to the correct expected value
        assert_eq!(avg_distance, expected_value);
    }
}
```

Test Function Name: test_six_degrees_of_separation

Objective: Examine the behavior of the six_degrees_of_separation function.

Graph Setup: Create another small-scale graph with specified nodes and edges.

Expected Result: Evaluate whether two designated nodes (1 and 4) are connected within six degrees.

Success is achieved if the actual result aligns with the expected value (true).


```
// test case for checking six degrees of separation in between the nodes
#[test]
▶ Run Test | Debug
fn test_six_degrees_of_separation() {
    let mut social_graph: HashMap<u32, Vec<u32>> = HashMap::new();
    social_graph.insert(k: 1, v: vec![2, 3]);
    social_graph.insert(k: 2, v: vec![1, 4]);
    social_graph.insert(k: 3, v: vec![1, 4]);
    social_graph.insert(k: 4, v: vec![2, 3]);

    let are_connected: bool = graph_analysis::six_degrees_of_separation(&social_graph, start_node: 1, end_node: 4, max_degrees: 6);
    let expected_value: bool = true; // updated to the correct expected value
    assert_eq!(are_connected, expected_value);
}
```

Relationship Strength Calculation Test:

Test Function Name: test_calculate_relationship_strength

Objective: Scrutinize the precision of the calculate_relationship_strength function.

Graph Setup: Construct a concise graph with predetermined nodes and edges.

Expected Result: Compute relationship strengths within the graph and verify a specific pair ((412, 374)). Success is declared if the calculated result matches expectations (None).

Additional Points: The assert_eq! macro is employed in the tests to assert that the computed result aligns with the expected value. println! statements are strategically used for debugging, offering a printout of calculated values during test execution for result inspection.

```
// test case for calc relationship strength
#[test]
▶ Run Test | Debug
fn test_compute_relationship_strength() {
    let mut social_graph: HashMap<u32, Vec<u32>> = HashMap::new();
    social_graph.insert(k: 1, v: vec![2, 3]);
    social_graph.insert(k: 2, v: vec![1, 4]);
    social_graph.insert(k: 3, v: vec![1, 4]);
    social_graph.insert(k: 4, v: vec![2, 3]);

    let relationship_strength: HashMap<u32, u32, usize> = graph_analysis::compute_relationship_strength(&social_graph);

    // print the relationship_strength map while debugging
    println!("{:?}", relationship_strength);

    let specific_pair: (u32, u32) = (412, 374); // define specific pair
    let expected_value: Option<usize> = Go to HashMap | RandomState
    relationship_strength

    // print the actual value for the sp
    if let Some(actual_value: &usize) = relationship_strength.get(&specific_pair) {
        println!("Actual value for {:?}: {}", specific_pair, actual_value);
    } else {
        println!("No value found for {:?}", specific_pair);
    }

    assert_eq!(relationship_strength.get(&specific_pair), expected_value);
} fn test_compute_relationship_strength
} mod tests
```

Output and results

CARGO.TOML:

```
FinalProject > Cargo.toml
1  [package]
2  name = "my_project"
3  version = "0.1.0"
4  edition = "2021"
5
6  # See more keys and their definitions at https://doc.rust-lang.org/cargo/reference/manifest.html
7
8  [dependencies]
9  serde = "1.0"
10 serde_derive = "1.0"
11 serde_json = "1.0"
12 petgraph = "0.6"
13 flate2 = "1.0"
14
15
```

- `serde` and `serde_derive` enable efficient and customizable serialization and deserialization of data.
- `serde_json` is a JSON-specific implementation for `serde`, facilitating easy handling of JSON data.
- `petgraph` supports the representation and analysis of graph structures.
- `flate2` is utilized for decompressing Gzip-compressed files in the context of the provided Rust code.

Cargo build which is use to import crates:

```
ls

The default interactive shell is now zsh.
To update your account to use zsh, please run `chsh -s /bin/zsh`.
For more details, please visit https://support.apple.com/kb/HT208050.
● (base) nat-wireless-guest-reg-153-54:Project210 rileykrisch$ ls
FinalProject
● (base) nat-wireless-guest-reg-153-54:Project210 rileykrisch$ cd FinalProject
● (base) nat-wireless-guest-reg-153-54:FinalProject rileykrisch$ cargo build
    Finished dev [unoptimized + debuginfo] target(s) in 0.68s
○ (base) nat-wireless-guest-reg-153-54:FinalProject rileykrisch$
```

Cargo run and results:

Average Distance: 3.69

This indicates the average shortest path length between any two nodes in the network. In a social network or any network where nodes represent entities and edges represent relationships, a lower average distance might suggest a more tightly connected network.

Nodes 1 and 100 are within 6 degrees of separation.

This means that there is a path of relationships connecting Node 1 to Node 100 that is no longer than 6 edges or links. The "degrees of separation" concept is often used to describe how well-connected or tightly knit a network is.

Top 10 Relationship Strengths:

“What does this mean?”

"Nodes 2459 and 2009: Relationship Strength 26" means that there is a strong relationship between Nodes 2459 and 2009, with a strength value of 26.

Nodes 1827 and 1662: Relationship Strength 103

This particular relationship is exceptionally strong, with a strength value of 103. This could indicate a very close or influential connection between Nodes 1827 and 1662 in the network.

Nodes 2030 and 2073: Relationship Strength 173

Similar to the previous example, this relationship has an even higher strength value (173), suggesting an even stronger connection between Nodes 2030 and 2073.

Nodes 1105 and 1002: Relationship Strength 3

In contrast, this relationship has a lower strength value (3), indicating a relatively weaker connection between Nodes 1105 and 1002 compared to the other relationships in the top 10.

Output results:

Nodes 2777 and 2806: Relationship Strength 27

Nodes 944 and 1630: Relationship Strength 21
Nodes 2172 and 2309: Relationship Strength 174
Nodes 1793 and 1214: Relationship Strength 67
Nodes 0 and 286: Relationship Strength 1
Nodes 3771 and 3727: Relationship Strength 2
Nodes 2132 and 2185: Relationship Strength 7
Nodes 389 and 1275: Relationship Strength 15
Nodes 2218 and 2638: Relationship Strength 161
Nodes 3773 and 3722: Relationship Strength 12
Nodes 1391 and 1470: Relationship Strength 43
Nodes 2718 and 2832: Relationship Strength 5
Nodes 2423 and 2329: Relationship Strength 102
Nodes 1310 and 1304: Relationship Strength 15
Nodes 2440 and 2089: Relationship Strength 18
Nodes 1608 and 1078: Relationship Strength 81
Nodes 3104 and 3390: Relationship Strength 12
Nodes 2463 and 2042: Relationship Strength 72
Nodes 3287 and 3225: Relationship Strength 16
Nodes 188 and 274: Relationship Strength 11
Nodes 3171 and 2934: Relationship Strength 1
Nodes 2436 and 2491: Relationship Strength 76
Nodes 2469 and 2266: Relationship Strength 133
Nodes 2002 and 2250: Relationship Strength 50
Nodes 1345 and 1120: Relationship Strength 43
Nodes 1235 and 1345: Relationship Strength 83
Nodes 805 and 831: Relationship Strength 8
Nodes 1101 and 1874: Relationship Strength 8
Nodes 2579 and 2543: Relationship Strength 94
Nodes 2419 and 2416: Relationship Strength 28
Nodes 2284 and 1998: Relationship Strength 44
Nodes 937 and 1106: Relationship Strength 5
Nodes 2655 and 2631: Relationship Strength 97
Nodes 1215 and 1103: Relationship Strength 6
Nodes 3000 and 3213: Relationship Strength 21
Nodes 3020 and 3012: Relationship Strength 7
Nodes 2194 and 2471: Relationship Strength 83
Nodes 1369 and 1617: Relationship Strength 16
Nodes 3437 and 3730: Relationship Strength 27
Nodes 2526 and 2005: Relationship Strength 130
Nodes 2142 and 2485: Relationship Strength 129
Nodes 1083 and 1370: Relationship Strength 78
Nodes 3866 and 3782: Relationship Strength 17
Nodes 2526 and 2579: Relationship Strength 103
Nodes 1449 and 1874: Relationship Strength 10

Nodes 2995 and 3051: Relationship Strength 7
Nodes 2904 and 1684: Relationship Strength 71
Nodes 1709 and 1304: Relationship Strength 19
Nodes 1283 and 1327: Relationship Strength 15
Nodes 1684 and 2934: Relationship Strength 19
Nodes 2978 and 3130: Relationship Strength 10
Nodes 1116 and 1845: Relationship Strength 21
Nodes 818 and 802: Relationship Strength 4
Nodes 1993 and 2347: Relationship Strength 171
Nodes 1269 and 1816: Relationship Strength 61
Nodes 1684 and 2854: Relationship Strength 35
Nodes 2600 and 2218: Relationship Strength 174
Nodes 3204 and 2751: Relationship Strength 12
Nodes 56 and 72: Relationship Strength 20
Nodes 1086 and 1243: Relationship Strength 72
Nodes 3722 and 3827: Relationship Strength 6
Nodes 946 and 1399: Relationship Strength 118
Nodes 3397 and 2973: Relationship Strength 60
Nodes 1951 and 2027: Relationship Strength 39
Nodes 1 and 0: Relationship Strength 16
Nodes 3102 and 3344: Relationship Strength 35
Nodes 2059 and 2340: Relationship Strength 183
Nodes 136 and 2491: Relationship Strength 66
Nodes 2385 and 2180: Relationship Strength 38
Nodes 1982 and 2280: Relationship Strength 5
Nodes 2329 and 2109: Relationship Strength 90
Nodes 3280 and 2785: Relationship Strength 16
Nodes 1184 and 1688: Relationship Strength 50
Nodes 422 and 592: Relationship Strength 19
Nodes 2196 and 2026: Relationship Strength 53
Nodes 3153 and 2745: Relationship Strength 5
Nodes 2124 and 2591: Relationship Strength 82
Nodes 1138 and 107: Relationship Strength 13
Nodes 3815 and 3629: Relationship Strength 13
Nodes 2123 and 2430: Relationship Strength 140
Nodes 3363 and 2689: Relationship Strength 64
Nodes 2654 and 2103: Relationship Strength 136
Nodes 2806 and 2782: Relationship Strength 27
Nodes 373 and 436: Relationship Strength 49
Nodes 423 and 561: Relationship Strength 42
Nodes 1374 and 930: Relationship Strength 19
Nodes 2354 and 2136: Relationship Strength 66
Nodes 3188 and 3058: Relationship Strength 14
Nodes 2782 and 2911: Relationship Strength 53

Nodes 3556 and 3611: Relationship Strength 4
Nodes 1881 and 1080: Relationship Strength 20
Nodes 2331 and 2083: Relationship Strength 134
Nodes 1839 and 1401: Relationship Strength 10
Nodes 238 and 271: Relationship Strength 18
Nodes 2462 and 2467: Relationship Strength 61
Nodes 1790 and 107: Relationship Strength 37
Nodes 906 and 1199: Relationship Strength 49
Nodes 1520 and 925: Relationship Strength 83
Nodes 1953 and 2005: Relationship Strength 104
Nodes 2668 and 3048: Relationship Strength 8
Nodes 1563 and 1835: Relationship Strength 93
Nodes 1843 and 1389: Relationship Strength 15
Nodes 716 and 763: Relationship Strength 7
Nodes 1298 and 1426: Relationship Strength 47
Nodes 331 and 0: Relationship Strength 19
Nodes 2951 and 2844: Relationship Strength 11
Nodes 1989 and 2040: Relationship Strength 63
Nodes 1630 and 1658: Relationship Strength 9
Nodes 1487 and 948: Relationship Strength 16
Nodes 2323 and 1997: Relationship Strength 121
Nodes 1367 and 1086: Relationship Strength 106
Nodes 1337 and 1561: Relationship Strength 10
Nodes 2091 and 2236: Relationship Strength 21
Nodes 2118 and 2045: Relationship Strength 161
Nodes 1912 and 2246: Relationship Strength 94
Nodes 2363 and 2386: Relationship Strength 125
Nodes 2370 and 2353: Relationship Strength 69
Nodes 683 and 514: Relationship Strength 17
Nodes 2655 and 2326: Relationship Strength 152
Nodes 1684 and 2701: Relationship Strength 25
Nodes 1896 and 1043: Relationship Strength 1
Nodes 412 and 461: Relationship Strength 40
Nodes 2326 and 2005: Relationship Strength 136
Nodes 2943 and 2706: Relationship Strength 47
Nodes 596 and 107: Relationship Strength 28
Nodes 3571 and 3759: Relationship Strength 15
Nodes 1941 and 2423: Relationship Strength 85
Nodes 2600 and 2213: Relationship Strength 91
Nodes 2409 and 2552: Relationship Strength 99
Nodes 1727 and 606: Relationship Strength 8
Nodes 3437 and 3864: Relationship Strength 6
Nodes 420 and 553: Relationship Strength 19
Nodes 1985 and 2376: Relationship Strength 162

Nodes 2118 and 1946: Relationship Strength 171
Nodes 1804 and 1608: Relationship Strength 93
Nodes 940 and 1418: Relationship Strength 6
Nodes 1706 and 1786: Relationship Strength 35
Nodes 1166 and 1020: Relationship Strength 37
Nodes 3154 and 3093: Relationship Strength 6
Nodes 2279 and 2451: Relationship Strength 84
Nodes 2093 and 2586: Relationship Strength 165
Nodes 2492 and 2340: Relationship Strength 171
Nodes 1626 and 1702: Relationship Strength 25
Nodes 2586 and 2348: Relationship Strength 141
Nodes 1771 and 1390: Relationship Strength 15
Nodes 1684 and 2827: Relationship Strength 74
Nodes 1850 and 1893: Relationship Strength 17
Nodes 2482 and 2150: Relationship Strength 149
Nodes 645 and 563: Relationship Strength 12
Nodes 1971 and 2150: Relationship Strength 160
Nodes 1280 and 1352: Relationship Strength 51
Nodes 2679 and 2890: Relationship Strength 56
Nodes 1123 and 1156: Relationship Strength 29
Nodes 512 and 394: Relationship Strength 13
Nodes 2139 and 2060: Relationship Strength 86
Nodes 1941 and 2280: Relationship Strength 36
Nodes 2186 and 2145: Relationship Strength 15
Nodes 2271 and 2376: Relationship Strength 154
Nodes 2319 and 1955: Relationship Strength 73
Nodes 405 and 568: Relationship Strength 4
Nodes 2783 and 3291: Relationship Strength 19
Nodes 1347 and 1158: Relationship Strength 44
Nodes 1146 and 1078: Relationship Strength 92
Nodes 3934 and 3437: Relationship Strength 9
Nodes 1604 and 1336: Relationship Strength 45
Nodes 2653 and 2087: Relationship Strength 67
Nodes 2611 and 2220: Relationship Strength 176
Nodes 1935 and 2627: Relationship Strength 35
Nodes 2928 and 2929: Relationship Strength 33
Nodes 1694 and 930: Relationship Strength 11
Nodes 1149 and 1078: Relationship Strength 73
Nodes 2212 and 1966: Relationship Strength 114
Nodes 2960 and 2706: Relationship Strength 41
Nodes 1805 and 1255: Relationship Strength 6
Nodes 1539 and 1367: Relationship Strength 61
Nodes 929 and 1838: Relationship Strength 3
Nodes 2649 and 2498: Relationship Strength 65

Nodes 3274 and 3145: Relationship Strength 23
Nodes 1688 and 1804: Relationship Strength 49
Nodes 2491 and 136: Relationship Strength 66
Nodes 1714 and 1483: Relationship Strength 63
Nodes 1380 and 107: Relationship Strength 84
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Nodes 2098 and 2131: Relationship Strength 110
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Nodes 206 and 178: Relationship Strength 1
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Nodes 2869 and 2849: Relationship Strength 39
Nodes 353 and 1529: Relationship Strength 5
Nodes 2384 and 2071: Relationship Strength 113
Nodes 2878 and 2844: Relationship Strength 3
Nodes 1297 and 1549: Relationship Strength 3
Nodes 1240 and 1642: Relationship Strength 1
Nodes 1339 and 1117: Relationship Strength 36
Nodes 1391 and 1341: Relationship Strength 87
Nodes 2187 and 136: Relationship Strength 77
Nodes 3443 and 3554: Relationship Strength 11
Nodes 2131 and 2506: Relationship Strength 113
Nodes 968 and 1110: Relationship Strength 9
Nodes 761 and 800: Relationship Strength 6
Nodes 1377 and 1146: Relationship Strength 122

Nodes 1894 and 1282: Relationship Strength 48
Nodes 2719 and 3060: Relationship Strength 56
Nodes 3657 and 3892: Relationship Strength 8
Nodes 1156 and 960: Relationship Strength 55
Nodes 2101 and 2222: Relationship Strength 33
Nodes 2593 and 1997: Relationship Strength 123
Nodes 2875 and 2742: Relationship Strength 30
Nodes 2504 and 2550: Relationship Strength 117
Nodes 1872 and 1591: Relationship Strength 32
Nodes 3906 and 3705: Relationship Strength 13
Nodes 1741 and 1707: Relationship Strength 81
Nodes 1519 and 995: Relationship Strength 15
Nodes 2655 and 2552: Relationship Strength 99
Nodes 332 and 224: Relationship Strength 12
Nodes 3403 and 2955: Relationship Strength 5
Nodes 2905 and 1684: Relationship Strength 73
Nodes 3902 and 3804: Relationship Strength 25
Nodes 1885 and 914: Relationship Strength 11
Nodes 1605 and 966: Relationship Strength 54
Nodes 3821 and 3947: Relationship Strength 4
Nodes 2315 and 2148: Relationship Strength 57
Nodes 1799 and 1597: Relationship Strength 86
Nodes 2638 and 1993: Relationship Strength 157
Nodes 1319 and 1118: Relationship Strength 26
Nodes 992 and 1097: Relationship Strength 27
Nodes 2003 and 2438: Relationship Strength 42
Nodes 1250 and 1861: Relationship Strength 42
Nodes 2268 and 2232: Relationship Strength 42
Nodes 2254 and 2247: Relationship Strength 53
Nodes 320 and 251: Relationship Strength 11
Nodes 1348 and 1121: Relationship Strength 19
Nodes 3505 and 3629: Relationship Strength 13
Nodes 2448 and 2120: Relationship Strength 8
Nodes 555 and 418: Relationship Strength 13
Nodes 1491 and 1689: Relationship Strength 77
Nodes 2578 and 2347: Relationship Strength 146
Nodes 1559 and 1214: Relationship Strength 81
Nodes 2071 and 2052: Relationship Strength 81
Nodes 1591 and 1229: Relationship Strength 26
Nodes 494 and 409: Relationship Strength 17
Nodes 1402 and 1800: Relationship Strength 62
Nodes 2112 and 2216: Relationship Strength 109
Nodes 2894 and 3327: Relationship Strength 7
Nodes 2573 and 2468: Relationship Strength 114

Nodes 1226 and 1415: Relationship Strength 16
Nodes 2877 and 3238: Relationship Strength 19
Nodes 1076 and 1811: Relationship Strength 38
Nodes 62 and 98: Relationship Strength 14
Nodes 2246 and 1947: Relationship Strength 70
Nodes 2465 and 2111: Relationship Strength 58
Nodes 3917 and 3871: Relationship Strength 6
Nodes 3728 and 3753: Relationship Strength 16
Nodes 3000 and 3348: Relationship Strength 39
Nodes 388 and 497: Relationship Strength 27
Nodes 1431 and 1879: Relationship Strength 131
Nodes 2190 and 2037: Relationship Strength 132
Nodes 1076 and 1888: Relationship Strength 130
Nodes 1584 and 1619: Relationship Strength 81
Nodes 3829 and 3714: Relationship Strength 4
Nodes 803 and 734: Relationship Strength 2
Nodes 1993 and 2088: Relationship Strength 184
Nodes 2028 and 2472: Relationship Strength 51
Nodes 1250 and 1730: Relationship Strength 107
Nodes 1039 and 1551: Relationship Strength 22
Nodes 1230 and 1331: Relationship Strength 80
Nodes 2679 and 3004: Relationship Strength 29
Nodes 1656 and 1327: Relationship Strength 9
Nodes 2218 and 2212: Relationship Strength 137
Nodes 1380 and 1132: Relationship Strength 65
Nodes 2590 and 2359: Relationship Strength 140
Nodes 2966 and 3085: Relationship Strength 33
Nodes 1907 and 1261: Relationship Strength 22
Nodes 2777 and 2928: Relationship Strength 45
Nodes 1191 and 1335: Relationship Strength 60
Nodes 1306 and 1525: Relationship Strength 12
Nodes 1129 and 1345: Relationship Strength 58
Nodes 2956 and 3384: Relationship Strength 40
Nodes 2451 and 2294: Relationship Strength 73
Nodes 2039 and 2144: Relationship Strength 62
Nodes 3120 and 3169: Relationship Strength 48
Nodes 3022 and 2925: Relationship Strength 47
Nodes 1765 and 1670: Relationship Strength 2
Nodes 2452 and 2325: Relationship Strength 8
Nodes 2334 and 2575: Relationship Strength 87
Nodes 1971 and 2623: Relationship Strength 111
Nodes 1080 and 1616: Relationship Strength 25
Nodes 1450 and 1411: Relationship Strength 1
Nodes 3926 and 3488: Relationship Strength 32

Nodes 3576 and 3543: Relationship Strength 3
Nodes 1669 and 1662: Relationship Strength 72
Nodes 999 and 1823: Relationship Strength 47
Nodes 1447 and 897: Relationship Strength 31
Nodes 3657 and 3743: Relationship Strength 12
Nodes 2046 and 2275: Relationship Strength 114
Nodes 2347 and 1577: Relationship Strength 106
Nodes 1930 and 2260: Relationship Strength 3
Nodes 2449 and 2339: Relationship Strength 24
Nodes 1864 and 1191: Relationship Strength 58
Nodes 203 and 322: Relationship Strength 30
Nodes 3355 and 2973: Relationship Strength 44
Nodes 500 and 538: Relationship Strength 35
Nodes 1132 and 1377: Relationship Strength 85
Nodes 3090 and 2890: Relationship Strength 67
Nodes 3545 and 3674: Relationship Strength 21
Nodes 2247 and 2603: Relationship Strength 36
Nodes 2592 and 2366: Relationship Strength 7
Nodes 3866 and 3511: Relationship Strength 1
Nodes 1255 and 1604: Relationship Strength 59
Nodes 1608 and 1528: Relationship Strength 33
Nodes 2469 and 2602: Relationship Strength 128
Nodes 1894 and 1204: Relationship Strength 29
Nodes 1804 and 1017: Relationship Strength 114
Nodes 971 and 1282: Relationship Strength 21
Nodes 1392 and 483: Relationship Strength 15
Nodes 2326 and 2559: Relationship Strength 147
Nodes 1525 and 1418: Relationship Strength 10
Nodes 3480 and 3437: Relationship Strength 24
Nodes 1229 and 1261: Relationship Strength 11
Nodes 1334 and 1389: Relationship Strength 24
Nodes 2056 and 2356: Relationship Strength 86
Nodes 2469 and 2556: Relationship Strength 94
Nodes 2339 and 1979: Relationship Strength 148
Nodes 1536 and 1496: Relationship Strength 24
Nodes 1559 and 1861: Relationship Strength 71
Nodes 376 and 391: Relationship Strength 55
Nodes 1962 and 2462: Relationship Strength 85
Nodes 1565 and 1645: Relationship Strength 28
Nodes 2313 and 2145: Relationship Strength 15
Nodes 1979 and 2059: Relationship Strength 159
Nodes 2536 and 2553: Relationship Strength 52
Nodes 1663 and 1554: Relationship Strength 134
Nodes 2520 and 2600: Relationship Strength 139

Nodes 122 and 303: Relationship Strength 15
Nodes 2133 and 2273: Relationship Strength 72
Nodes 3201 and 3185: Relationship Strength 48
Nodes 932 and 1580: Relationship Strength 28
Nodes 995 and 1580: Relationship Strength 25
Nodes 475 and 1692: Relationship Strength 22
Nodes 2356 and 2409: Relationship Strength 153
Nodes 2093 and 2030: Relationship Strength 155
Nodes 2359 and 2430: Relationship Strength 112
Nodes 2064 and 2121: Relationship Strength 147
Nodes 2241 and 2081: Relationship Strength 101
Nodes 1912 and 2106: Relationship Strength 3
Nodes 2169 and 2582: Relationship Strength 80
Nodes 3284 and 2986: Relationship Strength 58
Nodes 1468 and 1601: Relationship Strength 27
Nodes 1330 and 1714: Relationship Strength 87
Nodes 1310 and 1275: Relationship Strength 19
Nodes 722 and 745: Relationship Strength 12
Nodes 2748 and 2973: Relationship Strength 37
Nodes 3642 and 3574: Relationship Strength 7
Nodes 3172 and 3291: Relationship Strength 37
Nodes 773 and 724: Relationship Strength 23
Nodes 2635 and 1945: Relationship Strength 18
Nodes 2293 and 2319: Relationship Strength 45
Nodes 1779 and 1441: Relationship Strength 11
Nodes 1741 and 1867: Relationship Strength 46
Nodes 428 and 1226: Relationship Strength 6
Nodes 3039 and 3403: Relationship Strength 13
Nodes 1833 and 1198: Relationship Strength 77
Nodes 1438 and 1322: Relationship Strength 33
Nodes 3348 and 3339: Relationship Strength 53
Nodes 1604 and 993: Relationship Strength 75

Average Distance: 3.69

Nodes 1 and 100 are within 6 degrees of separation.

Top 10 Relationship Strengths:

Nodes 2459 and 2009: Relationship Strength 26
Nodes 2065 and 2567: Relationship Strength 16
Nodes 687 and 783: Relationship Strength 8
Nodes 1898 and 1517: Relationship Strength 24
Nodes 1827 and 1662: Relationship Strength 103
Nodes 2030 and 2073: Relationship Strength 173
Nodes 2462 and 2020: Relationship Strength 79
Nodes 3317 and 3010: Relationship Strength 6
Nodes 1037 and 1549: Relationship Strength 11

Nodes 1105 and 1002: Relationship Strength 3