AOA ASSIGNMENT

OBJECTIVE:

- Implement three graph functions such as shortest_path, connected_components and cycles in JAVA and then test these functions using three simulated graphs (n_cycles, complete_graph and Equivalence mod K).
- To construct graph using Netflix-prize challenge data for different adjacency criteria and output the number of connected components and size of each component for the graph.

DESCRIPTION:

GRAPH OPERATIONS:

The following three graph functions are implemented as follows:

- *Connected components ():* The depth first search methodology is used to return the connected components present in our graph for each vertex. If there are no vertices connected to the given vertex then also it is considered as a component. Our output is represented like v1->v2->…. ->vn (incase of n connected components) or v1(if the vertex has no other connected vertices).
- *one cycle ():* The depth first search methodology is used to return the first detected cycle present in the graph. If there are no cycles, then an empty list is returned.
- *shortest_path ():* We have implemented the Dijkstra's algorithm to find the shortest path to every other node from source in the graph. We have taken source to be 0 for all simulated graphs.

GRAPH SIMULATORS:

In our project we have generated three simulated graphs using JAVA namely,

- n_cycle
- a complete graph on n vertices
- Equivalence mod K.

SIMULATED TEST:

The simulated graphs produced are tested for different number of nodes for all three functions. The testing is done by getting the number of nodes from the user. Then the user choses any one of the simulated graphs and the system outputs the number of connected components, shortest path from vertex 0 to all other vertices (up to n-1), one cycle if present in the graph and the adjacency list of the graph.

NETFLIX DATA TEST:

For the Netflix data, we extract the data from the four .txt files. After storing the data we generate graphs based on different adjacency criteria.

Adjacency Criteria 1: We create an edge between the two customer ids if they have given a rating for at least one movie in common.

Adjacency Criteria 2: We create an edge between the two customer ids if they have given a rating for at least 5 movies in common.

DATA STRUCTURES USED FOR VARIOUS OPERATIONS:

- The data structure used to store the **Graph** for simulated test is ArrayList n nodes, where each index in the ArrayList contains a list edge objects associated with them. Each edge object contains source, destination and weight in it. Here we assume the weight to be a default 1 value.
- The data structure used in **connected components** is a Boolean array to mark the already visited nodes and a recursive DFS function is applied on unvisited nodes until they are also visited through traversal.
- The data structures used in **shortest_paths()** are Priority queue(minheap), list(size is total no of nodes) of integers to store the shortest distance, a Boolean array to keep track of nodes for which the shortest distance to node is already found and Integer array to store parent of each node.
- The data structures used in **one_cycle()** is a List to store one cycle present in the graph which makes use of the already defined DFS function to find the nodes in the cycle.
- The data structure used to store Netflix data is a Multimap where the customer ids are the key and the movies which were given rating by them are the corresponding values for that key.
- For both the adjacency criteria we use a HashSet. We find intersection between the two list of movies between two customers by storing them temporarily in HashSet for each loop iteration.

PEAK MEMORY USAGE AND CPU TIME FOR EXPERIMENT USING SIMULATED DATA:

- For the simulated graph, when n=10 the running time to execute all three functions is 205ms and the total memory usage is 500.50Kb.
- When n=100, the running time to execute all three functions is 3s and the total memory usage is 4030.77Kb.

Thus, the time complexity for performing three functions for simulated data is $O(n^2)$.

SAMPLE OUTPUT FROM TESTS OF SIMULATED DATA:
WHEN THE VALUE OF N IS 10,
OUTPUT:

```
Enter the number of Vertices you want
10
Enter the type of graph you want
1. N_Cycle Graph
2. Complete_Graph
3. Equivalence_Mod_K Graph
1
Following are the Shortest path from Vertex 0:
Path (0 -> 1): Minimum Cost = 1, Route = [0, 1]
Path (0 -> 2): Minimum Cost = 2, Route = [0, 1, 2]
Path (0 -> 3): Minimum Cost = 3, Route = [0, 1, 2, 3]
Path (0 -> 4): Minimum Cost = 4, Route = [0, 1, 2, 3, 4]
Path (0 -> 5): Minimum Cost = 5, Route = [0, 1, 2, 3, 4, 5]
Path (0 -> 6): Minimum Cost = 4, Route = [0, 9, 8, 7, 6]
Path (0 -> 7): Minimum Cost = 3, Route = [0, 9, 8, 7]
Path (0 -> 8): Minimum Cost = 2, Route = [0, 9, 8]
Path (0 -> 9): Minimum Cost = 1, Route = [0, 9]
Following are the Connected Graph Components:
0 1 2 3 4 5 6 7 8 9
```

Graph Display:

Adjacency list of vertex0
head -> 1 -> 9

Adjacency list of vertex1
head -> 0 -> 2

Adjacency list of vertex2
head -> 1 -> 3

Adjacency list of vertex3
head -> 2 -> 4

Adjacency list of vertex4
head -> 3 -> 5

Adjacency list of vertex5
head -> 4 -> 6

Adjacency list of vertex6
head -> 5 -> 7

Adjacency list of vertex7
head -> 6 -> 8

Adjacency list of vertex8
head -> 7 -> 9

Adjacency list of vertex9
head -> 0 -> 8
Following are one cycle details:
[0, 9, 8, 7, 6, 5, 4, 3, 2, 1]
******

Enter the type of graph you want
1. N_Cycle Graph
2. Complete_Graph
3. Equivalence_Mod_K Graph
2
Following are the Shortest path from Vertex 0:
Path (0 -> 1): Minimum Cost = 1, Route = [0, 1]
Path (0 -> 2): Minimum Cost = 1, Route = [0, 2]
Path (0 -> 3): Minimum Cost = 1, Route = [0, 3]
Path (0 -> 4): Minimum Cost = 1, Route = [0, 4]
Path (0 -> 5): Minimum Cost = 1, Route = [0, 5]

Path (0 -> 6): Minimum Cost = 1, Route = [0, 6]
Path (0 -> 7): Minimum Cost = 1, Route = [0, 7]
Path (0 -> 8): Minimum Cost = 1, Route = [0, 8]
Path (0 -> 9): Minimum Cost = 1, Route = [0, 9]
Following are the Connected Graph Components:
0 1 2 3 4 5 6 7 8 9
Graph Display:

Adjacency list of vertex0
head -> 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex1
head -> 0 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex2
head -> 0 -> 1 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex3
head -> 0 -> 1 -> 2 -> 4 -> 5 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex4
head -> 0 -> 1 -> 2 -> 3 -> 5 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex5
head -> 0 -> 1 -> 2 -> 3 -> 4 -> 6 -> 7 -> 8 -> 9

Adjacency list of vertex6
head -> 0 -> 1 -> 2 -> 3 -> 4 -> 5 -> 7 -> 8 -> 9

Adjacency list of vertex7
head -> 0 -> 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 8 -> 9

Adjacency list of vertex8
head -> 0 -> 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 9

Adjacency list of vertex9
head -> 0 -> 1 -> 2 -> 3 -> 4 -> 5 -> 6 -> 7 -> 8
Following are one cycle details:
[0, 2, 1]
******
Enter the type of graph you want
1. N_Cycle Graph
2. Complete_Graph
3. Equivalence_Mod_K Graph
3
Value of K:7
Following are the Shortest path from Vertex 0:
Path (0 -> 7): Minimum Cost = 1, Route = [0, 7]

Following are the Connected Graph Components:
0 7
1 8
2 9
3
4
5
6
Graph Display:

Adjacency list of vertex0
head -> 7

Adjacency list of vertex1
head -> 8

Adjacency list of vertex2
head -> 9

Adjacency list of vertex3
head

Adjacency list of vertex4
head

Adjacency list of vertex5
head

Adjacency list of vertex6
head

Adjacency list of vertex7
head -> 0

Adjacency list of vertex8
head -> 1

Adjacency list of vertex9
head -> 2
Following are one cycle details:
[]

SAMPLE OUTPUT FROM TESTS OF REAL DATA:
Adjacency Criteria 1 For the first 4 movies

Following are the Connected Graph Components:

0 1 2 3 4 5 6 9 11 12 13 15 16 17 18 19 20 22 23 24 26 27 28 29 30 31 32 34 37 38 39 40 41 42 43 56 57 58
59 60 61 62 63 66 67 68 72 73 74 75 78 80 81 83 84 85 86 87 88 89 91 92 95 97 98 99 100 102 103 104
105 107 110 111 112 113 114 116 118 119 120 121 122 123 126 127 130 131 132 133 134 136 137 138
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649 682 684 695 720 742 33 49 52 53 54 71 76 82 90 93 101 106 108 150 159 180 239 241 251 253 305
313 362 424 436 468 470 487 524 534 557 560 587 591 610 615 621 660 685 702 739 773 782 789 792
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397 401 413 421 425 430 437 440 441 447 455 458 474 484 485 486 488 500 502 503 507 508 512 516
522 528 529 533 535 543 561 567 569 573 575 583 588 597 607 613 624 626 632 635 654 657 661 662
665 679 706 709 713 716 728 729 735 741 743 747 748 749 750 755 756 757 759 763 764 768 776 786
787 788 790 805 839 842 850 855 857 859 867 874 875 880 883 885 888 894 895 916 920 936 954 959
970 975 976 981 982 983 987 988 990 995 999 1002 1010 556 558 559 562 565 566 568 571 572 574 576
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704 705 707 708 710 711 712 714 715 717 718 719 721 722 723 724 725 726 727 730 731 732 733 734
736 737 738 740 744 745 746 751 753 754 758 760 761 762 765 766 767 769 770 771 772 774 775 777
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2613 2620 2625 2626 2633 2647 2649 2651 2660 2667 2669 2677 2679 2687 2691 2692 2704 2707 2708
2678 2680 2681 2682 2683 2684 2685 2686 2688 2690 2693 2694 2695 2696 2697 2698 2700 2701 2702
2703 2705 2709 2710 2712 2713 2714 2715 2716 2717 2718 2719 2721 2723 2724 2456 2462 2481 2537
2540 2550 2563 2575 2590 2619 2635 2644 2654 2664 2673 2689 2706 2722 2740 2786 2789 2798 2711
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2762 2763 2766 2768 2769 2770 2771 2772 2773 2774 2775 2776 2777 2780 2781 2782 2783 2784 2785
2787 2788 2791 2793 2799 2800 2801 2802 2792 2794 2795 2796 2241 2284 2285 2320 2348 2353 2384
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Adjacency Criteria 2 For the first 4 movies

Following are the Connected Graph Components:
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