Lab #4: Informed Search

The Node structure in Lab #2,3 is modified by adding heuristic value (**h**) as follows:

(Deadline: 23h59 23/10/2023)

```
public class Node {
	private String label;
	private Node parent; // for printing the path from the start node to
//goal node
	private double g;// cost from the Start node to this node
	private double h;// heuristic cost from this node to the Goal node
	private List<Edge> children = new ArrayList<Edge>();
```

Next, the interface **IInformedSearchAlgo.java** defined the execute method as follows:

```
public interface IInformedSearchAlgo {
	public Node execute(Node root, String goal);
	public Node execute(Node root, String start, String goal);
}
```

===

Pseudocode of Uniform Cost Search (UCS) can be used to implement Greedy best-first search and A* search.

```
function UNIFORM-COST-SEARCH(problem) returns a solution, or failure
  node ← a node with STATE = problem.INITIAL-STATE, PATH-COST = 0
  frontier ← a priority queue ordered by PATH-COST, with node as the only element
  explored ← an empty set
  loop do
      if EMPTY?(frontier) then return failure
      node ← POP(frontier)  /* chooses the lowest-cost node in frontier */
      if problem.GOAL-TEST(node.STATE) then return SOLUTION(node)
      add node.STATE to explored
      for each action in problem.ACTIONS(node.STATE) do
          child ← CHILD-NODE(problem, node, action)
          if child.STATE is not in explored or frontier then
              frontier ← INSERT(child, frontier)
          else if child.STATE is in frontier with higher PATH-COST then
              replace that frontier node with child
```

The costs used in UCS, Greedy, and A* are as follows:

- **Uniform-cost search**: expand the lowest path cost

  f(n) = g(n)

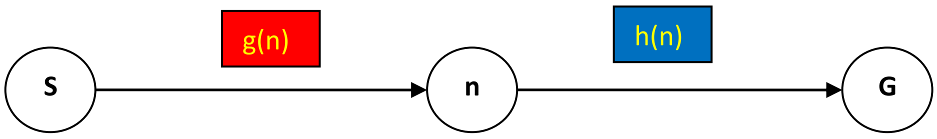
- **Greedy best-first search**: expand the node closest to the goal. *No pathcost is needed.*

  f(n) = h(n)

- **A* search**: combine UCS and Greedy (minimizing the total estimated solution cost)

  f(n) = g(n) + h(n)

Where g(n) represents the path cost from the Start node to n, h(n) represents the heuristic cost from n to the Goal.



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Task 1: Implement ***execute(Node root, String goal)*** in **GreedyBestFirstSearchAlgo.java**

Task 2: Implement ***execute(Node root, String goal)*** in **AStarSearchAlgo.java**

Notice that, using PriorityQueue for frontier and implementing Comparable interface for Node object (or using Comparator).

```
PriorityQueue<Node> frontier = new PriorityQueue<Node>(new
NodeComparatorByGn());// if NodeComparatorByGn is defined as an
//implementation of interface Comparator for comparing 2 nodes, or

==========================================================================
PriorityQueue<Node> frontier = new PriorityQueue<Node>();// if Node is
//implemented interface Comparable
```

In the case of using **GreedyBestFirstSearchAlgo**, if two nodes have the same heuristic, then the priority is based on the alphabets of node labels. The Comparator is defined as follows:

```
class NodeComparatorByHn implements Comparator<Node> {

      @Override
      public int compare(Node o1, Node o2) {
            Double h1 = o1.getH();
            Double h2 = o2.getH();
            int result = h1.compareTo(h2);
            if (result == 0)
                  return o1.getLabel().compareTo(o2.getLabel());
            else
                  return result;
      }
}
```

Test the implemented algorithms with the following state space:

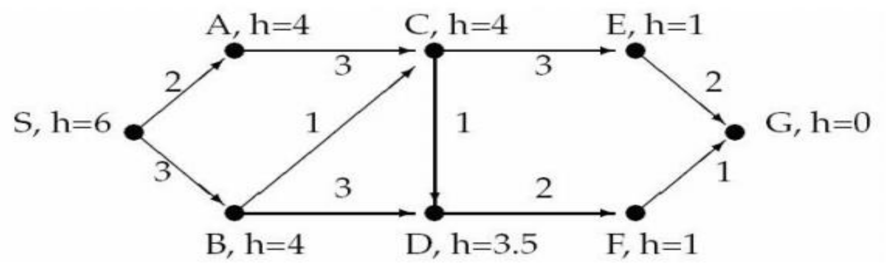

Fig. 1. State space 1

The result using A*:

iteration	node expanded	Priority queue at end of this iteration
0		S = 0 + 6 = 6 (i.e. S = g(S) + h(S) = f(S))
1	S	A = 2 + 4 = 6; B = 3 + 4 = 7
2	**A**	**B = 7, C = 2 + 3 + 4 = 9**
3	**B**	**C = 3 + 1 + 4 = 8, D = 3 + 3 + 3.5 = 9.5**
4	**C**	**E = 4 + 3 + 1 = 8, D = 4 + 1 + 3.5 = 8.5**
5	**E**	**D = 8.5, G = 7 + 2 + 0= 9**
6	**D**	**F = 5 + 2 + 1 = 8, G = 9**
7	**F**	**G = 7 + 1 + 0 = 8**
8	**G**	
9		
10		

Later, test the implemented algorithms with the following state space (*find the path from S to G1 or G2*):

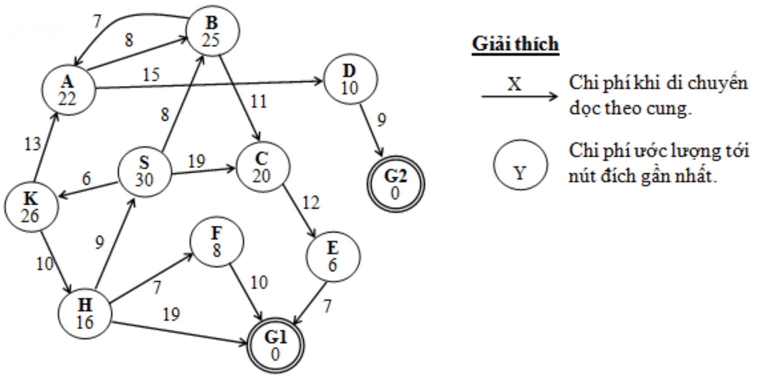

Fig. 2. State space 2

Notice that each node includes: a **label** and **heuristic cost** to the closest Goal.

Task 3: Implement the method ***public boolean isAdmissibleH(Node root, String goal)*** to check whether given heuristic values are admissible or not.

Notice that, a heuristic is admissible if it never overestimates the cost to reach the goal. The true cost of a given node to the goal is found by using A*

- h(n) <= h*(n) where h*(n) is the true cost from n to goal
- h(n) >= 0 so h(G)=0 for any goal G.

Task 4: Implement ***Node execute(Node root, String start, String goal)*** in the greedy best-first search and A* search algorithms to find a path from **Start** to **Goal** (not from the Root to Goal as in Tasks 1, 2).