

CSE341 – Programming Languages (Fall 2020)

Homework #4

Handed out: December 30, 2020.

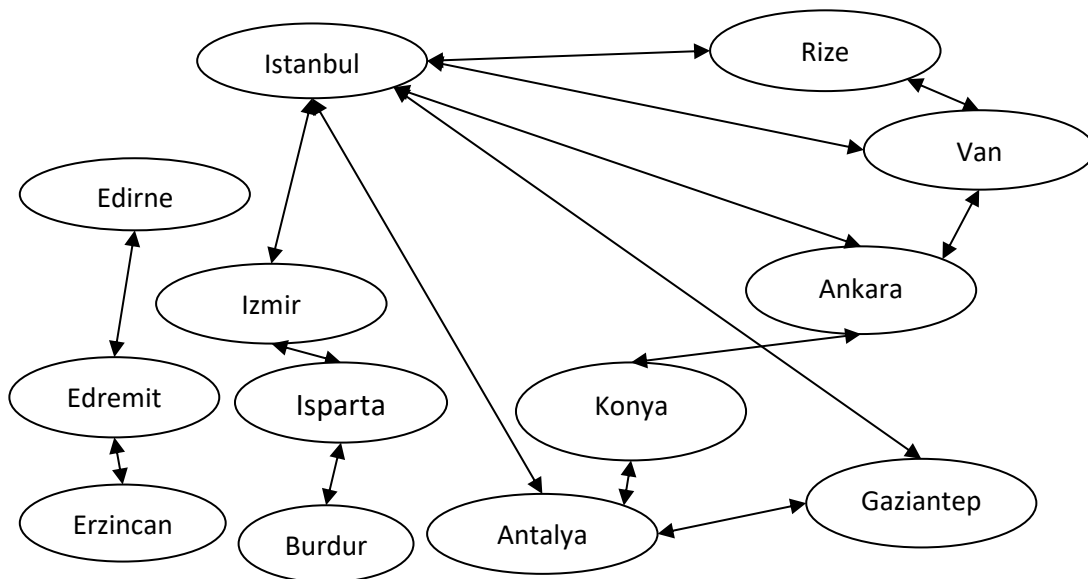
Due: 11:55pm January 10, 2021.

Hand-in Policy: Source code and documentation should be submitted online as a single .zip. File with naming convention studentid_lastname_firstname_hw4.zip via Moodle by the submission deadline. No late submissions will be accepted. Each part of the homework will be implemented in a single file named **partx.pl**. Thus we expect 6 different files in this homework.

Collaboration Policy: No collaboration is permitted. Any cheating (copying someone else's work in any form) will result in a grade of -100 for the first offense and -200 for the subsequent attempts.

Grading: Each homework will be graded on the scale 100. Unless otherwise noted, the questions/parts will be weighed equal.

Part 1. In the graph below you see the possible flights between some of the cities in Turkey. Write the predicate "route(X,Y) – a route between X and Y exists" that returns true if there is a route between any given two cities.



Your program should have all the facts and predicates/rules. See the following:

```
% knowledge base
...
flight(istanbul,antalya). % the fact that Istanbul and Antalya has a flight.
...
% rules
...
route(X,Y) :- flight(X,Y). % a predicate indicating there exist a route between
                          % X and Y if there is flight between X and Y.
...
```

A single query to complete your program should check if there is a direct route between two given cities. Alternatively, it can list all the connected cities for a given city. See the following:

```
?- route(edirne,X).
X = erzincan ;
X = edremit ;
```

Make sure that your predicate implementation handles cycles properly avoiding infinite loops.

Part 2. Continuing with the previous problem, you are asked to write a program that checks if a route exists between two cities and if so, provides the shortest route.

In the first step, you are to expand the knowledge by adding distances for the direct flights. E.g.,

```
% knowledge base
...
flight(istanbul, antalya). % the fact that Istanbul and Antalya has a flight.
distance(istanbul, antalya, 481). % flight distance – calculated using
                                % https://www.distancecalculator.net
% complete all the flights and distances ...
...
```

A query to complete your program should check if there is a direct route between two given cities and the shortest distance between them. See the following example:

```
?- sroute(edremit,erzincan,X).
X = 1044 ;
```

Part 3. You are given the following database about classes, classrooms and student enrollment.

Classes		
Class	Time	Room
102	10	z23
108	12	z11
341	14	z06
455	16	207
452	17	207

Enrollment	
Student	Class
a	102
a	108
b	102
c	108
d	341
e	455

Write the predicates “when(X,Y) – time of the course X is Y”, “where(X,Y) – place of the course X is Y”, and “enroll(X,Y) – student X is enrolled in course Y”. For example:

```
% facts..
when(102,10).
```

3.1. Define/write a predicate “schedule(S,P,T)” that associates a student to a place and time of class. See the example query and its result.

```
?- schedule(a,P,T).
```

```
P = 102
```

```
T = 10 ;
```

```
P = 108
```

```
T = 12 ;
```

3.2. Define/write another predicate “usage(P,T)” that gives the usage times of a classroom. See the example query and its result.

```
?- usage(207,T).
```

```
T = 455 ;
```

```
T = 456 ;
```

3.3. Define/write another predicate “conflict(X,Y)” that gives true if X and Y conflicts due to classroom or time.

3.4. Define/write another predicate “meet(X,Y)” that gives true if student X and student Y are present in the same classroom at the same time.


Part 4. Write the following predicates operating on sets.

4.1. Define a Prolog predicate “element(E,S)” that returns true if E is in S.

4.2. Define a Prolog predicate “union(S1,S2,S3)” that returns true if S3 is the union of S1 and S2.

4.3. Define a Prolog predicate “intersect(S1,S2,S3)” that returns true if S3 is the intersection of S1 and S2.

4.3. Define a Prolog predicate “equivalent(S1,S2)” that returns true if S1 and S2 are equivalent sets.

Part 5.  Given a list of integers, find a correct way of inserting arithmetic (operators) such that the result is a correct equation. Example: With the list of numbers [5,3,5,7,49] we can form the equations $(5-3+5*7) = 11$. Please pay attention to the **arithmetic operator precedence**.



Part 6. In this part you will solve a puzzle, Essentially, each row and column of a rectangular bitmap is annotated with the respective lengths of its distinct strings of occupied cells. The person who solves the puzzle must complete the bitmap given only these lengths.

Problem statement:

Solution:

_ _ _ _ _ _ _ 3	_ X X X _ _ _ _ 3
_ _ _ _ _ _ _ 2 1	X X _ X _ _ _ _ 2 1
_ _ _ _ _ _ _ 3 2	_ X X X _ _ X X 3 2
_ _ _ _ _ _ _ 2 2	_ _ X X _ _ X X 2 2
_ _ _ _ _ _ _ 6	_ _ X X X X X X 6
_ _ _ _ _ _ _ 1 5	X _ X X X X X _ 1 5
_ _ _ _ _ _ _ 6	X X X X X X _ _ 6
_ _ _ _ _ _ _ 1	_ _ _ X _ _ _ _ 1
_ _ _ _ _ _ _ 2	_ _ _ X X _ _ _ _ 2
1 3 1 7 5 3 4 3	1 3 1 7 5 3 4 3
2 1 5 1	2 1 5 1

For the example above, the problem can be stated as the two lists $[[3],[2,1],[3,2],[2,2],[6],[1,5],[6],[1],[2]]$ and $[[1,2],[3,1],[1,5],[7,1],[5],[3],[4],[3]]$ which give the

"solid" lengths of the rows and columns, top-to-bottom and left-to-right, respectively.

Test Cases: Top-to-bottom or Left-to-right

1. ($[[3], [2,1], [3,2], [2,2], [6], [1,5], [6], [1], [2]],$
 $[[1,2], [3,1], [1,5], [7,1], [5], [3], [4], [3]]$)
2. ($[[3,1], [2,4,1], [1,3,3], [2,4], [3,3,1,3], [3,2,2,1,3], [2,2,2,2,2],$
 $[2,1,1,2,1,1], [1,2,1,4], [1,1,2,2], [2,2,8], [2,2,2,4], [1,2,2,1,1,1],$
 $[3,3,5,1], [1,1,3,1,1,2], [2,3,1,3,3], [1,3,2,8], [4,3,8], [1,4,2,5], [1,4,2,2],$
 $[4,2,5], [5,3,5], [4,1,1], [4,2], [3,3]],$
 $[[2,3], [3,1,3], [3,2,1,2], [2,4,4], [3,4,2,4,5], [2,5,2,4,6], [1,4,3,4,6,1],$
 $[4,3,3,6,2], [4,2,3,6,3], [1,2,4,2,1], [2,2,6], [1,1,6], [2,1,4,2], [4,2,6],$
 $[1,1,1,1,4], [2,4,7], [3,5,6], [3,2,4,2], [2,2,2], [6,3]]$)
3. ($[[5], [2,3,2], [2,5,1], [2,8], [2,5,11], [1,1,2,1,6], [1,2,1,3],[2,1,1],$
 $[2,6,2], [15,4], [10,8], [2,1,4,3,6], [17], [17], [18], [1,14], [1,1,14], [5,9],$
 $[8], [7]], [5], [3,2], [2,1,2], [1,1,1], [1,1,1], [1,3], [2,2], [1,3,3],$
 $[1,3,3,1], [1,7,2], [1,9,1], [1,10], [1,10], [1,3,5], [1,8],$
 $[2,1,6],[3,1,7], [4,1,7], [6,1,8], [6,10], [7,10], [1,4,11], [1,2,11], [2,12],$
 $[3,13]]$)