### Course: CS420 - Artificial Intelligence

03 – Constraint Satisfaction Problems

**Question 1.** You are designing a menu for a special event. The menu includesfour dishes, each of which is a variable: **(A)**ppetizer, **(B)**everage, main **(C)**ourse, and **(D**)essert.

The domains of the variables are as follows:

**A:** **(v)**eggies, **(e)**scargot

**B: (w)**ater, **(s)**oda, **(m)**ilk

**C: (f)**ish, **(b)**eef, **(p)**asta

**D: (a)**pple pie, **(i)**ce cream, **(ch)**eese

Because all of your guests get the same menu, it must obey the following dietary constraints:

(i) Vegetarian options: If you serve the veggies, you must avoid everything made of meat (red meat, poultry, seafood, etc.)

(ii) Dairy products lover: You must serve at least one of milk, ice cream, or cheese.

(iii) Digestible: The main course must be fish or the beverage must be water or soda.

Formulate the problem as a CSP, stating the variables and corresponding domains.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | A | B | C | D |
| Domains | v,e | w,s,m | f,b,p | a,i,ch |

Binary constraints:

|  |  |  |
| --- | --- | --- |
| A and C (constraint i) | B and C (constraint iii) | B and D (constraint ii) |

|  |  |
| --- | --- |
| Draw the constraint graph associated with your CSP, in which each node represents a variable and an edge connecting two nodes represents the relation between the two variables denoted by these nodes. | A black and white diagram  Description automatically generated |

Again imagine we first assign A=v. Cross out eliminated values to show the domains of the variables after arc consistency has been enforced.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | A | B | C | D |
| Domains | **v** | w,s, ~~m~~ | ~~f,b~~,p | ~~a,~~i,ch |

Give a solution for this CSP or state that none exists.

One of many solutions: A = v, B = w, C = p, D = i

|  |  |
| --- | --- |
| **Question 2.** You are a map-coloring robot assigned to color the given map. Adjacent regions must be colored a different color (R=Red, B=Blue, G=Green).   1. Draw the constraint graph | A map of the country  Description automatically generated |

1. Find a solution by using backtracking search with appropriate heuristics (MRV, DH, and LCV). Explain your answer in detail.

LCV is implicitly implemented by the order of coloring: R, G, and B.

* Initially, all vertices have the same MRV = 3. Kien Giang has the highest DH = 5 → Kien Giang: Red (Figure A)
* An Giang, Bac Lieu, Ca Mau, Can Tho and Hau Giang have the same lowest MRV = 2. Bac Lieu and Hau Giang have the same highest DH = 3. Choose randomly among those vertices → Bac Lieu: Green (Figure B)
* Ca Mau and Hau Giang have the same lowest MRV = 1. Hau Giang has a higher DH = 2 → Hau Giang: Blue (Figure C)
* Can Tho, Ca Mau, and Soc Trang have the same lowest MRV = 1. Can Tho has the highest DH = 1 → Can Tho: Green (Figure D)
* Remaining vertices are isolated ones → Soc Trang: Red, Ca Mau: Blue, An Giang: Blue

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| A | B | C | D |

A network with colorful circles and letters

Description automatically generated