King Fahd University of Petroleum & Minerals

College of Computing and Mathematics

Information and Computer Science Department

ICS 381: Principles of AI – (242)

For questions contact Qasim (qasim.umer@kfupm.edu.sa)
and Mumin (g201708690@kfupm.edu.sa)

Problem 1 (20 total points)

ABC University wants to start a new degree program: B.S in Judgment Day Prevention (JDP).

Suppose the degree program is associated with the following courses:

15-211 Fundamental Data Structures and Algorithms

15-212 Principles of Programming

15-381 Artificial Intelligence: Representation and Problem-Solving

15-681 Machine Learning

80-310 Logic and Computation

21-484 Graph Theory

70-122 Accounting

70-311 Organizational Behavior

19-601 Information Warfare

In order to graduate from the degree program, one must complete the following four requirements:

Algorithms Requirement: (**15-211** AND **15-212**) OR (**15-211** AND **15-381**) OR (**15-681** AND **21484**)

Machine Learning Requirement: 15-381 OR **15-681** OR **80-310**

Communications Requirement: 21-484 OR **70-311** OR **70-122**

Information Warfare Requirement: 15-381 OR **19-601**

In addition, the department imposes the following restrictions:

Information Aggressiveness Restriction: So that they can't make their programs TOO smart, students can take only one class from the set **15-381**, **15-681**, and **19-601**.

Basic Arithmetic Restriction: Students can't take both **15-211** and **70-122**.

Organization Restriction: Students can't take both **21-484** and **70-311**.

Finally, courses cannot be used to count towards multiple graduation requirements - so if you use 15-381 to fulfill part of the Algorithms requirement it can't count towards either the Machine Learning Requirement or the Information Warfare Requirement.

Question 1.1 (5 points)

John Conner just started his junior year at ABC, and needs to graduate as soon as possible. Suppose all he has left to take are JDP required classes. Model the problem of his trying to find a set of classes to satisfy all requirements as a CSP (Hint: the requirements should be your variables). What are the initial domains for each of your variables?

5 variables - AR 1,AR 2,MLR,CR,IWR

4 constraints -

1. IAR says ≤ 1 of 15-381, 15-681, and 19-601 can be assigned to the 5 variables.
2. BAR says ≤ 1 of 15-211 and 70-122 can be assigned to the 5 variables
3. OR says ≤ 1 of 21-484 and 70-311 can be assigned to the 5 variables
4. No double counting says if a variable is assigned to one variable it can't be assigned to another variable

Initial domains:

AR1	15-211, 15-212, 15-381, 15-681, 21-484
AR_2	15-211, 15-212, 15-381, 15-681, 21-484
MLR	15-381, 15-681, 80-310
CR	21-484, 70-122. 70-311
IWR	15-381, 19-601

Question 1.2 (8 points)

Show a DFS with backtracking tree for finding a set of classes that fulfill all requirements using a variable order of the requirements in the order they are listed above, and using a value order that selects the lowest department/course number remaining in a variable's domain. Indicate which constraints were violated whenever the DFS needs to backtrack. (Note: to get full credit you must show the full DFS tree and not just the classes that are used to fulfill each requirement).

See Figure 1.

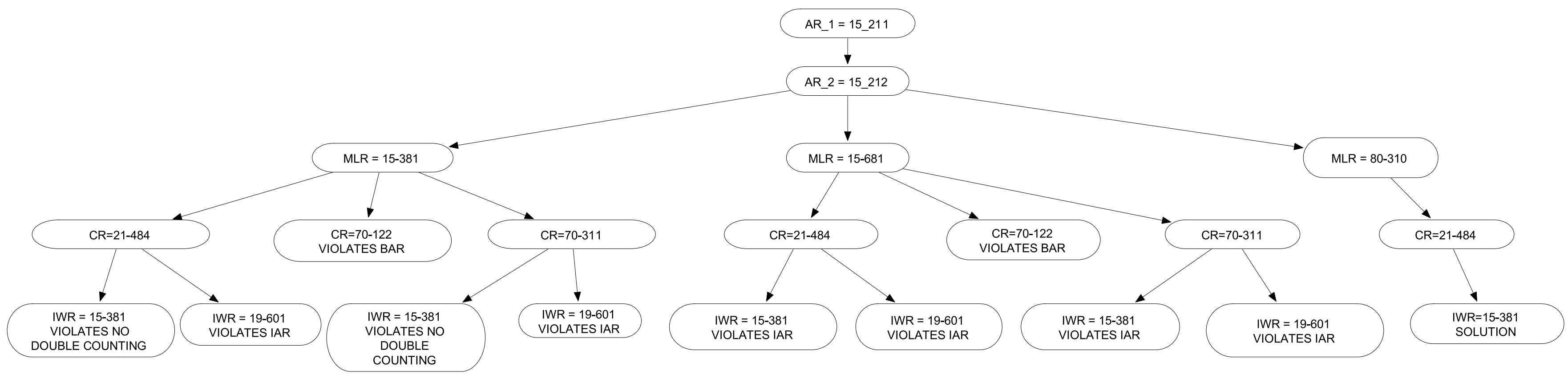


Figure1:DFStreewithbacktrackingforproblem1.2

Question 1.3 (7 points)

Suppose John has already taken **19-601** towards his Information Warfare Requirement and **15-211** towards his Algorithms Requirement. Use constraint propagation to determine other classes he must take to graduate - indicate which requirements the classes fulfill. Can you create a schedule that satisfies all constraints without using search?

AR _1 has been set to 15-211 and IWR has been set to 19-601. Forward checking can then be used as follows:

1. AR 2 domain goes from 15-212,15-381,15-681,21-484 to 15-212 due to IAR.
2. MLR domain goes to 80-310 due to IAR.
3. CR goes to 21-484,70-311 due to BAR.

Constraint propogation can then

1. MLR domain has a single member, so we select 80-310.
2. AR 2 also has a single member, so we can select 15-212.

So we have a schedule which satisfies AR 1, AR 2, MLR, and CR. But to satisfy the CR we have to select between 21-484 and 70-311 (we can't pick both). So technically we would need to do some search here to pick between them.

Problem 2 (20 total points)

Arthur is looking for a group of friends for his start-up, which develops and provides some web-based p2p downloading solutions to college students (this is before the lawsuits). Arthur has determined that he needs 2 C# Programmers, 2 Flash Designers, 1 Photoshop Guru, 1 Database Admin, and 1 Systems Engineer.

Assume that if a person knows two languages/softwares, he or she can take on two roles in the company.

So Arthurs narrowed down his selections to the following people:

Name	Abilities
Peter	C# and Flash
John	Photoshop and Flash

Jim Flash and Systems

Jane C# and Database

Mary Photoshop and Flash Bruce Systems and C#

Chuck Photoshop and Flash

Question 2.1 (5 points)

Suppose Arthur knows C#, and only has funds to hire three more people.

Model this scenario as a CSP - (using variables, value domains, and constraints).

There are a number of ways to model the domain. Variables can either be the people, the jobs, or the skills.

For the job-based variables, there are three variables, J_1,J_2 and J_3 (with J_4 already filled) representing the three openings. The domains of all three variables are initially all the people. We can then pose constraints in terms of the skills of people who fill those roles:

1. Number(J,C#) ≥ 2
2. Number(J,Flash) ≥ 2
3. Number(J,Photoshop) ≥ 1
4. Number(J,Database) ≥ 1
5. Number(J,Systems) ≥ 1

There's also a constraint that assigning someone to one job means that the person can't be assigned to another job opening.

We can also think of the skill spots as variables:

C# 1, C# 2, Flash 1, Flash 2, Photoshop, Database, and Systems.

For this, we would initial domains of

C# 1	Arthur
C# 2	Peter, Jane, Bruce
Flash 1	Peter, John, Mary, Chuck
Flash 2	Peter, John, Mary, Chuck
Photoshop	John, Jim, Mary, Chuck
Database	Jane
Systems	Jim, Bruce

We would additionally need constraints that say that one person couldn't fill both assignments of C#, and that we could only hire 3 additional people.

Anything that makes an argument for which things are variables and that properly represent the constraints (must hire at least to fill the requirements and can't hire more than three people) should get credit.

Question 2.2 (6 points)

Suppose Arthur decides to make Jim a co-founder. Arthur and Jim discover that all the developers absolutely refuse to abandon their favorite platforms, and that they can only afford two single-booted workstations.

Name	Abilities	OS
Arthur	C#	Windows
Peter	C# and Flash	Windows
John	Photoshop and Flash	Windows
Jim	Flash and Systems	FreeBSD
Jane	C# and Database	FreeBSD
Mary	Photoshop and Flash	Linux
Bruce	Systems and C#	Linux
Chuck	Photoshop and Flash	Windows

What are the domains for the two remaining positions after constraint propogation?

We'll model this using the skills formulation. We've already hired Jim and Arthur, so that means that we can't hire either Mary or Bruce, which leaves:

C# 1	Arthur
C# 2	Peter, Jane
Flash 1	Jim
Flash 2	Peter, John, Chuck
Photoshop	John, Chuck
Database	Jane
Systems	Jim

We have to hire Jane to satisfy the Database requirement, and then there is only one position left to fill, so we can't hire Peter. So we must hire either John or Chuck to satisfy both Flash and Photoshop.

This leaves

C# 1	Arthur
C# 2	Jane
Flash 1	Jim
Flash 2	John, Chuck
Photoshop	John, Chuck
Database	Jane
Systems	Jim

Question 2.3 (9 points)

Assume Arthur and Jim hired Bruce and Mary and they have awarded a contract for their first project, a rush job due Friday at 5 PM. It's Monday at 9 AM and they have to put in 50 total hours of work on it by the due date. There are a number of constraints associated with their work schedules:

- They only have access to two machines of the requisite platform, and only have access to those two machines between 9 AM and 5 PM every day.
- Each person can work a maximum of 20 hours over the course of the week.
- A work session by a single person on a particular machine can last no fewer than two hours.
- Arthur cannot work from 12-4 PM Tu/Th.
- Jim can't work MWF 9-12.
- Bruce can only work between noon and 2 PM every day.
- Mary can only work Thursday and Friday.

Model this scheduling problem as a CSP. Indicate how the indicated constraints impact the domains for all variables.

I will make the variables the hours of the day (as there are no constraints on half hour periods), where each day has values 1-8 for each of the two computers. This gives a variable domain T of

$$T = M11 - M81$$

$$M12 - M82$$

$$TU11 - TU81$$

$$TU12 - TU82$$

$$W11 - W81$$

$$W12 - W82$$

$$TH11 - TH81$$

$$TH12 - TH82$$

$$F11 - F81$$

$$F12 - F82$$

We can assign these hours one of 5 variables: A (Arthur), Jim(J), Bruce(B), Mary(M) or N(No one).

First we have the total hours for the project requirement, where total function counts over all variables in T: Total(T,N) $\geq$ 50.

Then we have constraints associated with the hour limits for each person:

- Total(T,A) $\leq$ 20
- Total(T,J) $\leq$ 20
- Total(T,B) $\leq$ 20
- Total(T,M) $\leq$ 20

Now we have the sessions are at least two hours on an individual constraint:

Assigning a given hour variable ($X_i^k = y$) implies ($X_{i+1}^k = y$) or (X_{i-1}^k)

Then we have individual people's constraints:

Arthur's constraint: $(TU_4^k - TU_6^k) \wedge (TH_4^k - TH_4^k) \neq A$ for $k = 1, 2.$

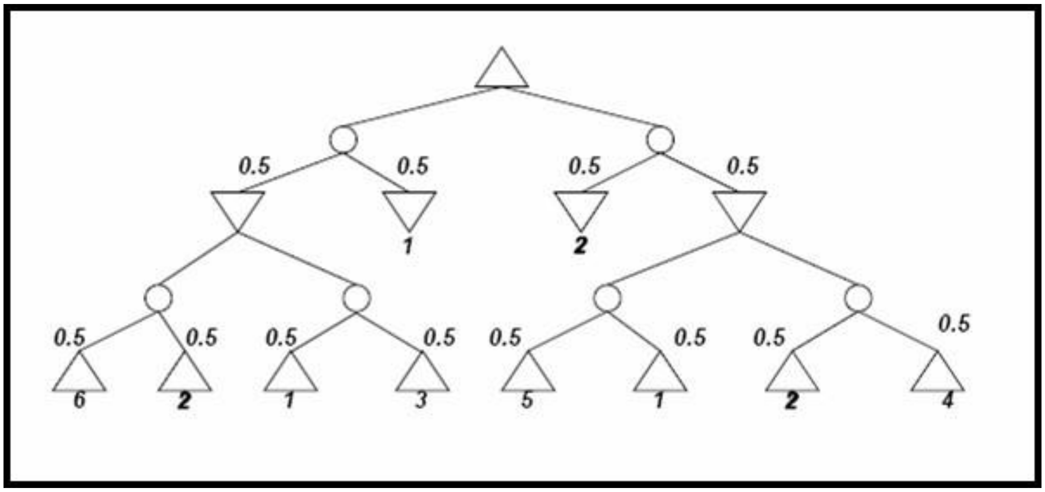
Jim's constraint: $(M_1^k - M_3^k) \wedge (W_1^k - W_3^k) \wedge (F_1^k - F_3^k) \neq J$ for $k = 1, 2.$

Bruce's constraint:$(X_1^k - X_3^k) \wedge (X_6^k - X_8^k) \neq B$ for $X = M, TU, W, TH, F$ and $k = 1,2$.

Mary's constraint:$(M_x^k) \wedge (TU_x^k) \wedge (W_x^k) \neq M$ for $X = 1, 2, \ldots,$ 8 and $k = 1,2$.

Problem 3 (20 total points)

Determine the values of all nodes in the following game tree with chance nodes using Expectiminimax. The utilities of terminal nodes are indicated below the leaf nodes and the probabilities of chance nodes are next to the corresponding branches.



Just propagate the expected utilities from the leaves upward.