

Part 1

Question 1: Show what happens to the variable domains when forward-checking is employed after each of the first two decisions:

a. CA is assigned B.

b. AZ is assigned O.

	CA	NV	UT	AZ	CO	NM	TX
Initial Domains	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O
CA is assigned B	Ⓟ	R Y O	R B Y O	R Y O	R B Y O	R B Y O	R B Y O
AZ is assigned O	Ⓟ	R Y	R B Y	Ⓞ	R B Y	R B Y	R B Y O

a. NV and AZ remove 'B' in their domains.

b. NV, UT, and NM remove 'O' in their domains

---

Question 2: Using maintaining arc consistency instead of forward checking.

	CA	NV	UT	AZ	CO	NM	TX
Initial Domains	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O	R B Y O
CA is assigned B	Ⓟ	R Y O	R B Y O	R Y O	R B Y O	R B Y O	R B Y O
AZ is assigned O	Ⓟ	R Y	R B Y	Ⓞ	R B Y	R B Y	R B Y O

a. Check (CA, NV) → (CA, AZ) → (AZ, NM) → (AZ, CO) → (AZ, UT) → (AZ, NV) → (NV, UT) → (NV, AZ): NV and AZ remove 'B' in their domains.

b. Check (AZ, NV) → (AZ, UT) → (AZ, CO) → (AZ, NM) → (NV, UT) → (UT, CO) → (CO, NM) → (NM, CO) → (NM, TX): NV, UT, CO, and NM remove 'O' in their domains

---

Question 3: Show how the conflict sets would be updated for these two moves if we were using conflict-directed backjumping.

$\{\}$  ← Conflict set ;  $\bigcirc$  ← Assigned

Conflict set	CA	NV	UT	AZ	CO	NM	TX
Initial set							
CA is assigned B	$\bigcirc_R$	{ CA= R }		{ CA= R }			
AZ is assigned O	$\bigcirc_R$	{ CA= R, AZ=O }	{ AZ=O }	$\bigcirc_O$	{ AZ=O }	{ AZ=O }	

Question 4: Suppose students have the following set of simplified constraints:

- Students cannot be enrolled in overlapping courses.
- Students cannot enroll in classes on days that they work.
- A student may not enroll in a course that does not have space.

a. Write a specification for this constraint satisfaction problem.

Variables:

Divide a student's timetable into four parts.

- MW 14:00~15:15  $\rightarrow S_iMW1$  (A period, 14:00 to 15:15, of Student i on Monday and Wednesday)
- MW 15:00~16:15  $\rightarrow S_iMW2$  (A period, 15:00 to 16:15, of Student i on Monday and Wednesday)
- TTh 14:00~15:30  $\rightarrow S_iTTh2$  (A period, 14:00 to 15:30, of Student i on Tuesday and Thursday)
- TTh 18:00~19:15  $\rightarrow S_iTTh2$  (A period, 18:00 to 19:15, of Student i on Tuesday and Thursday)

One student has 4 periods, so we have  $i*4$  variables.

For example,

Variables= {  $S_1MW1$ ,  $S_1MW2$ ,  $S_1TTh1$ ,  $S_1TTh2$ ,  $S_2MW1$ ,  $S_2MW2$ ,  $S_2TTh1$ ,  $S_2TTh2$ , ... }

Domain:

Four Courses,  $C_1$ ,  $C_2$ ,  $C_3$  and  $C_4$ . One Empty, E, and a Work, W.

$C_1$ : A course whose Tutorial is 1

E: The period is free.

$C_2$ : A course whose Tutorial is 2

W: Students work either days.

$C_3$ : A course whose Tutorial is 3

$C_4$ : A course whose Tutorial is 4

For example,

$S_1MW1 = W$  means  $S_1$  works either Monday or Wednesday.

$S_2MW1 = C_1$  means  $S_2$  take a course  $C_1$ .

Constraints:

1.  $MW1$  and  $MW2$  cannot take course simultaneously. If  $MW1 = C_1$ , the other must be  $E$ .
2.  $TTh1$  and  $TTh2$  cannot take course simultaneously. If  $TTh1 = C_1$ , the other must be  $E$
3. If  $MW_x$  is  $W$  then the other must be  $W$  as well.  $\rightarrow MW1 = W \leftrightarrow MW2 = W$
4. If  $TTh_x$  is  $W$  then the other must be  $W$  as well.  $\rightarrow TTh1 = W \leftrightarrow TTh2 = W$
5. The number of  $C_x$  cannot be more than 30. E.g. Cannot be more than 30 students taking  $C_1$ .

b. Show how encapsulation could be used to create a binarize the constraint between multiple students the enrollment limit.

i. Students cannot be enrolled in overlapping courses. & ii. Students cannot enroll in classes on days that they work.

Combine  $MW1$  and  $WM2$  into a set and  $TTh1$  and  $TTh2$  into a set. The elements in a set cannot be two  $C_i$  or more. Also, if an element is  $W$ , the other must be  $W$  too.

E.g.  $U_{i,ii} = [ \{ S_1MW1 = C1, S_1MW2 = C2 \}, \{ S_1MW1 = C1, S_1MW2 = E \}, \{ S_1TTh1 = C3, S_1TTh2 = W \}, \{ S_1TTh1 = E, S_1TTh2 = C4 \}, \dots ]$

$\{ S_1MW1 = C1, S_1MW2 = C2 \} = \text{False}$

$\{ S_1MW1 = C1, S_1MW2 = E \} = \text{True}$

$\{ S_1TTh1 = C3, S_1TTh2 = W \} = \text{False}$

$\{ S_1TTh1 = W, S_1TTh2 = W \} = \text{True}$

$\{ S_1TTh1 = E, S_1TTh2 = W \} = \text{False}$

$\{ S_1TTh1 = E, S_1TTh2 = C4 \} = \text{True}$

iii. A student may not enroll in a course that does not have space:

We can combine all  $S_xMW1$  to be a set and count how many  $C1$ . If the number of  $C1$  is larger than 30 then it conflicts. Following this rule, we can combine different  $MW$  and  $TTh$  to be sets respectively.

E.g.  $U_{iii} = [ \{S_1 = C1, S_2 = C1, S_3 = C1, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C1\dots\}, \{S_1 = C2, S_2 = C2, S_3 = C2, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C2\dots\}, \{S_1 = C3, S_2 = C3, S_3 = C3, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C3\dots\}, \{S_1 = C4, S_2 = C4, S_3 = C4, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C4\dots\} ]$ .

If  $\{S_1 = C1, S_2 = C1, S_3 = C1, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C1\dots\}$  contains more than 30 C1, then it is failure.

If  $\{S_1 = C2, S_2 = C2, S_3 = C2, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C2\dots\}$  contains more than 30 C2, then it is failure.

If  $\{S_1 = C3, S_2 = C3, S_3 = C3, S_4 = E, S_5 = E \dots, S_i = W\dots, S_j = C3\dots\}$  contains more than 30 C3, then it is failure.