CENG 462 - Artificial Intelligence Homework 2

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I.

a. Below, given problem is defined as a constraint satisfaction problem. Notice that a constraint satisfaction problem is formally defined as a triple (X, D, C), where X is a set of variables, D is a set of their respective domains of values, and C is a set of constraints.

Given scheduling problem is defined as a triple (X, D, C), where

–
$$X = \{\texttt{CENG111}, \texttt{CENG213}, \texttt{CENG223}, \texttt{CENG315}, \texttt{CENG331}, \texttt{CENG351}\}$$

–
$$D = \{(x, \delta) \mid \forall x \in X\}, \text{ where } \delta = \{(\texttt{BMB1, 09:30}), (\texttt{BMB1, 13:30}), (\texttt{BMB2, 09:30}), (\texttt{BMB2, 13:30}), (\texttt{BMB3, 13:30}), (\texttt{BMB3, 16:30})\}$$

–
$$C = \big\{\texttt{TIME[CENG213]} \neq \texttt{TIME[CENG223]}, \texttt{TIME[CENG315]} \neq \texttt{TIME[CENG331]}, \texttt{TIME[CENG331]} \neq \texttt{TIME[CENG351]}, \texttt{TIME[CENG315]} \neq \texttt{TIME[CENG351]}, \forall x \forall y \big(x \in X \wedge y \in X \wedge x \neq y \wedge (\texttt{CLASS}[x], \texttt{TIME}[x]) \neq (\texttt{CLASS}[y], \texttt{TIME}[y])\big)\big\}$$

b. Table for the application of backtracking by forward checking is given below.

CENG111	CENG213	CENG223	CENG315	CENG331	CENG351
{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}
(BMB3, 16:30)	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}
(BMB3, 16:30)	{(BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	(BMB1, 09:30)	{(BMB1, 13:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 13:30), (BMB2, 13:30), (BMB3, 13:30)}
(BMB3, 16:30)	{(BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	(BMB1, 09:30)	(BMB1, 13:30)	∅

c. Table for the application of backtracking by arc consistency is given below.

CENG111	CENG213	CENG223	CENG315	CENG331	CENG351
{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30), (BMB3, 16:30)}
(BMB3, 16:30)	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 09:30), (BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}
(BMB3, 16:30)	{(BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	{(BMB1, 13:30), (BMB2, 09:30), (BMB2, 13:30), (BMB3, 13:30)}	(BMB1, 09:30)	{(BMB1, 13:30), (BMB2, 13:30), (BMB3, 13:30)}	$\emptyset$

II.

node	v	α	β
A	5	5	$+\infty$
B	5	$-\infty$	5
C	2	5	2
D	5	5	$+\infty$
E	6	6	5
F	2	5	$+\infty$
G	–	–	–

Notice that the node G and the final states with value 0, 1, and 10 are not explored, i.e., they are pruned by the α/β pruning.

III.

a. Below, a sequence of tables are given for the forward chaining.

Step 1

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	2
$E \wedge H \implies G$	2
$E \wedge F \implies H$	2
$G \wedge A \implies E$	2
$A \wedge B \implies E$	2
$B \wedge C \implies F$	2
A	0
B	0
C	0
D	0
agenda	(A, B, C, D)

Step 2

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	2
$E \wedge H \implies G$	2
$E \wedge F \implies H$	2
$G \wedge A \implies E$	1
$A \wedge B \implies E$	1
$B \wedge C \implies F$	2
A	0
B	0
C	0
D	0
agenda	(B, C, D)

Step 3

c	count$[c]$
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	2
$E \wedge H \implies G$	2
$E \wedge F \implies H$	2
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	1
A	0
B	0
C	0
D	0
$agenda$	(C, D, E)

Step 4

c	count$[c]$
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	2
$E \wedge H \implies G$	2
$E \wedge F \implies H$	2
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
$agenda$	(D, E, F)

Step 5

c	count$[c]$
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	1
$E \wedge H \implies G$	2
$E \wedge F \implies H$	2
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(E, F)

Step 6

c	count$[c]$
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	1
$E \wedge H \implies G$	1
$E \wedge F \implies H$	1
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(F)

Step 7

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	2
$H \wedge D \implies J$	1
$E \wedge H \implies G$	1
$E \wedge F \implies H$	0
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(H)

Step 8

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	1
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	1
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(G, J)

Step 9

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	2
$G \wedge H \implies I$	0
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	0
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(J, I)

Step 10

c	count[c]
$K \implies L$	1
$I \wedge J \implies K$	1
$G \wedge H \implies I$	0
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	0
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	(I)

Step 11

c	count$[c]$
$K \implies L$	1
$I \wedge J \implies K$	0
$G \wedge H \implies I$	0
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	0
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
$agenda$	(K)

Step 12

c	count$[c]$
$K \implies L$	0
$I \wedge J \implies K$	0
$G \wedge H \implies I$	0
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	0
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
$agenda$	(L)

Final, $K \implies L$ is proved.

c	count[c]
$K \implies L$	0
$I \wedge J \implies K$	0
$G \wedge H \implies I$	0
$H \wedge D \implies J$	0
$E \wedge H \implies G$	0
$E \wedge F \implies H$	0
$G \wedge A \implies E$	0
$A \wedge B \implies E$	0
$B \wedge C \implies F$	0
A	0
B	0
C	0
D	0
agenda	()

b. Below, a sequence of steps are given for the backward chaining.

1. Start with the goal $K \implies L$. Find proof for K.
2. For K, I and J must be proved.
3. For I, G and H must be proved.
4. For J, H and D must be proved.
5. For G, E and H must be proved.
6. For H, E and F must be proved.
7. For E, A and B must be proved. Since both are in the knowledge base, E is proved and added to the knowledge base.
8. For F, B and C must be proved. Since both are in the knowledge base, F is proved and added to the knowledge base.
9. Using E and F, H is proved and added to the knowledge base.
10. Using E and H, G is proved and added to the knowledge base.
11. Using H and D, J is proved and added to the knowledge base.
12. Using G and H, I is proved and added to the knowledge base.
13. Using I and J, K is proved and added to the knowledge base.
14. Using K, L is proved; hence, the goal proposition $K \implies L$ is proved.