Q3: CSPs: Time Management

Problem 3: CSP Time Management

Two of our TAs, Arjun and Peter, are making their schedules for a busy morning. There are five tasks to be carried out:

- (F) Pick up food for the group's research seminar, which, sadly, takes one precious hour.
- (H) Prepare homework questions, which takes 2 consecutive hours.
- (P) Prepare the PR2 (robot that Pieter uses for research) for a group of preschoolers' visit, which takes one hour.
- (S) Lead the research seminar, which takes one hour.
- (T) Teach the preschoolers about the PR2 robot, which takes 2 consecutive hours.

The schedule consists of one-hour slots: 8am-9am, 9am-10am, 10am-11am, 11am-12pm. The requirements for the schedule are as follows:

a. In any given time slot each TA can do at most one task (F, H, P, S, T).
b. The PR2 preparation (P) should happen before teaching the preschoolers (T).
c. The food should be picked up (F) before the seminar (S).
d. The seminar (S) should be finished by 10am.
e. Arjun is going to deal with food pick up (F) since he has a car.
f. The TA not leading the seminar (S) should still attend, and hence cannot perform another task (F, T, P, H) during the seminar.
g. The seminar (S) leader does not teach the preschoolers (T).
h. The TA who teaches the preschoolers (T) must also prepare the PR2 robot (P).
i. Preparing homework questions (H) takes 2 consecutive hours, and hence should start at or before 10am.
j. Teaching the preschoolers (T) takes 2 consecutive hours, and hence should start at or before 10am.

Keep Constraints Always Visible

To formalize this problem as a CSP, use the variables F, H, P, S and T. The values they take on indicate the TA responsible for it, and the startin time slot during which the task is carried out (for a task that spans 2 hours, the variable represents the starting time, but keep in mind that the TA will be occupied for the next hour also - make sure you enforce constraint (a)!). Hence there are eight possible values for each variable, whi we will denote by A1, A2, A3, A4, P1, P2, P3, P4, where the letter corresponds to the TA and the number corresponds to the time slot. For example, assigning the value of A1 to a variables means that this task is carried about by Arjun from 8am to 9am.

We recommend you work out the solutions to the following questions on a sheet of scratch paper, and then enter your results below.

Part 1

1 point possible (ungraded)
What is the size of the state space for this CSP?

- **40**
- **13**
- 5^8

- ◉ 8^5
- ○ 2^5
- ○ 2^8

Submit

Part 2

1/1 point (ungraded)

Which of the statements above include unary constraints?

- ☐ a
- ☐ b
- ☐ c
- ☑ d
- ☑ e
- ☐ f
- ☐ g
- ☐ h
- ☑ i
- ☑ j

✔

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✔ Correct (1/1 point)

Part 3

3/3 points (ungraded)

Check all remaining values after enforcing all unary constraints.

F	H	P	S	T
☑ A1	☑ A1	☑ A1	☑ A1	☑ A1

☑ A2	☑ A2	☑ A2	☑ A2	☑ A2
☑ A3	☑ A3	☑ A3	☐ A3	☑ A3
☑ A4	☐ A4	☑ A4	☐ A4	☐ A4
☐ P1	☑ P1	☑ P1	☑ P1	☑ P1
☐ P2	☑ P2	☑ P2	☑ P2	☑ P2
☐ P3	☑ P3	☑ P3	☐ P3	☑ P3
☐ P4	☐ P4	☑ P4	☐ P4	☐ P4
✔	✔	✔	✔	✔

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✔ Correct (3/3 points)

Part 4

3/3 points (ungraded)

Start from the table above, select the variable S and assign the value A2 to it. Check all remaining values below after performing forward checking.

F	H	P	S	T
☑ A1	☐ A1	☑ A1	☐ A1	☐ A1
☐ A2	☐ A2	☐ A2	☑ A2	☐ A2
☐ A3	☑ A3	☑ A3	☐ A3	☐ A3
☐ A4	☐ A4	☑ A4	☐ A4	☐ A4
☐ P1	☐ P1	☑ P1	☐ P1	☐ P1
☐ P2	☐ P2	☐ P2	☐ P2	☐ P2
☐ P3	☑ P3	☑ P3	☐ P3	☑ P3
☐ P4	☐ P4	☑ P4	☐ P4	☐ P4
✔	✔	✔	✔	✔

Submit

✔ Correct (3/3 points)

Part 5

1/1 point (ungraded)

Based on the result of Part 4, what variable will we choose to assign next based on the MRV heuristic (breaking ties alphabetically)?

- (•) F ✔
- ( ) H
- ( ) P
- ( ) S
- ( ) T

Submit

✔ Correct (1/1 point)

Part 6

3/3 points (ungraded)

Assign the first possible value to the variable chosen in Part 5, then perform forward checking. Check all remaing values left below.

F	H	P	S	T
[x] A1	[ ] A1	[ ] A1	[ ] A1	[ ] A1
[ ] A2	[ ] A2	[ ] A2	[x] A2	[ ] A2
[ ] A3	[x] A3	[x] A3	[ ] A3	[ ] A3
[ ] A4	[ ] A4	[x] A4	[ ] A4	[ ] A4
[ ] P1	[ ] P1	[x] P1	[ ] P1	[ ] P1
[ ] P2	[ ] P2	[ ] P2	[ ] P2	[ ] P2
[ ] P3	[x] P3	[x] P3	[ ] P3	[x] P3
[ ] P4	[ ] P4	[x] P4	[ ] P4	[ ] P4
✔	✔	✔	✔	✔

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✔ Correct (3/3 points)

Part 7

1/1 point (ungraded)
Have we arrived at a dead end (i.e., have any of the domains become empty?

- ○ Yes
- ◉ No ✔

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✔ Correct (1/1 point)

Part 8

4/4 points (ungraded)
We return to the result from enforcing just the unary constraints, which we did in Part 3. Select the variable S and assign the value A2. Enforce arc consistency, then check all remaining values below.

F	H	P	S	T
☑ A1	☐ A1	☐ A1	☐ A1	☐ A1
☐ A2	☐ A2	☐ A2	☑ A2	☐ A2
☐ A3	☑ A3	☐ A3	☐ A3	☐ A3
☐ A4	☐ A4	☐ A4	☐ A4	☐ A4
☐ P1	☐ P1	☑ P1	☐ P1	☐ P1
☐ P2	☐ P2	☐ P2	☐ P2	☐ P2
☐ P3	☐ P3	☐ P3	☐ P3	☑ P3
☐ P4	☐ P4	☐ P4	☐ P4	☐ P4
✔	✔	✔	✔	✔

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✔ Correct (4/4 points)

Part 9

1/1 point (ungraded)
Compare your answers from Part 6 and Part 8. Which of the following statements explains the difference between the two sets of domains?

- ○ Forward checking removes more values than arc consistency because forward checking checks consistency between any pair of variables while arc consistency only checks relationships between pairs of assigned and unassigned variables.

- (•) Arc consistency removes more values than forward checking because arc consistency checks consistency between any pair of variables, while forward checking only checks relationships between pairs of assigned and unassigned variables. ✔

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✔ Correct (1/1 point)

Part 10

2/2 points (ungraded)

Examine your answer to Part 8. Without backtracking, does any solution exist along this path in the search tree? If so, mark the solution below there is no solution, leave all checkboxes unchecked.

F	H	P	S	T
☑ A1	☐ A1	☐ A1	☐ A1	☐ A1
☐ A2	☐ A2	☐ A2	☑ A2	☐ A2
☐ A3	☑ A3	☐ A3	☐ A3	☐ A3
☐ A4	☐ A4	☐ A4	☐ A4	☐ A4
☐ P1	☐ P1	☑ P1	☐ P1	☐ P1
☐ P2	☐ P2	☐ P2	☐ P2	☐ P2
☐ P3	☐ P3	☐ P3	☐ P3	☑ P3
☐ P4	☐ P4	☐ P4	☐ P4	☐ P4
✔	✔	✔	✔	✔

Submit

✔ Correct (2/2 points)