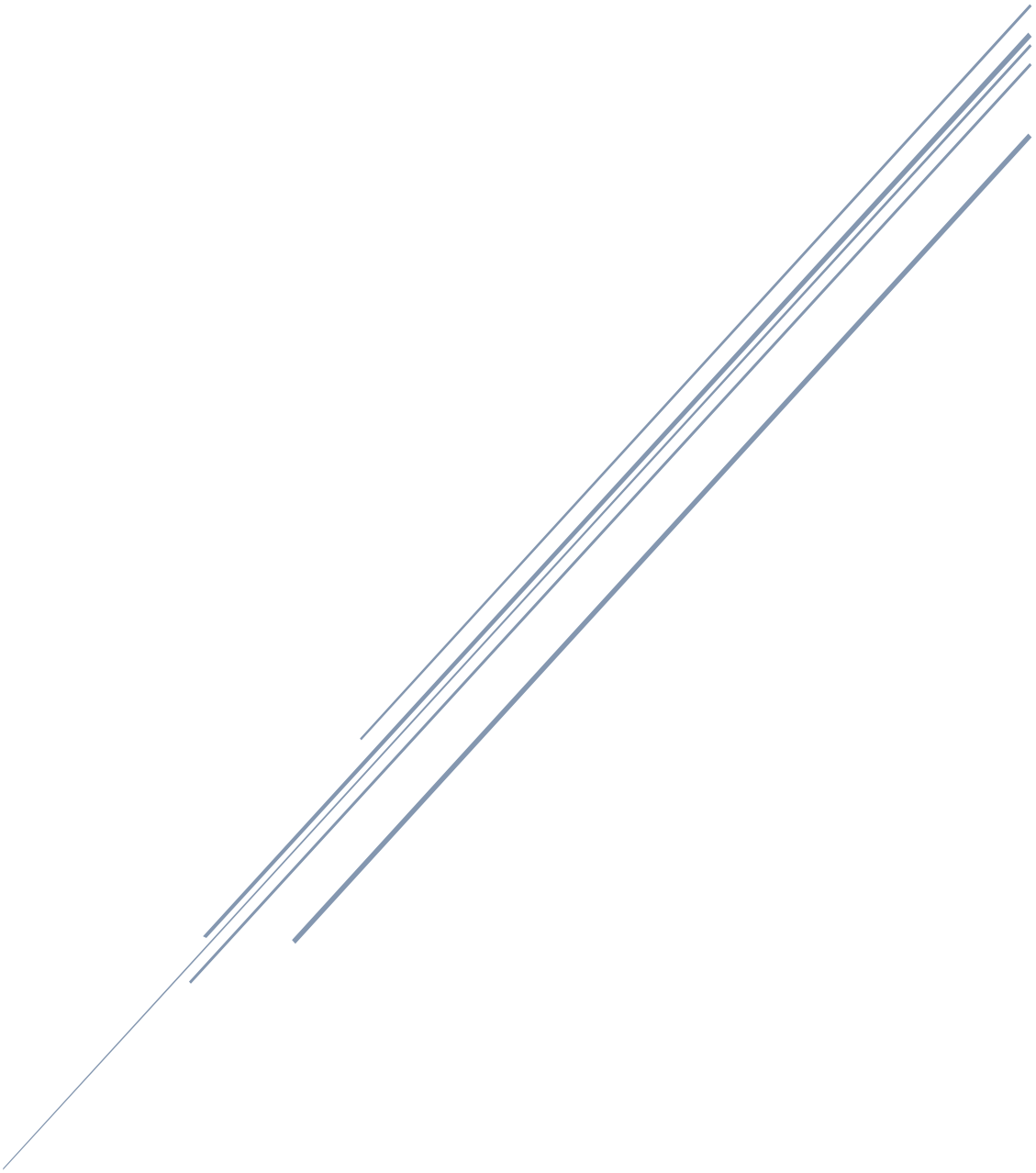
CHAPTER 3

Constraint Satisfaction Problems



Exercise 1: n-Queens problem

The n-Queens problem involves placing four queens on a n × n chessboard in such a way that no two queens attack each other. Specifically, no two queens are allowed to be positioned in the same row, column, or diagonal. We will be seeking a solution for n = 4 on a 4 × 4 chessboard.

1. Propose a CSP formulation for the 4-Queens problem (define the set of variables with their domains and the set of constraints)
2. Propose a solution for this CSP using the Backtracking Search Algorithm (without using any heuristic or inference).
3. Propose a solution for this CSP using the Backtracking Search Algorithm with Forward-Checking. Do not use any heuristic for variable and value selection.

Exercise 2: Australia map coloring

Use the AC-3 algorithm to demonstrate how arc consistency can identify the inconsistency in the partial assignment {WA = green, V = red} for the Australia map coloring problem. X = {*WA*, *NT*, *Q*, *NSW*, *V*, *SA*, *T*}, and C = { ⟨(SA, WA), SA ≠ WA⟩ , ⟨(SA, NT), SA ≠ NT⟩ , ⟨(SA, Q), SA ≠ Q⟩ , ⟨(SA, NSW), SA ≠ NSW⟩ , ⟨(SA, V), SA ≠ V⟩ , ⟨(WA, NT), WA ≠ NT⟩ , ⟨(NT, Q), NT ≠ Q⟩ , ⟨(Q, NSW), Q ≠ NSW⟩ , ⟨(NSW, V), NSW ≠ V⟩ }.

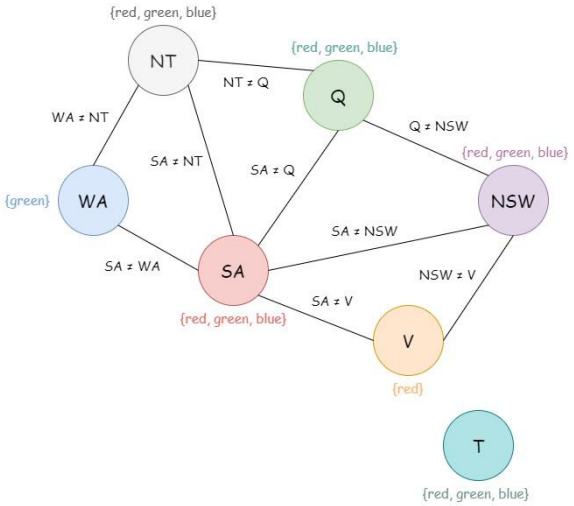


Figure 3. 1 Constraint graph for Australia map coloring problem

Exercise 3: Exam-scheduling problem

Students 1-4 are each enrolled in three courses from A, B, …, G. Every course requires an exam, and exams can be scheduled on Monday, Tuesday, or Wednesday. However, a student cannot have two exams on the same day. This can be illustrated as follows (Figure 3.21):

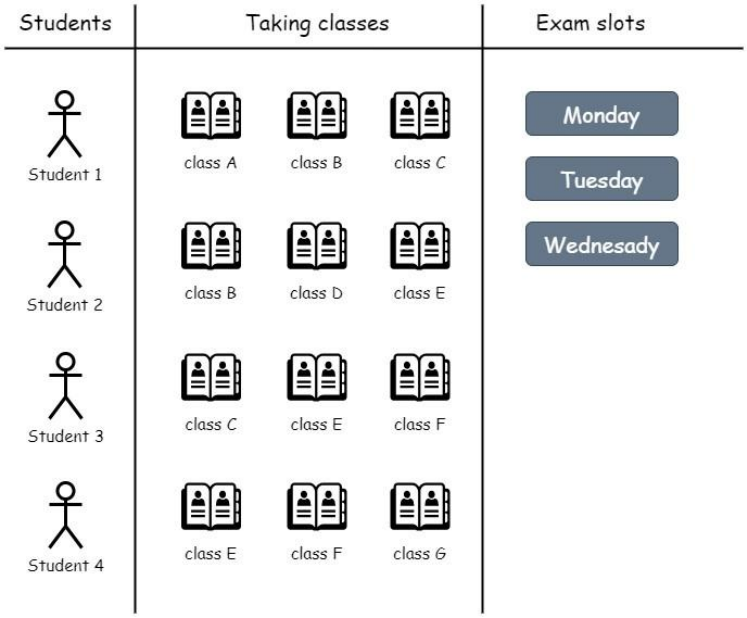


Figure 3.2 Exam scheduling problem

4. Propose a CSP formulation for the exam scheduling problem: define the variables with their domains and the constraints (give a graph representation for the constraints).
5. Propose a solution for this CSP using the Backtracking Search Algorithm with Forward-Checking. Use the MRV and the Degree heuristics for variable selection and the LCV heuristic for value selection.

Exercise 4: Office organization problem

A company has 8 coworkers W={W1, W2, W3, W4, W5, W6, W7, W8}, and four offices B={B1, B2, B3, B4}. Each office has a limited capacity, and some coworkers dislike each other, creating conflicts if placed in the same office. Additionally, some coworkers prefer to be grouped together. Furthermore, some offices are equipped with specialized facilities that some coworkers require to work. The following facts are known:

- W1 and W2 dislike each other.
- W3 and W4 dislike each other.
- W5 and W6 prefer to work in the same office.
- W1 and W7 prefer to work in the same office.
- W1, W3, and W5 require office B1 or B2 because they need specialized equipment.
- W8 requires office B3 or B4.
- B1 can hold a maximum of 3 coworkers.
- B2 can hold a maximum of 2 coworkers.
- B3 can hold a maximum of 2 coworkers.
- B4 can hold a maximum of 3 coworkers.

1- Propose a CSP formulation for the office assignment problem: define the variables with their domains and the constraints.

2- Solve this CSP using the Backtracking algorithm.

Exercise 5: Gardens problem

Three gardens in a row are planted with different flowers, tended by gardeners of different ages, and watered with different types of irrigation systems. The following facts are known:

- The garden on the left is planted with daisies.
- The garden in the middle is watered by a drip system.
- The middle garden is tended by a gardener who is 30 years old.
- The garden with roses is watered by a sprinkler system.
- The youngest gardener is 20 years old.
- The youngest gardener tends the garden with tulips.
- The oldest gardener is 40 years old.
- The garden tended by the oldest gardener is next to the garden watered with a hose.

1- Propose a CSP formulation for the garden puzzle problem: define the variables with their domains and the constraints.

2- Is this CSP arc-consistent?