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Constraint Satisfaction Problem (CSP)

⇒ Assumption about the world:

- A single agent
- Deterministic action
- Fully observed state
- Discrete state space

Planning: Sequence of action

- Path to the goal is the important thing
- Paths have various costs, depths
- Heuristics give problem-specific guidance

Identification: Assignments to variables

- The goal itself is important, not the path
- All paths at the same depth
(for some formulations)
- CSPs are a specialized class of identification problems.

Standard Search Problem

- State is a "black box": arbitrary data structure
- Goal test can be any function over states
- Successor function can also be anything.

Constraint Satisfaction Problem (CSP)

- A special subset of search problem.
- State is defined by variable X_i with value from Domain D_i .
- Goal test is a set of constraints specifying allowable combinations of values for subset of variables.

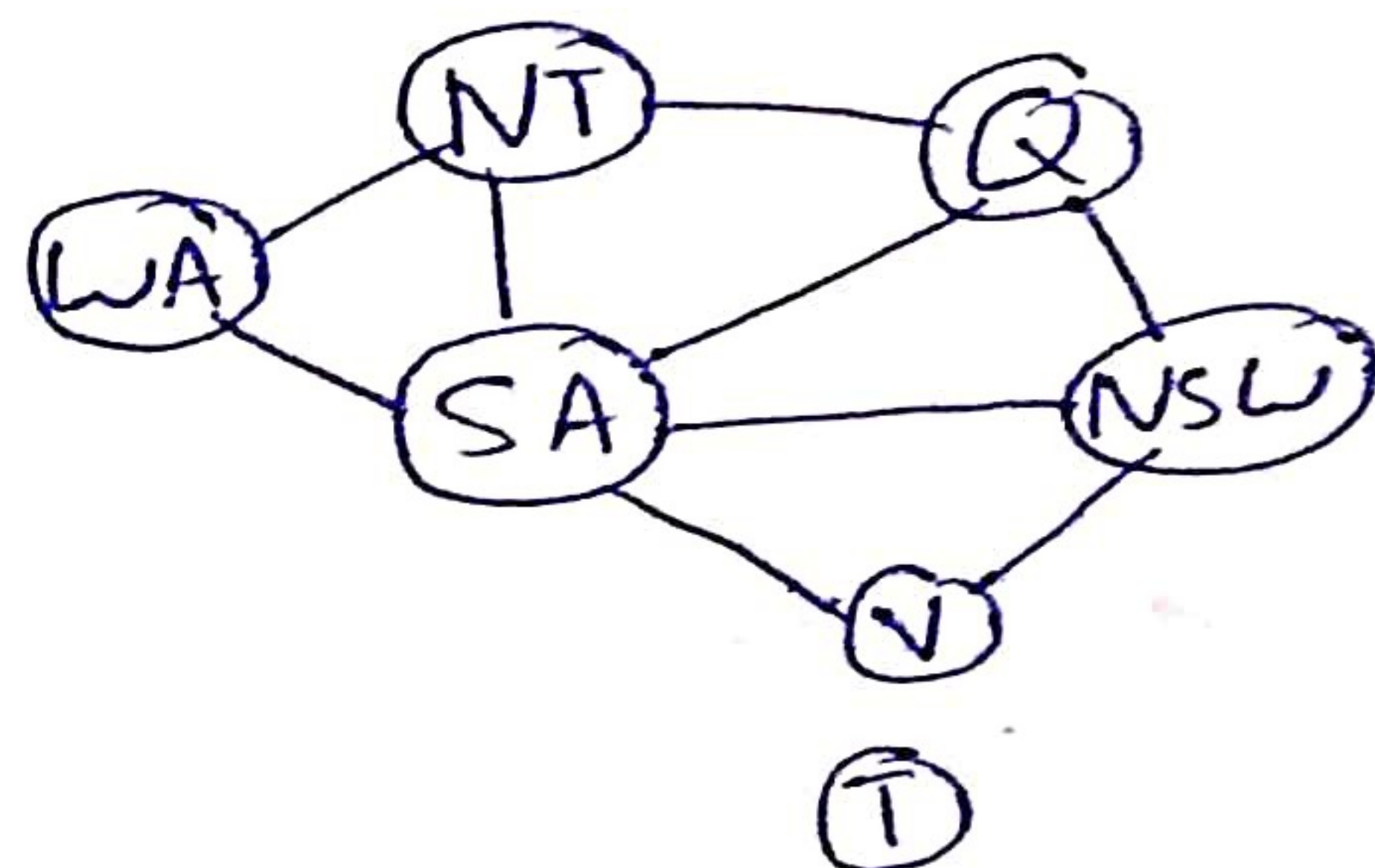
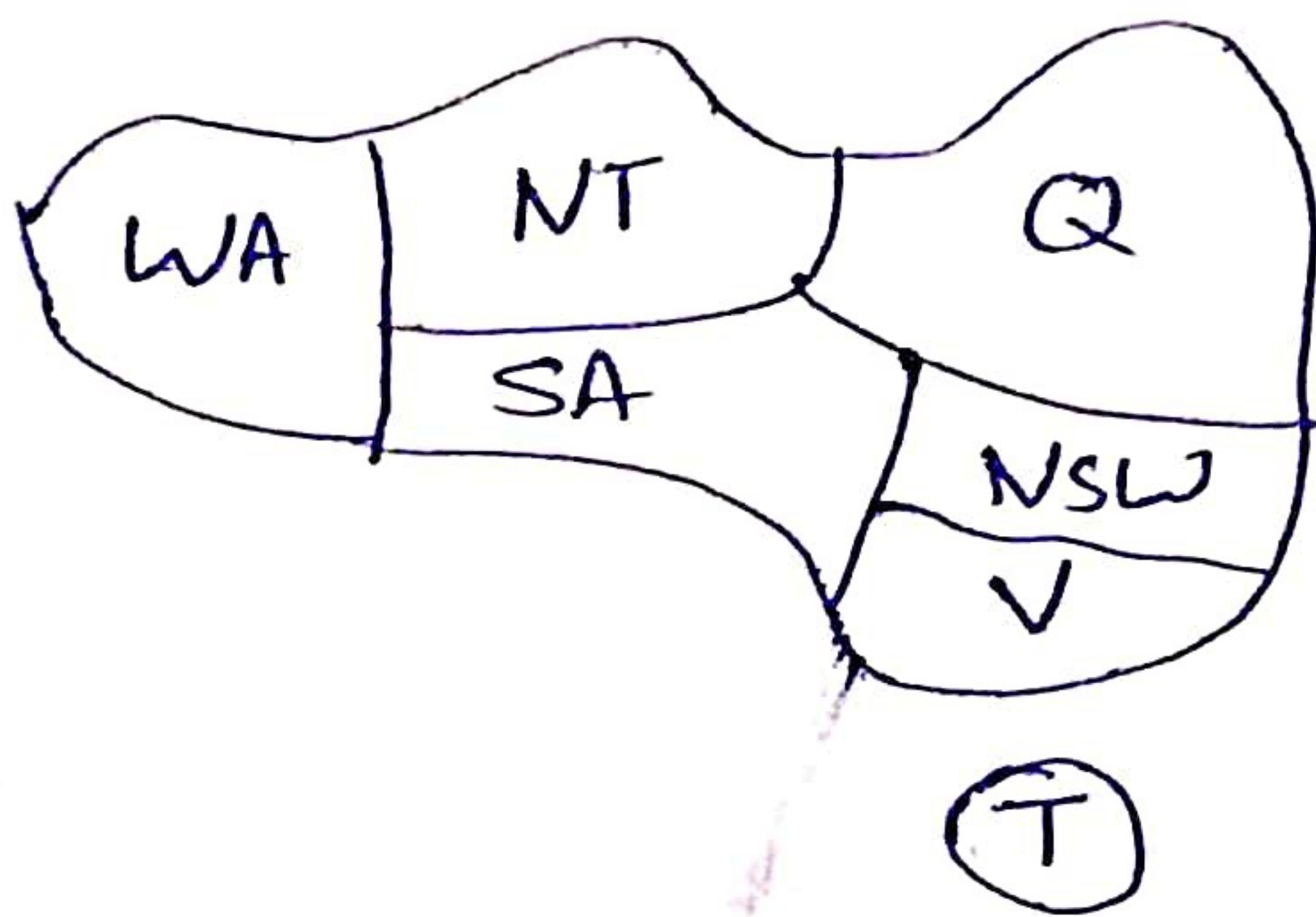
★ Example 1: Map Colouring {For Australia}

⇒ Variables: WA, NT, Q, NSW, V, SA, T
{States of Australia}

⇒ Domains: $D = \{\text{red, green, blue}\}$

⇒ Constraint: Adjacent regions must have different colour.

Constraint Graphs



⇒ Solution: An assignment satisfying all constraints.

★ Example 2: N-Queens

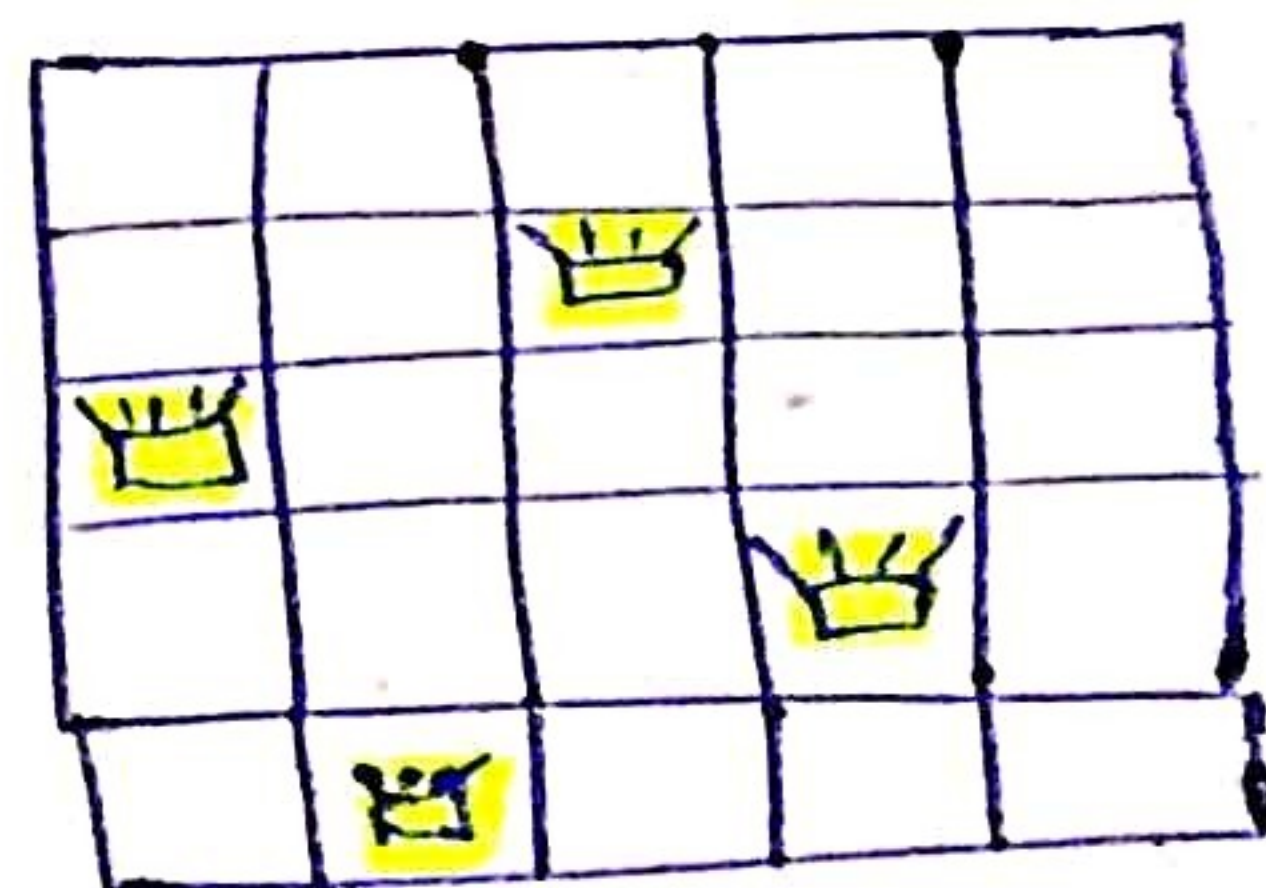
Variables: X_{ij}

Domains: $\{0, 1\}$

Constraints:

$$(1) \sum_{i,j} X_{ij} = N$$

(2) Queens are non-threatening



★ Constraint Graphs

⇒ Binary CSP: Each constraint relates (at most) two variables.

⇒ Binary Constraint Graph

↳ nodes are variables
↳ arcs show constraints

⇒ General-purpose CSP algorithms use the graph structure to speed up search.

★ Example 3: Sudoku

Variables: Each Open Square

Domain: $\{1, 2, \dots, 9\}$

Constraints:

↳ 9-way alldiff for each column
↳ 9-way alldiff for each row
↳ 9-way alldiff for each region

★ Varieties of CSPs

⊕ Discrete Variables

① Finite domain

↳ d means $O(d^n)$ complete assignments

② Infinite domain (Integers, strings etc.)

⊕ Continuous Variables

* Varieties of Constraints

- Unary constraints involve a single variable
- Binary constraints involve pairs of variables
- Higher-order constraints involve 3 or more variables.

* Preference (Soft Constraints)

- Example: red is better than green
- Often represented by a cost for each variable assignment
- Give constrained optimization problem.