INDIAN INSTITUTE OF INFORMATION TECHNOLOGY

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ज्ञानेन विकासः

Constraint Satisfaction Problems (CSPs)

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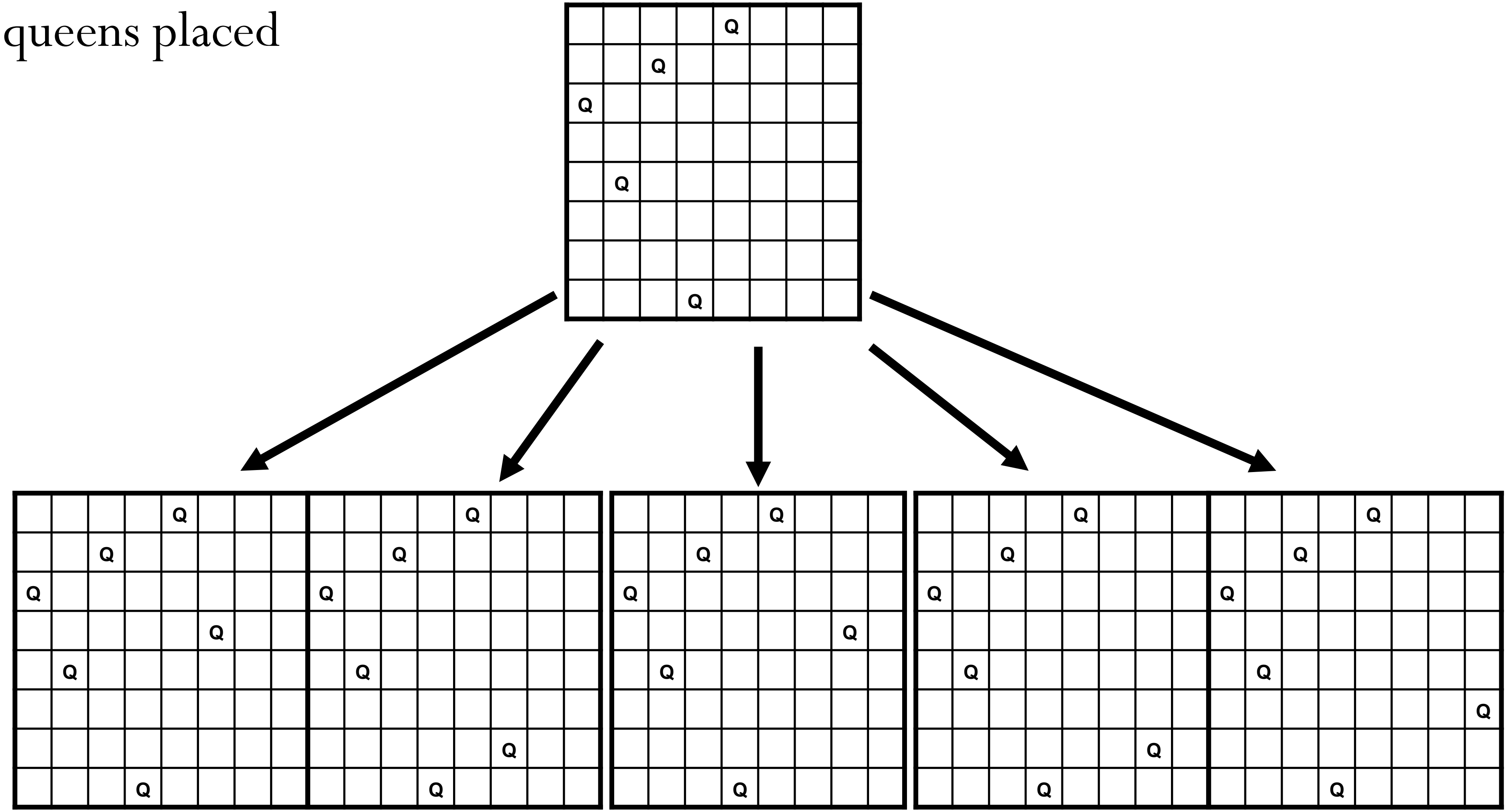
Queens puzzle

- Place eight queens on a chessboard so that no two attack each other

				Q			
		Q					
Q							
						Q	
	Q						
							Q
					Q		
			Q				

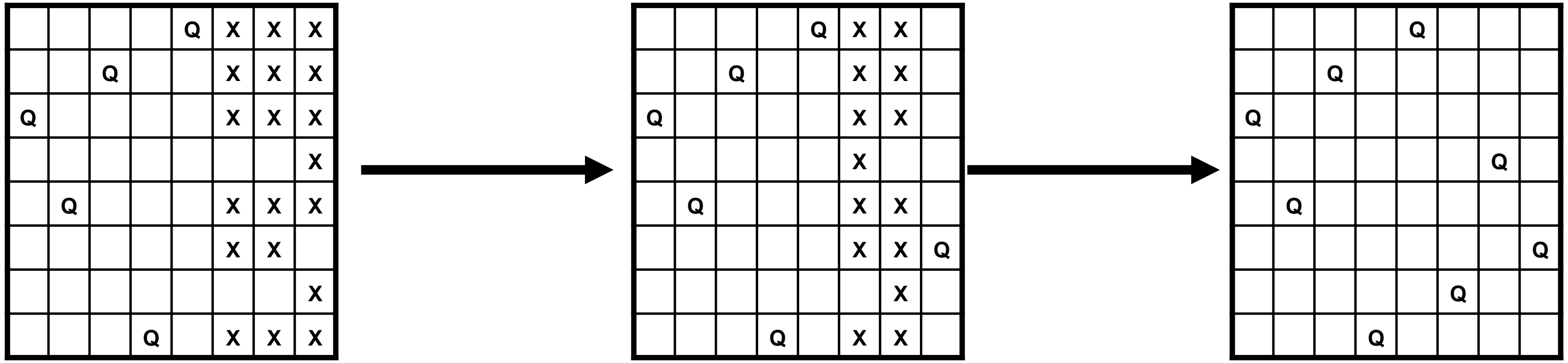
Search formulation of the queens puzzle

- Successors: all valid ways of placing additional queen on the board; goal: eight queens placed



Keeping track of remaining possible values

- For every variable, keep track of which values are still possible
- General heuristic: branch on variable with fewest values remaining



only one possibility for last column; might as well fill in

now only one left for other two columns

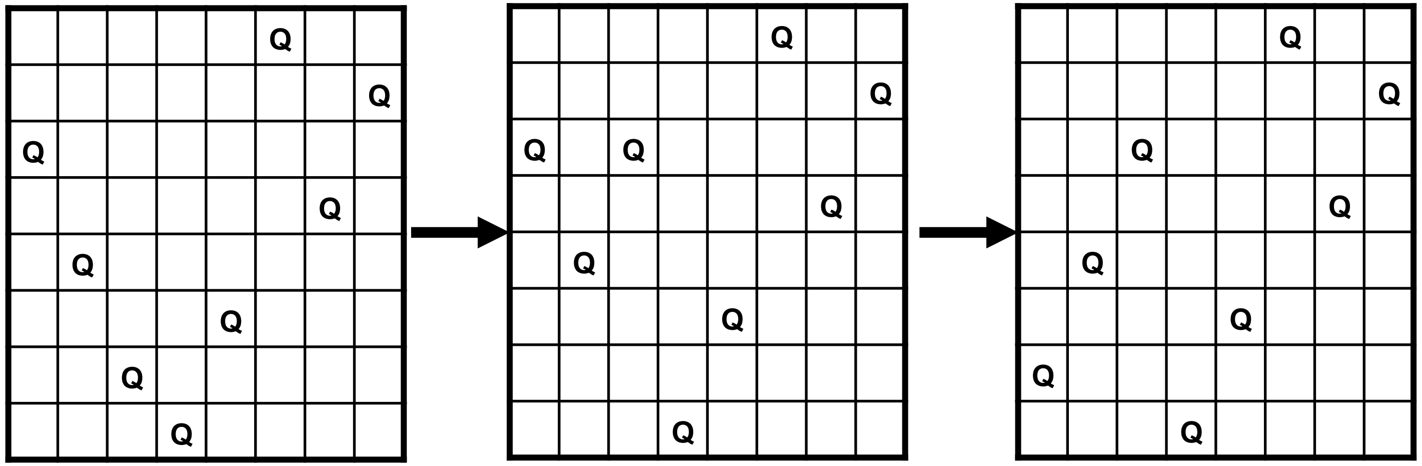
done!
(no real branching needed!)

Constraint Satisfaction Problems (CSPs)

- Defined by:
  - A set of variables $x_1, x_2, \ldots, x_n$
  - A domain D_i for each variable x_i
  - Constraints $c_1, c_2, \ldots, c_m$
- A constraint is specified by
  - A subset (often, two) of the variables
  - All the allowable joint assignments to those variables
- Goal: find a complete, consistent assignment
- Queens problem: (other examples in next slides)
  - x_i in $\{1, \ldots, 8\}$ indicates in which row in the i^{th} column to place a queen
  - For example, constraint on x_1 and x_2: $\{(1,3), (1,4), (1,5), (1,6), (1,7), (1,8), (2,4), (2,5), \ldots, (3,1), (3,5), \ldots \ldots\}$

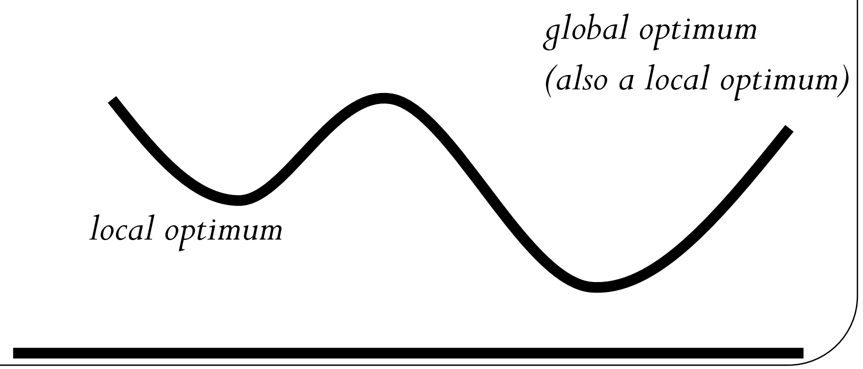
Local search: hill climbing

- Start with a complete state
- Move to successor with best (or at least better) objective value
  - Successor: move one queen within its column
- Local search can get stuck in a local optimum



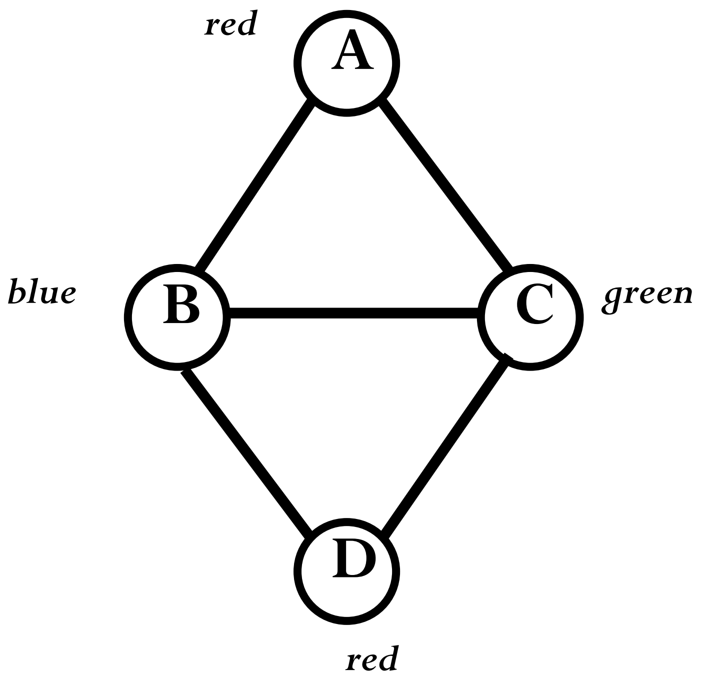
no more improvements

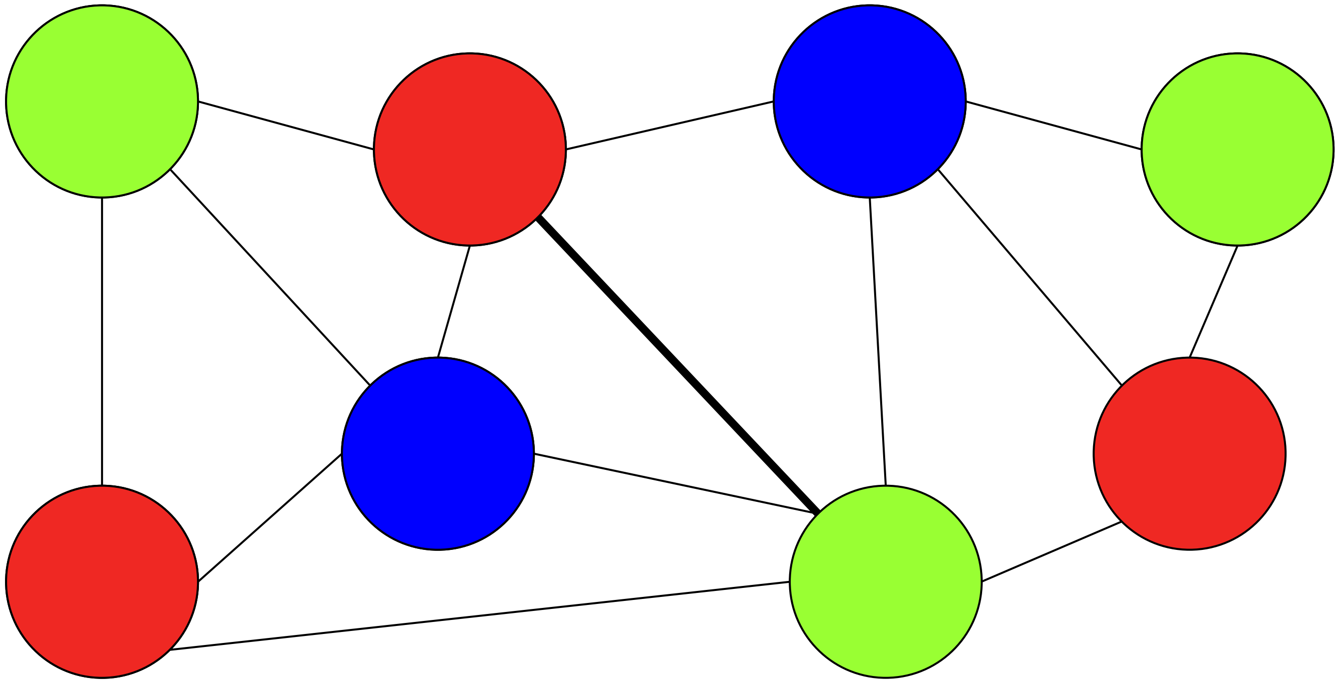
4 attacking pairs *3 attacking pairs* *2 attacking pairs*



Graph coloring

- Fixed number of colors; no two adjacent nodes can share a color





Constrained optimization

- Process of optimizing an objective function with respect to some variables in the presence of constraints on those variables.
  - primarily equality constraints, inequality constraints, and integer constraints
  - set of candidate solutions that satisfy all constraints is called the feasible set
- A general constrained minimization problem may be written as follows:

$$\begin{array}{rlll} \min & f(\mathbf{x}) & & \\ \text{subject to} & g_i(\mathbf{x}) = c_i & \text{for } i = 1, \ldots, n & \text{Equality constraints} \\ & h_j(\mathbf{x}) \geqq d_j & \text{for } j = 1, \ldots, m & \text{Inequality constraints} \end{array}$$

where $g_i(x)$ and $h_j(x)$ are constraints that are required to be satisfied, and $f(x)$ is the objective function that needs to be optimized subject to the constraints

https://en.wikipedia.org/wiki/Constrained_optimization

References

- Vincent Conitzer, CPS 270: Artificial Intelligence
  http://www.cs.duke.edu/courses/fall08/cps270/

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