CS 275, Assignment 1

Instructor: Rina Dechter Due: Wednesday, October 11

Read chapters 1 and 2 in the textbook and answer the following questions:

1. (Question 1 in chapter 1, 10 pts.) Let $R_1 = \{(a,b),(c,d),(d,e)\}$ and $R_2 = \{(b,c),(e,a),(b,d)\}$.
   (a) Compute $R_1 \cup R_2$,
   (b) Compute $R_1 - R_2$,
   (c) Assume the scope of R_1 is $\{x,y\}$ and the scope of R_2 is $\{y,z\}$ compute:
      i. $R_{xy} \bowtie R_{yz}$,
      ii. $\pi_x R_{xy}$
      iii. $\sigma_{x=c}(R_{xy} \bowtie R_{yz})$,

2. (Question 1 chapter 2, 10 pts.). Nadel [216] proposes a variant of n-queens called confused n-queens. The problem is to find all ways to place n-queens on an n by n chess board, one queen per column, so that all pairs of queens do attack each other.
   - Propose a formulation of the problem as a constraint network. Specify the variables, their domains and the set of constraints.
   - Implement your model in MiniZinc. Run it for n=8.

3. (Question 5 chapter 2, 30 pts.)
   The Zebra Problem: There are five houses in a row, each of a different color, inhabited by women of different nationalities. The owner of each house owns a different pet, serves different drinks, and smokes different cigarettes from the other owners. The following facts are also known:

   The Englishwoman lives in the red house
   The Spaniard owns a dog
   Coffee is drunk in the green house
   The Ukrainian drinks tea
   The green house is immediately to the right of the ivory house
   The Oldgold smoker owns the snail
   Kools are smoked in the yellow house
   Milk is drunk in the middle house
   The Norwegian lives in the first house on the left
   The Chesterfield smoker lives next to the fox owner
   The yellow house is next to the horse owner
   The Lucky Strike smoker drinks orange juice
   The Japanese smokes Parliament
   The Norwegian lives next to the blue house

The Question: who drinks water and who owns the zebra?

- Formulate the zebra problem as a constraint problem: provide variables, and their domains. Then provide a formal specification of the first 5 constraints (that correspond to the first 5 conditions in the order of their appearance) only. Finally draw the full primal constraint graph.
- Implement your model in MiniZinc (http://www.minizinc.org/). How difficult and time consuming was this experience? How far did you get? Did you learn from this experience? Provide the model and run it.

4. (Extra credit, Question 6b chapter 2, 20 pts.)
   - Provide two formulations for the Cryptarithmetic problem: HOCUS +POCUS = PRESTO as a constraint network. Provide the variables, domains and constraints.
   - Draw the primal and the dual constraint graphs for each formulation.
   - Discuss which formulation is superior, in your opinion.
   - Model one of the problems using one of the constraint languages: Google's CP-SAT solver or MiniZinc (http://www.minizinc.org/). Provide the model and the solution output and report how much time it took you to model the problem and how much time it took to solve it.
5. (Question 11 chapter 2, 5 pts.) Find the minimal network of the crossword puzzle (Figure 1.1 in the book) when the problem is modeled as a binary set of constraints.
6. (Question 12 chapter 2, 5 pts.) Consider the following relation ρ on variables x, y, z, t.

$$\rho(x, y, z, t) = \{(a, a, a, a)(a, b, b, b)(b, b, a, c)\}$$

   (a) Find the projection network $P(\rho)$.

   (b) Is ρ representable by a network of binary constraints? Justify you answer.