Rina Dechter, Winter-2016

ICS 275, Assignment 2

Read chapter 3 in book and answer the following questions. Whenever you are asked to generate arc, path consistent network you should not only show the end-result but show also how it is derived. You can either implement one of the known algorithms and hand-in your code, or hand-simulate one of the known algorithm. Stop when your simulation takes more then one page.

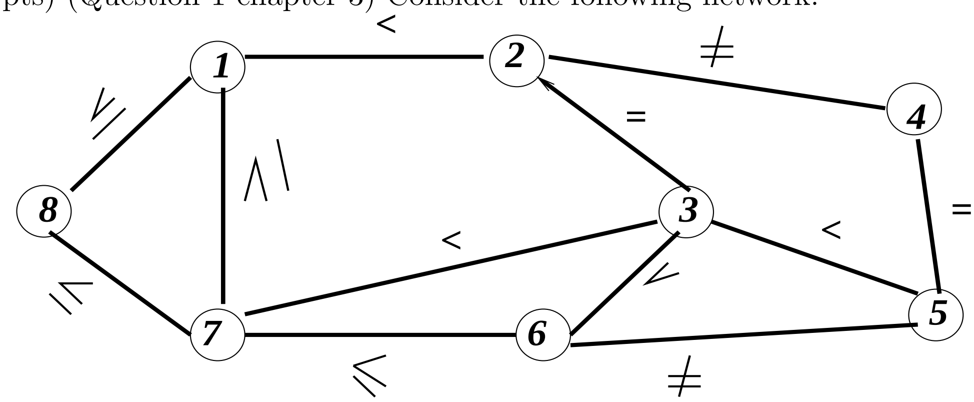
1. (Question 11 chapter 2, 5 pts.) Find the minimal network of the crossword puzzle (Figure 1.1 in the book) when the problem is modeled as a binary set of constraints.

2. (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 $P(\rho)$. Is ρ representable by a network of binary constraints? Justify you answer.

3. (20 pts) (Question 1 chapter 3) Consider the following network.

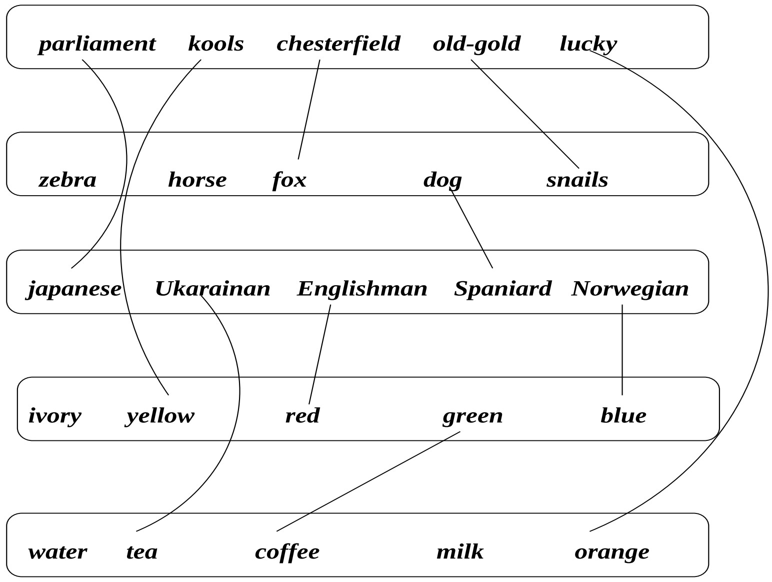


Assume that each variable has a domain of $\{1, 2, 3, 4\}$ and the constraints are the algebraic constraints.

   (a) Find an equivalent arc-consistent network.
   (b) Find an equivalent arc and path-consistent network.
   (c) Is the path-consistent network minimal?
   (d) Is the path-consistent network backtrack-free?

4. (15 pts) (Question 2 chapter 3). Consider the CSP formulation of the Zebra problem where you have 25 variables, divided into clusters and where the domains are the houses numbers (see attached figure). Is the problem arc-consistent? If not specify

an equivalent arc-consistent problem (give the revised domains). Is the problem path-consistent?



5. (20 pts extra credit)

   (a) Using Numberjack programming or Minizinc, model the Zebra problem and find a solution.

   (b) Implement arc-consistency algorithm (in Python or any other language). Submit your code and the result of running the algorithm on the formulation of the Zebra model in the previous question. Compare with your results in the previous question. How much time did it take to generate an arc-consistent network?

6. (10 pts) (question 6 chapter 3) Prove that the minimal network is always path-consistent: Any consistent pair of values can always be extended to any third variable.

7. (10 pts) (extra credit, question 7 chapter 3) Prove that a bi-valued non-empty path-consistent network is consistent. Prove that it is also the minimal network.

8. (15 pts) (question 11 chapter 3) Consistency algorithms may *effect* a constraint network by changing it (i.e., tightening domains or constraints, and adding constraints of various scope sizes).

   (a) Let $\mathcal{R}$ be an arbitrary 3-graph coloring problem, where the domain of every variable has 3 values. Discuss what would be the effect of enforcing 2-consistency on $\mathcal{R}$. What would be the effect of enforcing 3-consistency, or 4-consistency on $\mathcal{R}$.

   (b) In general, what would be the effect of enforcing $2, 3, 4, ...k-1, k, k+1$-consistency on a k-coloring problem?