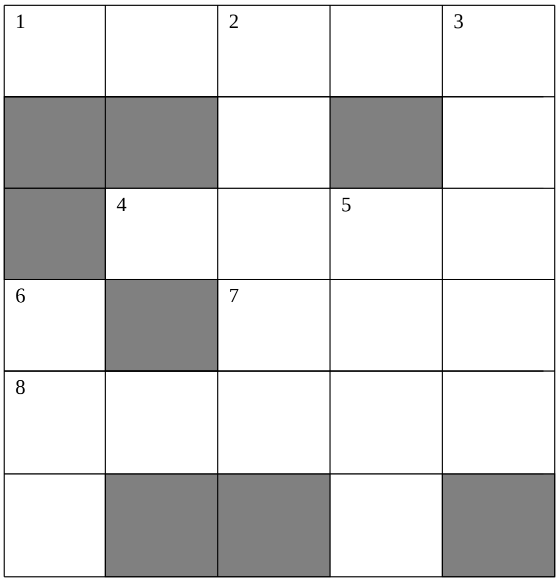
Rina Dechter, Fall-01

ICS 275a, Assignment 7

1. (NOT optional!) Read chapters 9 throughly and provide a review while answering the following questions.
   - Is the chapter clear? readable?
   - As far as you can see, does the chapter contain valuable information?
   - Is the chapter technically difficult?
   - Enough examples and illustrations?
   - Any typos? technical inaccuracies?
   - Are the algorithm's code clear?
   - What do you want to see more of? less of?
   - Please provide an overall evaluation
2. (NOT optional!) Read chapters 10 throughly and provide a review while answering the following questions.
   - Is the chapter clear? readable?
   - As far as you can see, does the chapter contain valuable information?
   - Is the chapter technically difficult?
   - Enough examples and illustrations?
   - Any typos? technical inaccuracies?
   - Are the algorithm's code clear?
   - What do you want to see more of? less of?
   - Please provide an overall evaluation
3. Consider the crossword puzzle:



Word List

aft	laser
ale	lee
eel	line
heel	sails
hike	sheet
hoses	steer
keel	tie
knot	

(a) Is the crossword puzzle an acyclic constraint network? Justify your answer.

(b) Consider the (primal) constraint graph of the problem and an ordering that has a minimum induced-width.
a. Create the set of cliques that will be generated by tree-clustering and provide one tree-decomposition.
b. Using the tree of cliques you created generate the actual constraint for each cliques so that the original problem is equivalent to the tree-structured problem. State explicitly the join-tree you created.
c. Apply CTE (show the messages schematically).
d. Compare the performance of adaptive-consistency, JTC and CTE for this problem.

(c) Suppose you want to solve the crossword puzzle using the cycle-cutset scheme. Discuss the approach. Can you bound the complexity of the cycle-cutset scheme for problems having this constraint graph? Compare with previous approaches.

(d) Bound the complexity of solving problems having this constraint graph using the the non-separable-components method.

(e) What are the best time-space guarantees you can get for this instance of the crossword puzzle. What are the best time/space guarantees you can provide for a crossword puzzle of size nxn.

(f) In your opinion, which of the methods you have learned in the constraint class is best suited for cross-word puzzles?

4. Consider the graph problem in Figure 9.7a of chapter 9 and assume that all the constraints are binary "not-equal" constraints and all the domains of the variables have the values $\{1, 2\}$ except the domain of B is $\{1, 2, 3\}$. a. Generate a tree-decomposition. b. Apply CTE to this problem fully (show the messages exactly).

5. Consider a grid problem with 9 variables and binary constraints. Describe a join-tree decomposition created by JTC.
   (a) What is the tree-width, hyper-width and separators of your decomposition.
   (b) What is the time and space complexity of CTE on the decomposition.
   (c) Show schematically how adaptive-tree-consistency will work on this problem. What would be the time and space complexity?
6. (optional) Apply the same question to the graph coloring problem in homework 6.
7. (Optional) The Golumb ruler is the following: place a set of n markers $X_1 > ... > X_n$ on the integer line, (assigning a positive integer to each marker) such that the distances between any two markers are all different, and such that the *length of the ruler*, namely the assignment to X_n, is the smallest possible.
   (a) Read[1] a paper on Golumb ruler.
   (b) Provide two ways of formulating the Golumb ruler as a constraint satisfaction. Assume that you know the optimal length l and you have to provide values for the markers. Demonstrate your formulation on a problem of small size (5 variables).
   (c) Discuss briefly the solution of the problem by *Look-ahead methods* such as 1. DVFC, 2. Forward-checking, 3. full-arc-consistency look-ahead, 4. partial look-ahead, as well as *look-back methods* such as 5. backjumping 6. learning and inference-based methods such as 7. adaptive-consistency 8. JTC 9. CTE and hybrids.
   (d) Propose two algorithm which you would like to apply and test for the problem.
8. The *combinatorial auction* problem is the following: There is a set of items $S = \{a_1, ..., a_n\}$ and a set of m bids $B = \{b_1, ..., b_m\}$ Each bid is $b_i = (S_i, r_i)$ where $S_i \subseteq S$ and $r_i = r(b_i)$ is the cost to be paid for bid b_i. The task is to find a subset of bids $B_i \subseteq B$ s.t. any two bids in B_i do not share an item and to maximize for every $B_i \subseteq B$, $R(B_i)$ defined by: $R(B_i) = \sum_{b \in B_i} r(b)$.
   (a) Read the paper on combinatorial auctions.
   (b) Answer items b,c,d of question 5.
9. (optional) The *Rain* problem is defined as follows: Given a communication network modeled as a graph $G = (N, E)$ where the set of nodes are processing nodes and the links are bidirectional communication links, each link e is associated with *bandwidth capacity* $c(e)$. A *demand* is a communication-need between a pair of nodes $d_u = (x_u, y_u, \beta_u)$ where x_u is the source y_u is the destination and β_u is the required bandwidth. Given a set of demands $\{d_1, ..., d_m\}$, the task is assign a route (a simple path) from source to destination for each demand such that the total capacity used over each link is below the available bandwidth.

[1] All mentioned papers are available in the class folder in the file cabinet

(a) Read the paper on Bandwidth allocation.

(b) Answer questions b,c,d of question 5.