CONSTRAINT SATISFACTION – EXERCISES 2003-04

Question 1

Problem Modeling, Constraint Optimisation

The Minimal Bandwidth Ordering Problem:

Given a graph (V, E), where V is a set of nodes and E is a set of edges (x, y), if we order the nodes, the bandwidth of a node x is the maximum distance between x and a node y that is adjacent to it (i.e. (x, y) is an edge). The bandwidth of the ordering is the maximum bandwidth of all the nodes under that ordering. The minimal bandwidth ordering problem is to find an ordering with the minimum bandwidth.

(a) Formulate the Minimal Bandwidth Ordering Problem as a constraint satisfaction problem. Clearly state the variables, domains and constraints. Ignore the minimization requirement. [15%]

(b) Given your formulation in (a), describe the topology of the constraint graph. [5%]

(c) Given your formulation in (a), what is the size of the search space? [5%]

(d) Extend your formulation in (a) to a constraint optimization problem. Describe the objective function by reference to your variable assignments. [5%]

(e) Are there any constraint satisfaction techniques effective for solving the optimization problem that you formulated above? If yes, name one such technique and evaluate how effective it is. If no, justify your answer carefully. [10%]

Question 2

Problem Formulation, Constraint Satisfaction Techniques Application

The Bandwidth Decision Problem:

Given a graph (V, E), where V is a set of nodes and E is a set of edges (x, y), if we order the nodes the bandwidth of a node x is the maximum distance between x and a node y that is adjacent to it (i.e. (x, y) is an edge). The bandwidth of the ordering is the maximum bandwidth of all the nodes under that ordering. The problem is to find an ordering which bandwidth is no greater than a constant k.

(a) Formulate the Bandwidth Decision Problem as a constraint satisfaction problem. Contrast this formulation with the problem in Question 1 (a). [15%]

(b) Are there any constraint satisfaction techniques effective for solving the Bandwidth Decision Problem that you have formulated? If yes, name one such technique and evaluate how effective it is in relation to the value k. If no, justify your answer carefully. Contrast your answer with your answer given to Question 1, part (e). [15%]

Question 3

Application of Algorithms and Heuristics

Explain what algorithms or heuristics are relevant to solving constraint satisfaction problems under the following situations. Justify your answers carefully. There is no need to explain the details of the algorithms or heuristics that you propose unless they are relevant to your justifications.

(i) The problem is so tightly constrained that it is highly unlikely that solutions exist. [10%]

(ii) The domain sizes vary significantly: some variables have very large domains (over 1,000 values) and some have very small domains (with fewer than 10 values). [10%]

(iii) The variables and domains are handled by one computer M. Each constraint is handled by a networked computer. Traffic in the networks is slow. To check a particular constraint, computer M sends a message to the corresponding computer through the network, which will send a message back to indicate whether the constraint is satisfied or violated. [10%]