COEN 266 Artificial Intelligence

Homework #4

Guideline: Please complete the following problems and submit the answers as a single PDF file to Camino.

Problem 1: Define the cryptarithmetic problem (shown in Figure 4.1) as a CSP, using A, E, H, L, P, and T as variables with single digits as values (i.e., 0, 1, 2, ..., 9), subject to the following constraints: all these six variables must take unique values, and leading zeroes are not allowed. You may add additional variables as needed, but define their domains. Write all the necessary constraints.

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    E A T
+ T H A T
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A P P L E
```

Figure 4.1

Problem 2: Three robots (A, B, C) have two hours to complete five tasks (1,2,3,4,5). Each task takes one hour to complete, each robot can work on only one task at a time, and only one robot may work on a task at a time. Each robot is only equipped to perform certain tasks, as shown in Table 4.1.

Robot	Tasks
A	1,2,3
B	1,2,5
C	2,4,5

Table 4.1

Finally, task 1 must be completed before task 2, and task 3 must be completed before task 5. We can formulate this problem as a CSP, using one variable for each task: X_1,..., X_5, whose possible values are a subset of $\{A_1, A_2, B_1, B_2, C_1, C_2\}$, where $X_5=C_2$ means that task 5 is done by robot C and **Time(X_5)** is 2, that is, time slot 2 is allocated to task 5. We have written the domain of each variable in Figure 4.2 below.

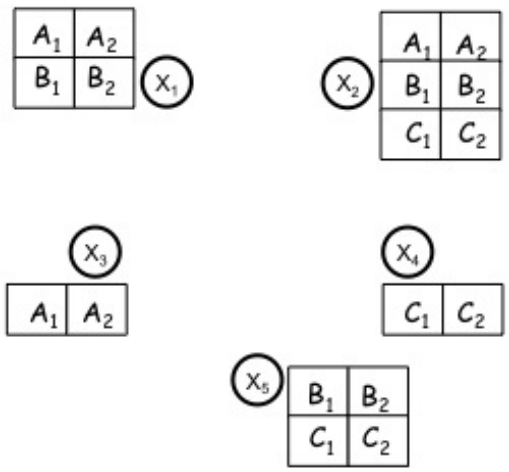


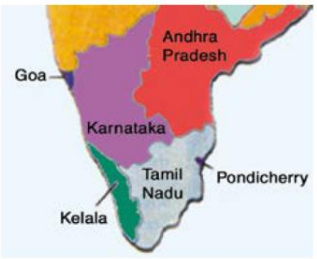
Figure 4.2

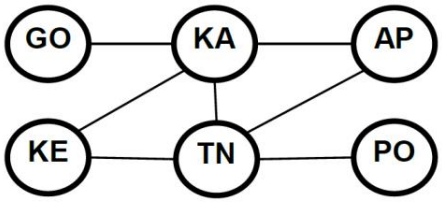
a. Write all the constraints (either binary or n-ary forms are ok).

b. Complete the constraint graph in Figure 4.2 by drawing links (arcs) that connect variables.

c. Is the initial state arc-consistent? If not, cross out the values for each variable that would be pruned by running AC-3 algorithm. Show your work.

Problem 3 You are a map-coloring robot assigned to color this Southern India map. Adjacent regions must be colored a different color (R=Red, B=Blue, G=Green). The constraint graph is shown.





GO = Goa
KA = Karnataka
AP = Andhra Pradesh
KE = Kerala
TN = Tamil Nadu
PO = Pondicherry

3.a FORWARD CHECKING. Cross out all values that would be eliminated by Forward Checking, after variable KA has just been assigned value R as shown:

GO	KA	AP	KE	TN	PO
R G B	R	R G B	R G B	R G B	R G B

3.b MINIMUM-REMAINING-VALUES HEURISTIC. Consider the assignment below. KA is assigned and forward checking has been done. List all unassigned variables that might be selected by the Minimum-Remaining-Values (MRV) Heuristic:

GO	KA	AP	KE	TN	PO
R B	G	R B	R B	R B	R G B

3.c DEGREE HEURISTIC. Consider the assignment below. KA is assigned and forward checking has been done. List all unassigned variables that might be selected by the Degree Heuristic:

GO	KA	AP	KE	TN	PO
R B	G	R B	R B	R B	R G B

3.d MIN-CONFLICTS HEURISTIC. Consider the assignment below. TN has been selected to be assigned a new value. What new value would be chosen below for TN by the Min-Conflicts Heuristic?

GO	KA	AP	KE	TN	PO
B	G	B	G	**?**	B

Problem 4 The objective of map coloring in Figure 6.1 is to assign each region a color from the set {red, green, blue}, such that neighboring regions do not have the same color. Use the Maintaining Arc Consistency (MAC) algorithm to show that the partial assignment {WA=green, V =red} is inconsistent.

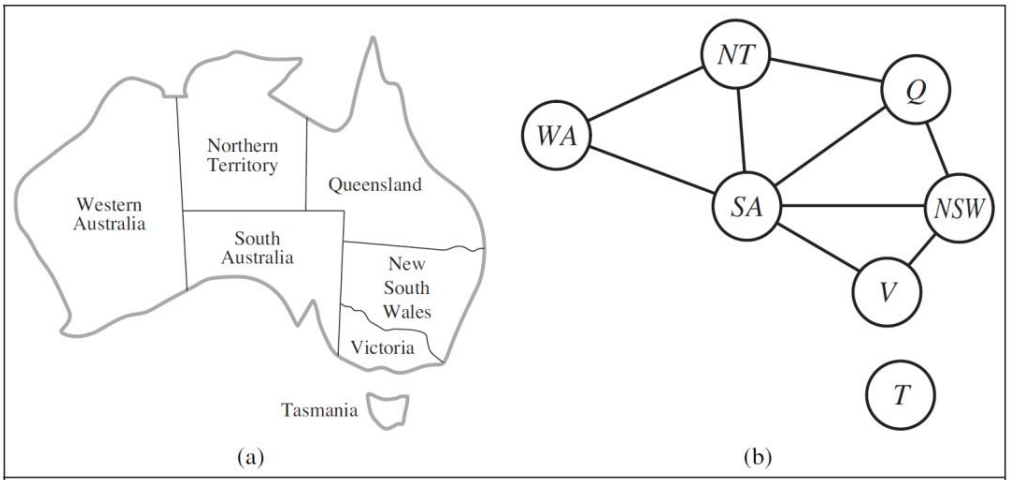


Figure 6.1 (a) The principal states and territories of Australia. Coloring this map can be viewed as a constraint satisfaction problem (CSP). The goal is to assign colors to each region so that no neighboring regions have the same color. (b) The map-coloring problem represented as a constraint graph.