Problem & Solution

E

v

O

L

A I

If A = 3 && 5<L<O<V<E<10

E

v

O

L

A I

If A = 3 && $5<L<O<V<E<10$

Value of I ?

SRM

CSE

ODD

Constrains : 0 <= {S, R, M, C, S, E, O, D} <= 9

IF

S, R, M = 2, 3, 4

What is/are **ODD**?

234+721=955

234+621=855

SRM

CSE

GOOD

Constrains : 0 <= {S, R, M, C, S, E, O, D} <= 9

IF

(G = 1) && (S = 7)

How many GOOD(S)?

756+473=1229

735+274=1009

734+275=1009

753+476=1229

793+872=1665

792+873=1665

LOCK

KEYS

DOOR

Constrains : 0 <= {L,O,C, K, E, Y, S, D, R} <= 9

LOCK
KEYS
DOOR

Constrains : 0 <= {L,O,C, K, E, Y, S, D, R} <= 9

Satisfactions : 1638+8027=9665

Satisfactions : 2617+7048=9665

Satisfactions : 1956+6038=7994

Satisfactions : 1956+6042=7998

Satisfactions : 2381+1956=4337

Satisfactions : 2381+ ? = ?

Constraint Satisfaction

Constraint Satisfaction

- Many AI problems can be viewed as problems of constraint satisfaction.

Constraint Satisfaction

- As compared with a straightforward search procedure, viewing a problem as one of constraint satisfaction can reduce substantially the amount of search.

Constraint Satisfaction

- Operates in a space of constraint sets.
- Initial state contains the original constraints given in the problem.
- A goal state is any state that has been constrained "enough".

Constraint Satisfaction

Two-step process:

1. Constraints are discovered and propagated as far as possible.
2. If there is still not a solution, then search begins, adding new constraints.

Constraint Satisfaction

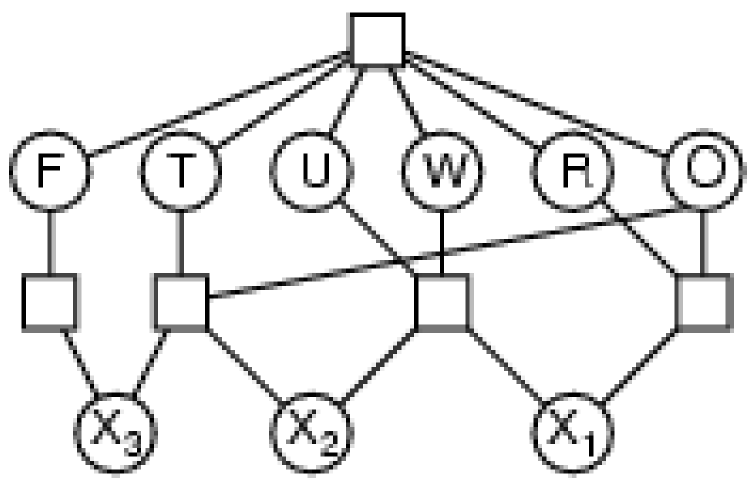
Two kinds of rules:

1. Rules that define valid constraint propagation.
2. Rules that suggest guesses when necessary.

Constraints

- The simplest type is the **unary constraint**, which constraints the values of just one variable.
- A binary constraint relates two variables.
- Higher-order constraints involve three or more variables. Cryptarithmetic puzzles are an example:

```
    T W O
  + T W O
  -------
  F O U R
```



Cryptarithmetic puzzles

- Variables: $F, T, U, W, R, O, X_1, X_2, X_3$
- Domains: $\{0,1,2,3,4,5,6,7,8,9\}$
- Constraints:
  - Alldiff (F,T,U,W,R,O)
  - $O + O = R + 10 \cdot X_1$
  - $X_1 + W + W = U + 10 \cdot X_2$
  - $X_2 + T + T = O + 10 \cdot X_3$
  - $X_3 = F$, $T \neq 0$, $F \neq 0$

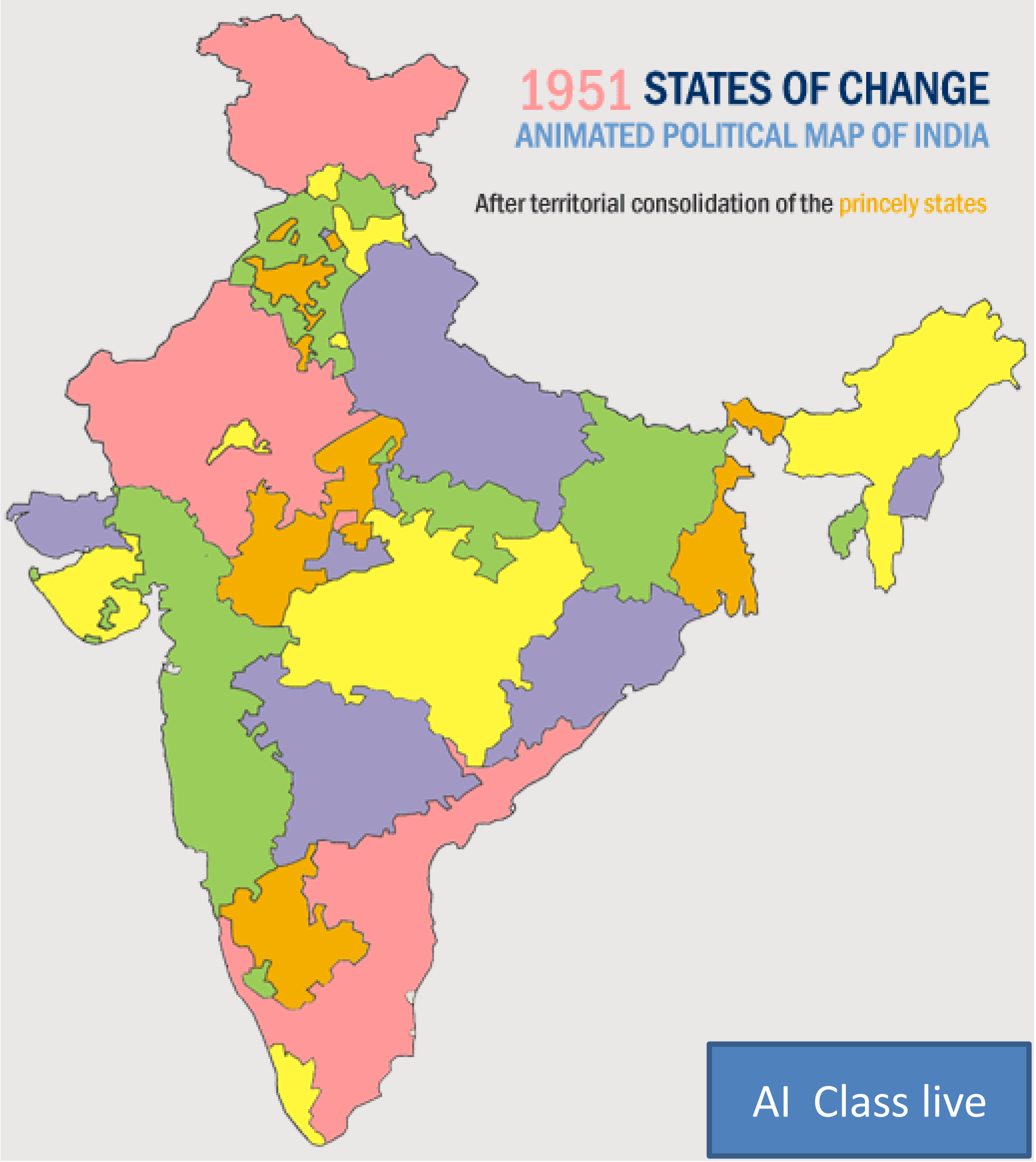
```
    T W O
  + T W O
  -------
  F O U R
```

If 2+2 = 4, F=1, then how many four

TWO
TWO

FOUR

938+938=1876
928+928=1856
867+867=1734
846+846=1692
836+836=1672
765+765=1530
734+734=1468

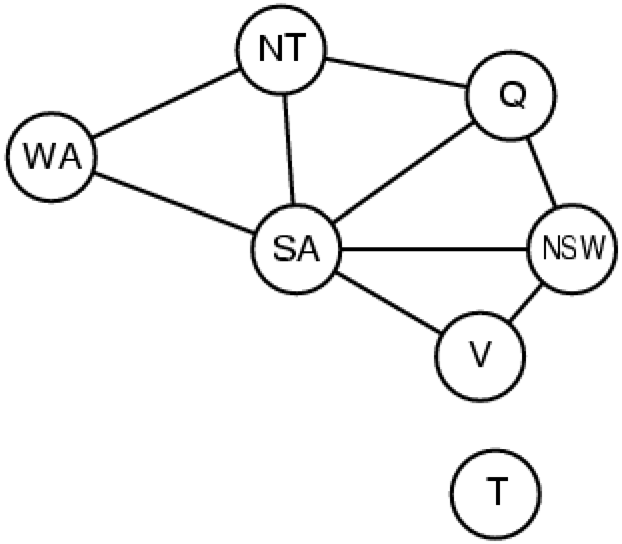


AI Class live

Map Colo(u)ring

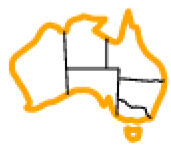
RED
GREEN
BLUE

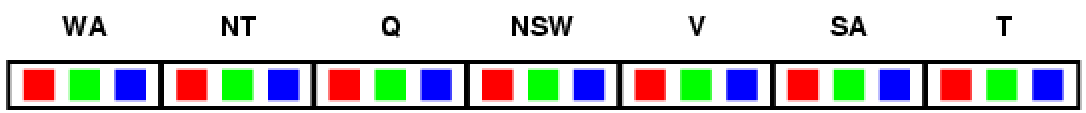
Map Coloring

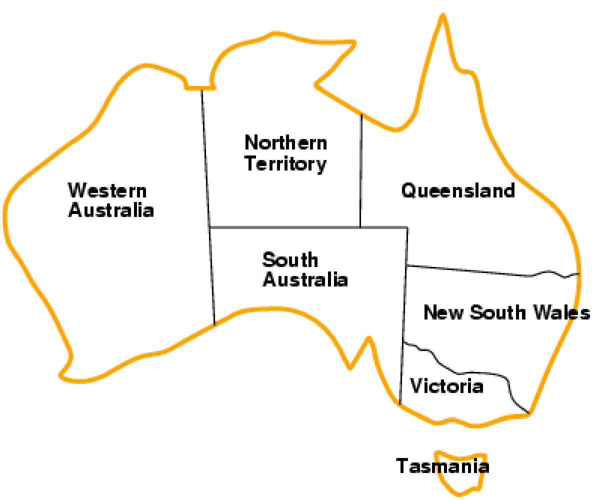


Map Coloring

- Idea:
  - Keep track of remaining legal values for unassigned variables
  - Terminate search when any variable has no legal values







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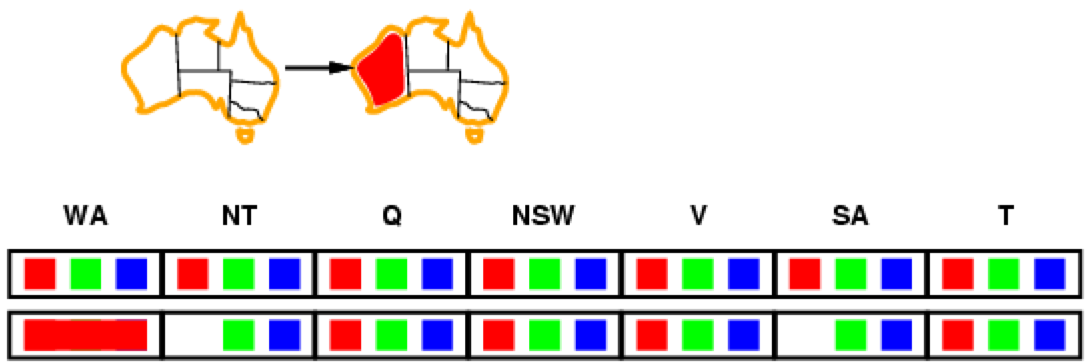

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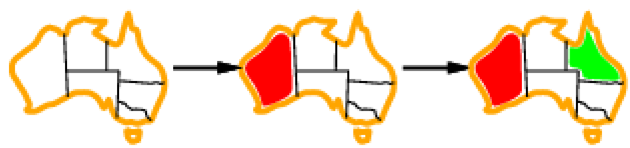

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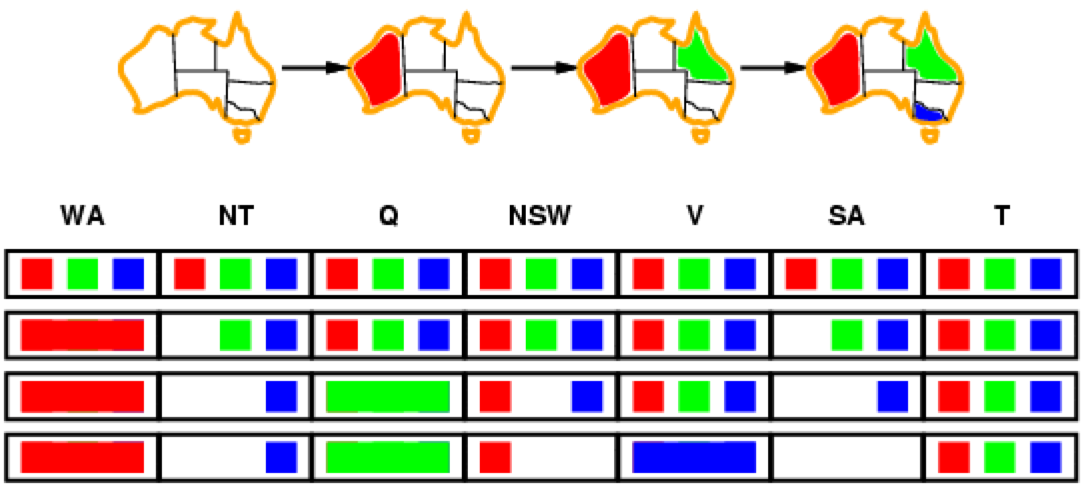
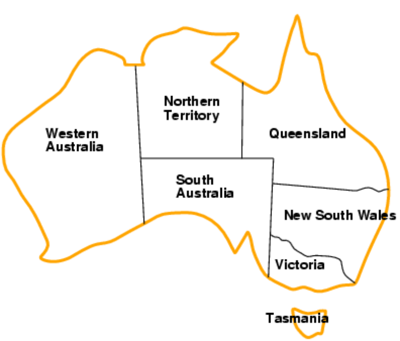
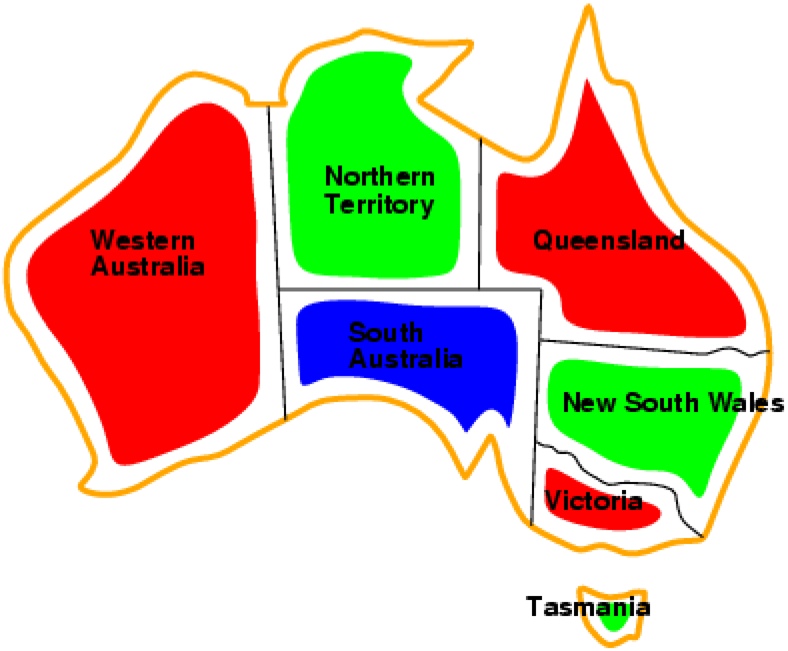




Solution?

WA =
NT=
Q=
NSW=
V=
SA=
T=


Northern Territory
Western Australia
Queensland
South Australia
New South Wales
Victoria
Tasmania

SEND + MORE = MONEY

SEND + MORE = MONEY

1. We have to find values for S,E,N,D,M,O,R,Y (8 digits out of 10). Now, we're adding 2 4-digits numbers. Since 9999+9999 < 20000, M cannot be >=2. And by the "usual rules" for this kind of question, it can't be 0. So M=1.

SEND + MORE = MONEY

2. Now, looking at the fourth (left-most) column, we have either S+1>=10 (if there's no carry) or 1+S+1>=10 (if there's carry). So S=8 or 9, and O=0 or 1. Since 1 is already taken, O=0 (just as well that, or the typography would get confusing).

SEND + MORE = MONEY

3. In the third column, we can't have E+0=N (no carry), so E+1=N and there's carry from the second column. So in the second column either N+R=10+E=9+N, and R=9, or there's carry and 1+N+R=10+E=9+N, and R=8. So R=8 or 9, just like S.

SEND + MORE = MONEY

4. IF S=8 and R=9,
we're looking at

8END

+ 109E

=======

10NEY

SEND + MORE = MONEY

5. But this cannot possibly work: we need to get either E+0=10+N or 1+E+0=10+N in the third column, to get carry in the fourth column. Neither is possible (we've already used up both 9 and 0). So...

S=9 and R=8.

We're looking at

```
  9END
+ 108E
======
 10NEY
```

SEND + MORE = MONEY

6. We've already used up the digits 0,1,8,9, and N=E+1, so the only choices for E are 6,5,4,3,2.

7. We know we must have carry from the first column into the second, so D+E>=10. D is at most 7, so we immediately rule out E=2 (7+2<10). Also E=3 is impossible (because then either D=7 and Y=0=O, or D<7 and E+D<10, both of which are impossible).

SEND + MORE = MONEY

8. If E=4, then D=7 or D=6 don't work (because then Y=1 or Y=0, and both are already taken), and D<6 doesn't work because then E+D<10.

9. If E=6 then N=7, so D<=5. But D=5 yields Y=1 and D=4 yields Y=0, both taken, and D<=3 gives E+D<10.

SEND + MORE = MONEY

10. So E=5 and N=6. D=7 (the alternative, D<=4, is again too small), so Y=2 and the solution is

  9567
+ 1085
======
 10652

Initial state:

- No two letters have the same value.
- The sum of the digits must be as shown.