Knowledge Representation and Reasoning

- Answer Set Programming
  - a non-monotonic reasoning language
  - specification and program are the same
  - Prolog
  - Answer set solvers

Example I

There are five houses in five different colors. In each house lives a person of different nationality. These owners drink a certain beverage, smoke a certain brand of cigarettes and keep a certain pet. No owner has the same pet, drinks the same drink or smokes the same brand. Question: Who owns the fish? Hints:

- The Brit lives in the red house.
- The Swede keeps a dog.
- The Dane drinks tea.
- The green house is on the left of the white house.
- The green house's owner drinks coffee.
- The person who smokes Pall Mall rears birds.
- The owner of the yellow house smokes Dunhill.
- The man living in the house right in the center drinks milk.
- The Norwegian lives in the first house.
- The man who smokes Blend lives next to the one who has cats.
- The man who has horses lives next to the Dunhill smoker.
- The owner who smokes Bluemaster drinks beer
- The German smokes Princess.
- The Norwegian lives next to the blue house.
- The man who smokes Blend has a neighbour who drinks water.

Logic Program

$$
\begin{aligned}
h(1,red) \oplus h(1,wh) \oplus h(1,gr) \oplus h(1,ye) \oplus h(1,bl) &\leftarrow \\
h(2,red) \oplus h(2,wh) \oplus h(2,gr) \oplus h(2,ye) \oplus h(2,bl) &\leftarrow \\
h(3,red) \oplus h(3,wh) \oplus h(3,gr) \oplus h(3,ye) \oplus h(3,bl) &\leftarrow \\
h(4,red) \oplus h(4,wh) \oplus h(4,gr) \oplus h(4,ye) \oplus h(4,bl) &\leftarrow \\
h(5,red) \oplus h(5,wh) \oplus h(5,gr) \oplus h(5,ye) \oplus h(5,bl) &\leftarrow \\
n(1,br) \oplus n(1,sw) \oplus n(1,no) \oplus n(1,da) \oplus n(1,ge) &\leftarrow \\
n(2,br) \oplus n(2,sw) \oplus n(2,no) \oplus n(2,da) \oplus n(2,ge) &\leftarrow \\
n(3,br) \oplus n(3,sw) \oplus n(3,no) \oplus n(3,da) \oplus n(3,ge) &\leftarrow \\
n(4,br) \oplus n(4,sw) \oplus n(4,no) \oplus n(4,da) \oplus n(4,ge) &\leftarrow \\
n(5,br) \oplus n(5,sw) \oplus n(5,no) \oplus n(5,da) \oplus n(5,ge) &\leftarrow
\end{aligned}
$$

Code cont.

$$
\begin{aligned}
a(1, dog) \oplus a(1, bi) \oplus a(1, ca) \oplus a(1, ho) \oplus a(1, fi) &\leftarrow \\
a(2, dog) \oplus a(2, bi) \oplus a(2, ca) \oplus a(2, ho) \oplus a(2, fi) &\leftarrow \\
a(3, dog) \oplus a(3, bi) \oplus a(3, ca) \oplus a(3, ho) \oplus a(3, fi) &\leftarrow \\
a(4, dog) \oplus a(4, bi) \oplus a(4, ca) \oplus a(4, ho) \oplus a(4, fi) &\leftarrow \\
a(5, dog) \oplus a(5, bi) \oplus a(5, ca) \oplus a(5, ho) \oplus a(5, fi) &\leftarrow \\
b(1, tea) \oplus b(1, co) \oplus b(1, mi) \oplus b(1, be) \oplus b(1, wa) &\leftarrow \\
b(2, tea) \oplus b(2, co) \oplus b(2, mi) \oplus b(2, be) \oplus b(2, wa) &\leftarrow \\
b(3, tea) \oplus b(3, co) \oplus b(3, mi) \oplus b(3, be) \oplus b(3, wa) &\leftarrow \\
b(4, tea) \oplus b(4, co) \oplus b(4, mi) \oplus b(4, be) \oplus b(4, wa) &\leftarrow \\
b(5, tea) \oplus b(5, co) \oplus b(5, mi) \oplus b(5, be) \oplus b(1, wa) &\leftarrow
\end{aligned}
$$

Code cont.

$$
\begin{array}{ll}
c(1,pm) \oplus c(1,bl) \oplus c(1,bm) \oplus c(1,du) \oplus c(1,pr) & \leftarrow \\
c(2,pm) \oplus c(2,bl) \oplus c(2,bm) \oplus c(2,du) \oplus c(2,pr) & \leftarrow \\
c(3,pm) \oplus c(3,bl) \oplus c(3,bm) \oplus c(3,du) \oplus c(3,pr) & \leftarrow \\
c(4,pm) \oplus c(4,bl) \oplus c(4,bm) \oplus c(4,du) \oplus c(4,pr) & \leftarrow \\
c(5,pm) \oplus c(5,bl) \oplus c(5,bm) \oplus c(5,du) \oplus c(5,pr) & \leftarrow
\end{array}
$$

$$
\begin{array}{ll}
\leftarrow & h(S,H), h(T,H), T \neq S \\
\leftarrow & b(S,B), b(T,B), T \neq S \\
\leftarrow & c(S,C), c(T,C), T \neq S \\
\leftarrow & n(S,N), n(T,N), T \neq S \\
\leftarrow & a(S,A), a(T,A), T \neq S
\end{array}
$$

Code cont.

$$
\begin{array}{rcl}
n(O, br) & \leftarrow & h(O, red) \\
n(O, sw) & \leftarrow & a(O, dog) \\
n(O, da) & \leftarrow & b(O, tea) \\
 & \leftarrow & h(W, wh), h(G, gr), W \leq G \\
h(O, gr) & \leftarrow & b(O, co) \\
a(O, bi) & \leftarrow & c(O, pm) \\
h(O, ye) & \leftarrow & c(O, du) \\
b(3, mi) & \leftarrow & \\
n(1, no) & \leftarrow &
\end{array}
$$

Code cont.

$$
\begin{array}{rcl}
a(O_1, ca) \oplus a(O_2, ca) & \leftarrow & c(O, bl), O_1 = O + 1, O_2 = O - 1 \\
a(O_1, ho) \oplus a(O_2, ho) & \leftarrow & c(O, du), O_1 = O + 1, O_2 = O - 1 \\
b(O, be) & \leftarrow & c(O, bm) \\
n(O, ge) & \leftarrow & c(O, pr) \\
n(O_1, no) \oplus n(O_2, no) & \leftarrow & h(O, bl), O_1 = O + 1, O_2 = O - 1 \\
c(O_1, bl) \oplus c(O_2, bl) & \leftarrow & b(O, wa), O_1 = O + 1, O_2 = O - 1
\end{array}
$$

Solution

The solution for this riddle equals:

number	color	nationality	pet	beverage	cigarettes
1	yellow	Norwegian	cats	water	Dunhill
2	blue	Dane	horses	tea	Blend
3	red	Brit	birds	milk	Pall Mall
4	green	**German**	**fish**	coffee	Princess
5	white	Swede	dog	beer	Bluemaster

Applications

ASP is being used in the real world!

- ★ Decision support systems (NASA)
- ★ Data-integration (Info-Mix)
- ★ Circuit design and verification (A-Circuit)
- ★ Planning (Qsmodels)
- ★ Agents (Dali)

Project Proposals in ASP

- An IDE for ASP
- ASP Agent Framework
- Finite State Autonoma Generation
- Incremental Propositional OCLP
- Compute Time Estimator for ASP
- Precompute branching for ASP
- An open implementation of DLT

Non-ASP Project Proposals

- ★ Call Graphing in C
- ★ Customised Wiki
- ★ E-learning Site for @lis
- ★ SSH Key Distribution