Answer Set Programming

Vladimir Lifschitz
University of Texas at Austin
What is Answer Set Programming?

ASP is a declarative methodology for solving difficult combinatorial search problems.

ASP combines ideas coming from research
- on the design and use of SAT solvers, and
- on the use of PROLOG in knowledge representation.
Input:

\[
\begin{align*}
p & : - q. \\
q & : - \text{not } r.
\end{align*}
\]

Output:

Answer: 1
Stable Model: \( q \ p \)

\[
\begin{align*}
p & : - \text{not } q. \\
q & : - \text{not } p.
\end{align*}
\]

Answer: 1
Stable Model: \( p \)
Answer: 2
Stable Model: \( q \)
Choice Rules and Constraints

Input:

\begin{align*}
  p & :- q. \\
  q & :- \text{not } r. \\
  \{s, t\} & :- p. \\
  :- s, \text{ not } t.
\end{align*}

Output:

\begin{align*}
  & \text{Answer: 1} \\
  & \text{Stable Model: } t \ s \ p \ q \\
  & \text{Answer: 2} \\
  & \text{Stable Model: } p \ q \\
  & \text{Answer: 3} \\
  & \text{Stable Model: } t \ p \ q
\end{align*}
ASP Programs with Variables

Input:

- p(a).
- p(b).
- \{q(X) : p(X)\}.

Output:

- Answer: 1
  - Stable Model: p(b) p(a)
- Answer: 2
  - Stable Model: q(a) p(b) p(a)
- Answer: 3
  - Stable Model: q(b) p(b) p(a)
- Answer: 4
  - Stable Model: q(b) q(a) p(b) p(a)
Using ASP to Find a Large Clique

A clique in a graph is a set of pairwise adjacent vertices.

vertex(1..99). % 1,...,99 are vertices
edge(3,7). % 3 is adjacent to 7

10 {in(X) : vertex(X)}.
:- in(X), in(Y), vertex(X), vertex(Y),
   X!=Y, not edge(X,Y), not edge(Y,X).
A Hamiltonian cycle in a directed graph is a closed path that passes through each vertex of the graph exactly once.

\[
\{\text{in}(X,Y)\} :- \text{edge}(X,Y).
\]

\[
:- 2 \{\text{in}(X,Y) : \text{edge}(X,Y)\}, \text{vertex}(X).
\]

\[
:- 2 \{\text{in}(X,Y) : \text{edge}(X,Y)\}, \text{vertex}(Y).
\]

\[
\text{r}(X) :- \text{in}(0,X), \text{vertex}(X).
\]

\[
\text{r}(Y) :- \text{r}(X), \text{in}(X,Y), \text{edge}(X,Y).
\]

\[
:- \text{not r}(X), \text{vertex}(X).
\]
Some Applications of ASP

Automated Product Configuration (Ilkka Niemelä and others): A commercially available web-based product configurator.

Decision Support for the Space Shuttle (Michael Gelfond and others): A system capable of solving some planning and diagnostic tasks related to the operation of the Space Shuttle.

Inferring Phylogenetic Trees (Esra Erdem and others): A method for reconstructing a phylogeny for a set of taxa, applied to linguistics and zoology.
Research on ASP at the University of Texas

- Theory of stable models (Joohyung Lee, Paolo Ferraris)
- Designing new answer set solvers (Yuliya Lierler)
- Applications (Esra Erdem, Selim Erdogan)