The DLVHEX System for Knowledge Representation: Recent Advances (System Description)

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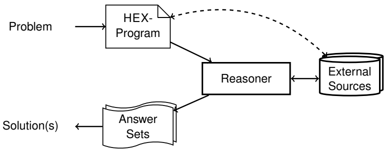
Outline

Motivation

HEX-Programs

- Extend ASP by external sources:



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$$a_1 \vee \cdots \vee a_k \leftarrow b_1, \ldots, b_m, \text{not } b_{m+1}, \ldots, \text{not } b_n,$$

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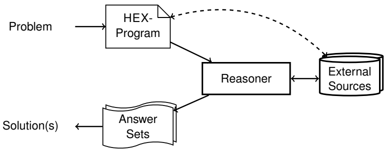

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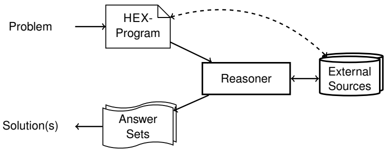

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Formally:
An external atom is of the form $\&p[q_1,\ldots,q_k](t_1,\ldots,t_l)$, where
p ...external predicate, q_i ...predicates or constants, t_j ...terms.

Semantics given by a $1+k+l$-ary Boolean oracle function $f_{\&p}$:
$I \models \&p[q_1,\ldots,q_k](t_1,\ldots,t_l)$ if $f_{\&p}(I,q_1,\ldots,q_k,t_1,\ldots,t_l) = \mathbf{T}$
(and $I \not\models \&p[q_1,\ldots,q_k](t_1,\ldots,t_l)$ otherwise).

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DLVHEX

http://www.kr.tuwien.ac.at/research/systems/dlvhex

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- Supported platforms: Linux-based, OS X, Windows.
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This talk: presentation of

- **novelties done in the last three years** and
- **current state of the system.**

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From Black-box to Grey-box

Previous Evaluation Bottleneck

- External sources were seen as black boxes.
- Behavior under an interpretation did not allow for drawing conclusions about other interpretations.
- Algorithms must be very general $\Rightarrow$ room for optimizations limited.

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- Developers of external sources and/or implementer of HEX-program might have useful additional information.
- Provide a (predefined) list of possible properties of external sources.
- Let the developer and/or user specify which properties are satisfied.
- Algorithms exploit them for various purposes, most importantly:
  - efficiency improvements and
  - language flexibility (reducing syntactic restrictions).

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Important:
User specifies them but does **not** need to know how they are exploited!

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Exploiting Properties for Efficiency Improvement

Conflict-driven Solving

- ASP program is internally represented by nogoods (sets of literals which cannot be simultaneously true).
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- We evaluate $\&diff[p,q](X)$ under $I = \{p(a), q(b)\}$.
- It is true for $X = a$ (and false otherwise), i.e., $I \models \&diff[p,q](a)$.
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Exploiting Properties

- Known properties used to shrink nogoods to their essential part.
- Example: $\&diff[p,q](X)$ is monotonic in p:
  Shrink above nogood N to $N' = \{p(a), \neg q(a), q(b), \neg\&diff[p,q](a)\}$.
  (If $p(b)$ turns to true, $\&diff[p,q](a)$ is still true $\Rightarrow \neg p(b)$ not needed.)

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- External atoms may introduce new constants: value invention.
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Exploiting Properties

- Properties may allow for identifying finite groundability even in presence of recursive value invention (in some cases).
- Example:
  Known finiteness of the graph above allows for establishing safety.

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Python Programming Interface

More convenient interface

Previously only C++ support, but Python preferred by many developers:

- No overhead due to makefiles, compilation, linking, etc.
- High-level features.
- Negligible overhead compared to plugins implemented in C++.

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Example

Program

$$\Pi = \left\{ \begin{array}{l} r_1 : start(s). \\ r_2 : scc(X) \leftarrow start(X). \quad r_3 : scc(Y) \leftarrow scc(X), \&edge[X](Y). \end{array} \right\}$$

compute the strongly connected component of a node s in a graph.

Implementation of $\&edge[X](Y)$:

```
def edge(x):
  graph=((1,2),(1,3),(2,3))           # simplified implementation
  for edge in graph:                  # search for out-edges of node x
    if edge[0]==x.intValue():
      dlvhex.output((edge[1],))       # output edge target

def register():
  prop = dlvhex.ExtSourceProperties() # inform dlvhex about
  prop.addFiniteOutputDomain(0)       # finiteness of the graph
  dlvhex.addAtom("edge", (dlvhex.CONSTANT, ), 1, prop)
```

Further Improvements

Availability

- Pre-compiled binaries for major platforms available (previously distributed only as sourcecode).
- Online demo: `http://www.kr.tuwien.ac.at/research/systems/dlvhex/demo.php`.

Interoperability

- Support for all features of the ASP-Core-2 standard.
- Support for input/ouput in CSV format (interoperability with tools and spreadsheet programs).

Outline

Applications of HEX-Programs

- Multi-context Systems (interconnection of knowledge-bases)
- DL-programs (integration of ASP with ontologies)
- Constraint ASP (programs with constraint atoms)
- Physics simulation (e.g. AngryBirds agent)
- Route planning (possibly semantically enriched)
- Robotics applications (planning)
- ACTHEX (programs with action atoms)
- ...

Outline

Conclusion

DLVHEX

Two main categories of improvements:

Exploiting external source properties

- Plugin developer or HEX-programmer tags guaranteed properties.
- Algorithms exploit these properties where applicable.
- User does not need to know how they are exploited to benefit.
- Used for efficiency improvements and language flexibility.

Usability and System Improvements

- New programming interface (API) for Python-based plugins.
- Binaries for Linux, OS X and Windows available.
- Online demo allows for testing in the browser.
- Support for ASP-Core-2 standard and for input/output in CSV format.

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