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Development of a Belief Merging Framework for dlvhex

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1. Goal

Using multiple belief sources simultaneously!

Challenges

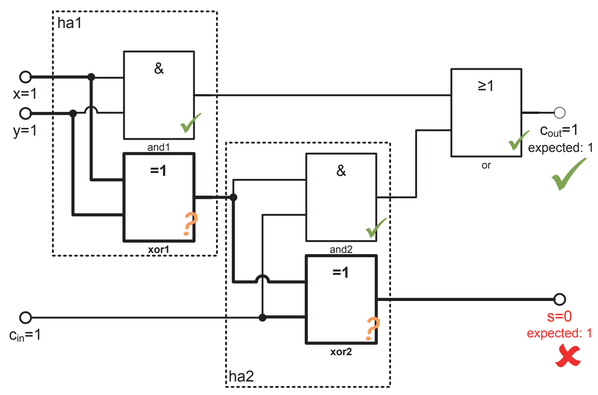
- Incompatible knowledge representation formalisms
- Different data schemas
- Logical contradictions
- Undesired artefacts prior to data cleansing
  (differing naming conventions, several entries referring to the same real-world object, etc.)

Applications

judgment aggregation, classifier merging, ontology merging, fusion of business databases, ...

2. Application Scenario

Fault Diagnosis: Malfunctioning Full Adder



Suppose we have three experts, each with different hypothesis about the fault:
(1) “*xor1* is defect!” (2) “*xor2* is defect!” (3) “*xor1* is defect, but *xor2* works!”

We want to make a group decision such that

- it explains the observation
- it is as similar to the individual decisions as possible

Expected result *depends on cost model*; one intuitively reasonable possibility: “*xor1* is defect” since it satisfies two of the three experts.

3. State-of-the-art

Many application-specific solutions which contain a lot of routine tasks

- Calling different sources of computation and parsing results
- Organizing the information flow through different merging procedures
- Extracting the final result

Drawbacks

- Changes in the merging strategy or parameters require lots of time-consuming repetitive work
- Hence, empirical test of several scenarios in order to find the optimal one is difficult

4. New approach

A framework and language for formal description of merging tasks

The implementation is based on an extension of the answer set semantics, called HEX semantics. Then the merging task consists of 3 steps:

Step 1: User specifies the merging scenario declaratively; this description is called *merging task description*. For this purpose, the framework provides a user-friendly *merging language*.

Step 2: The merging task description is translated into a semantically equivalent HEX program by the *merging plan-compiler*

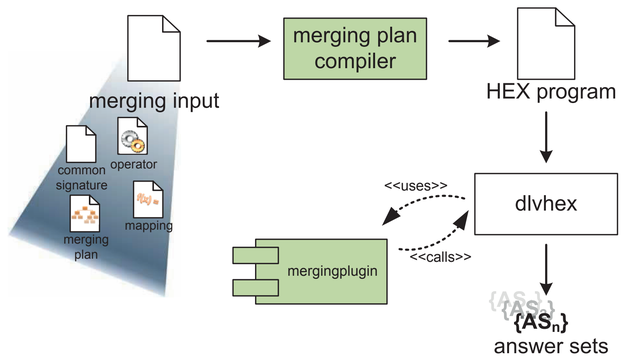
Step 3: The generated program is executed by the reasoner *dlvhex* to produce the new belief set according to the defined merging plan

5. Merging Language

A declarative merging task description consists of

- **Common Signature**
  A set of predicates that is expressive enough to represent the contents of all data sources, i.e., a shared vocabulary
- **Mappings**
  Translate sources into the language of the common signature
- **Merging Operators**
  Operators are algorithms which incorporate n belief sets into one
- **Merging Plan**
  Arranges *merging operators* hierarchically in a tree-like structure with the input belief sets in the leafs

6. Framework Architecture: Implementation



Technical Facts

- **Formalism**: Logic programs under the HEX semantics; their answer-sets are regarded as derived knowledge, called *belief sets*
- **Reasoner**: dlvhex and DLV
- **Data Sources**: arbitrary, as long as suitable plugins for dlvhex exist
- **Operator Implementations**: C++ classes

7. Solving the Fault Diagnosis Problem

```
% File: diagnosis.mp
[common signature]
  predicate: ab/1;
[belief base]
  name: expert1; source: "e1.dl";          % yields {ab(xor1)}
[belief base]
  name: expert2; source: "e2.dl";          % yields {ab(xor2)}
[belief base]
  name: expert3; source: "e3.dl";          % yields {ab(xor1), ¬ab(xor2)}
[merging plan] {
  operator: dalal; aggregate: "sum";
  constraintfile: "fulladder.dl"; constraintfile: "fault.obs";
  {expert1}; {expert2}; {expert3};
}
```

Command line: $ mpcompiler diagnosis.mp | dlvhex --filter=ab --
Result: $\{ab(xor1)\}$

Advantage of the tool: Easy to exchange operator or modify parameters, e.g., the cost model!

8. Conclusion

Very flexible due to generic design: useful for many application scenarios!

Advantages

- As of June 2010, most general framework available
- It is easy to change the merging strategy: no repetition of routine tasks
- Merging procedures implemented once and applied in many scenarios
- Implementation for dlvhex available; only very few comparable systems were actually implemented

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