User-Assisted Constraint Modelling Using Semantic Web Technology

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Background

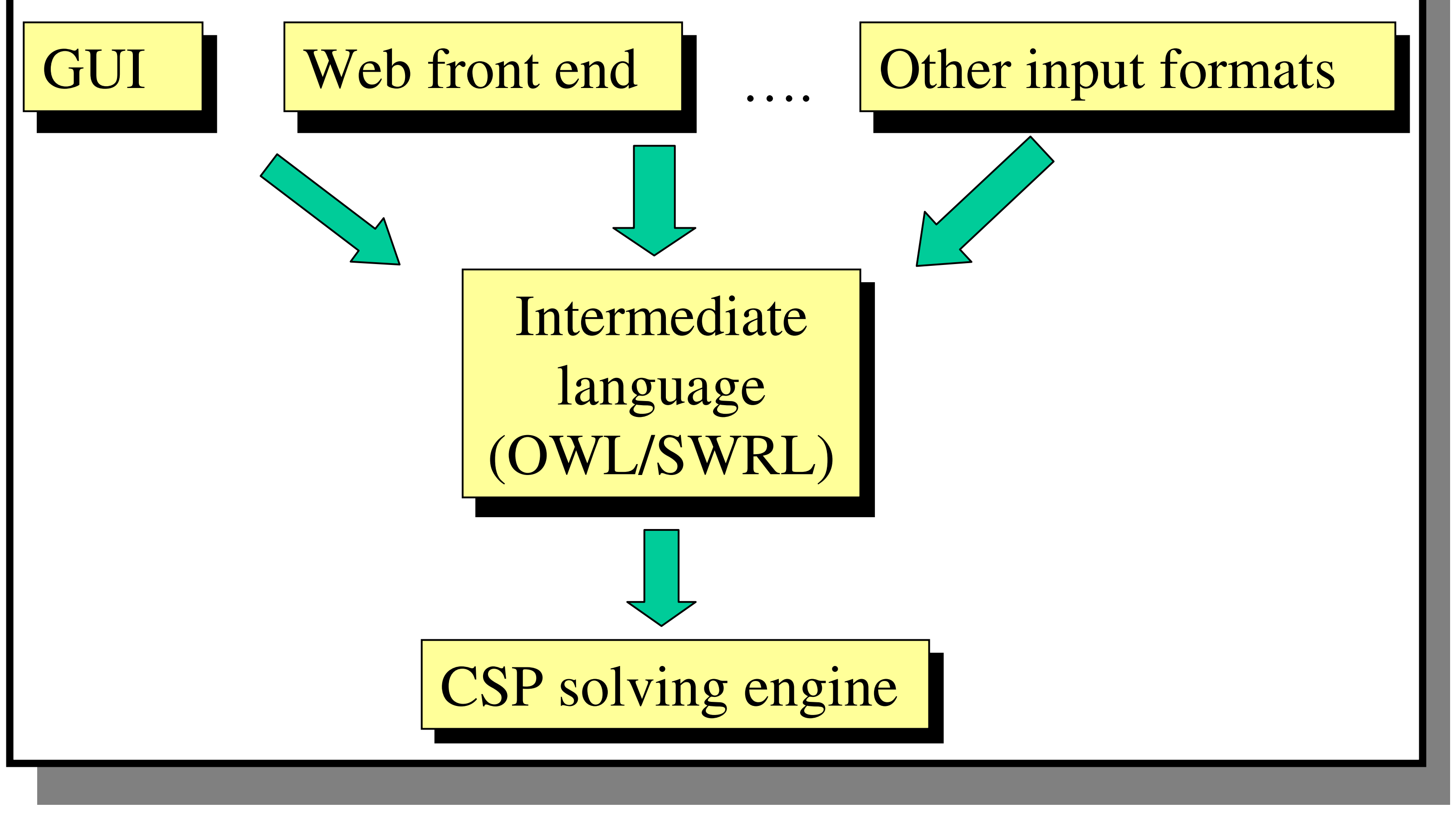
Many applications and problems can be solved (or at least can be aided by) basic constraint based algorithms.

Most modern software engineering tasks require some form of spatial or scheduling work. A problem with this is that to implement such an algorithm requires a great deal of expertise in both constraint programming languages and constraint modelling not normally associated with general software engineering design and implementation.

Another drawback is that many of the current implementations of such algorithms are based on "closed world" models, that is, the solver is customised to work with a particular application or implementation and requires specialised data structures and constraint formats to be used.

With the growing interest in semantic web applications and the use of semantic web standards there is a knowledge gap in the acceptance and use of semantic web based constraint solvers as general reusable components. If such a set of algorithms were available using open standards such as OWL, RDF and CIF/SWRL to define the data structures and the constraint format we could provide an open, standard interface for specific user interfaces to be built for solving specific problems.

Architecture



Project Aims

Frisch, Miguel et al. define 5 CSP problem categories:

- Scheduling, Configuration, Assignment, Construction, Positioning

We want to:

- Find specific characteristics of these categories – create templates
- Assist user in choosing appropriate template for their problem
- Help to instantiate this template – elicit user knowledge
- Solve as CSP (or make recommendations if no solution found or problem under-specified)

Example

How to get from this…to this?

```
     SEND
+    MORE
=   MONEY
```

What numbers do the letters S,E,N,D,M,O,R,Y represent?

→

```
:- use_module(library(clpfd)).

mm([S,E,N,D,M,O,R,Y], Type) :-
        domain([S,E,N,D,M,O,R,Y], 0, 9),
        S#>0, M#>0, all_different([S,E,N,D,M,O,R,Y]),
        sum(S,E,N,D,M,O,R,Y),
        labeling(Type, [S,E,N,D,M,O,R,Y]).

sum(S, E, N, D, M, O, R, Y) :- 1000*S + 100*E + 10*N
        + D + 1000*M + 100*O + 10*R + E #= 10000*M
        + 1000*O + 100*N + 10*E + Y.

Answer:
S = 9, E = 5, N = 6, D = 7,
M = 1, O = 0, R = 8, Y = 2
```

Method

Knowledge Capture

- User interfaces capture information from user on problem representation.

Transformation

- Create OWL/RDF instance representation of problem + CIF/SWRL representation of constraints (below).

Solving

- Constraint solver takes OWL+CIF/SWRL and uses generalised CSP algorithm to transform into CSP problem.

```
<cif:Constraint>
 <cif:hasQuantifiers rdf:parseType="Collection">
  <cif:Forall>
   <cif:var rdf:resource="#svar"/>
   <cif:set rdf:resource="cspTemplate#variable"/>
  </cif:Forall>
</cif:hasQuantifiers>
 <cif:hasImplication>
   <swrl:Imp>
     <swrl:body rdf:parseType="Collection"/>
     <swrl:head rdf:parseType="Collection">
       <!-- CONSTRAINT1: S > 0 -->
       <swrl:DatavaluedPropertyAtom>
           <swrl:propertyPredicate rdf:resource="http://www.w3.org/2003/11/swrlb#greaterThan"/>
           <swrl:argument1 rdf:resource="#svar"/>
           <swrl:argument2 rdf:datatype="http://www.w3.org/2001/XMLSchema#int">0</swrl:argument2>
      </swrl:DatavaluedPropertyAtom>
     </swrl:head>
   </swrl:Imp>
 </cif:hasImplication>
</cif:Constraint>
```

References

C McKenzie, P Gray & A Preece.
Extending SWRL to Express Fully-Quantified Constraints.
In G Antoniou & H Boley (eds) *Rules and Rule Markup Languages for the Semantic Web (RuleML 2004)*, pages 139-154, Springer, 2004.

A.M. Frisch, B. Hnich, I. Miguel, B. M. Smith, T. Walsh. Transforming and Refining Abstract Constraint Specifications. *Proceedings of CSCLP04: Joint Annual Workshop of ERCIM/Colognet on Constraint Solving and Constraint Logic Programming, 2004*

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