DAMLJessKB/OWLJessKB:
Tools for Reasoning with the Semantic Web

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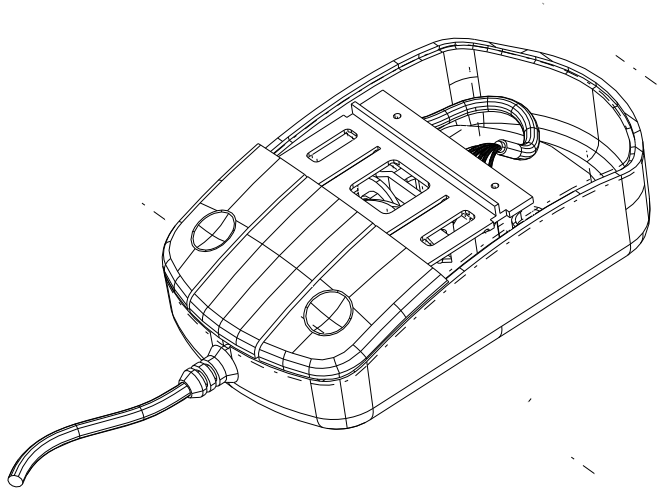
Motivating Application: Design Repositories

Engineering firms maintain large collections of complex design knowledge

- **Part/Design Libraries**
  - **Used in: assembly design, variant design, process/analysis re-use**
- **Design Databases**
  - **Used in: collaborative design, life-cycle management (e.g. maintenance, disassembly)**
- **Legacy Data**
  - **Weakly organized (if at all)**



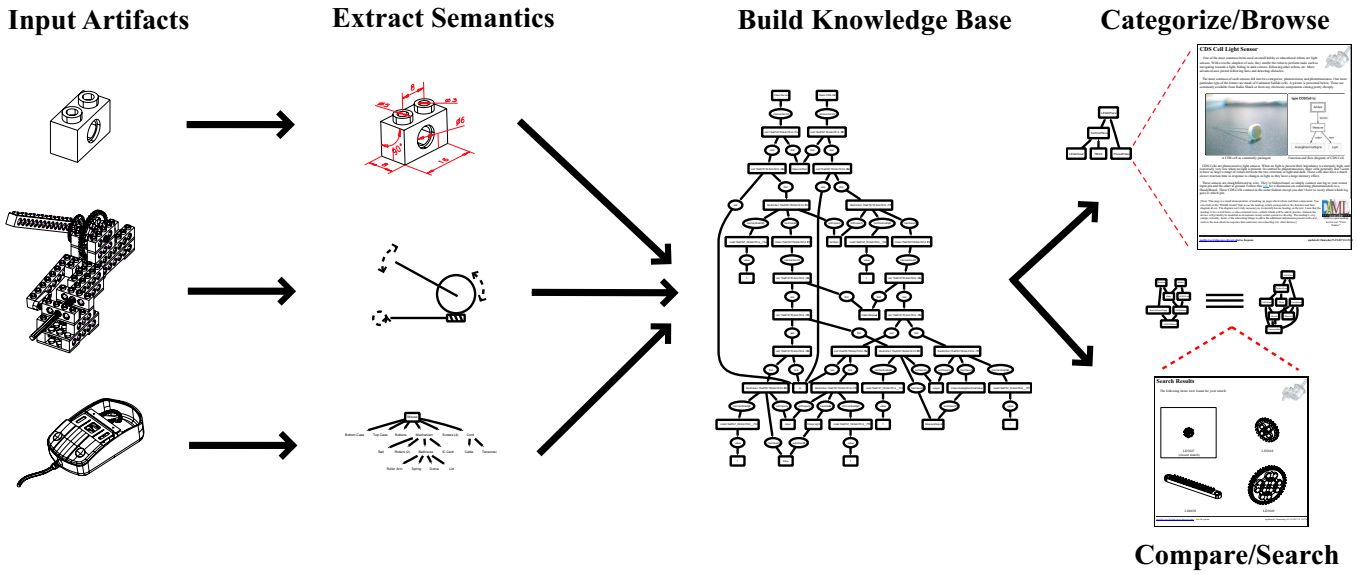
Design repositories—an evolution of traditional design databases

- **Capture and utilize more design knowledge**
- **Enable enhanced services**

(figure © SDRC)

Repository Operations

Knowledge-based repository process:



Major services of interest that a repository may provide:

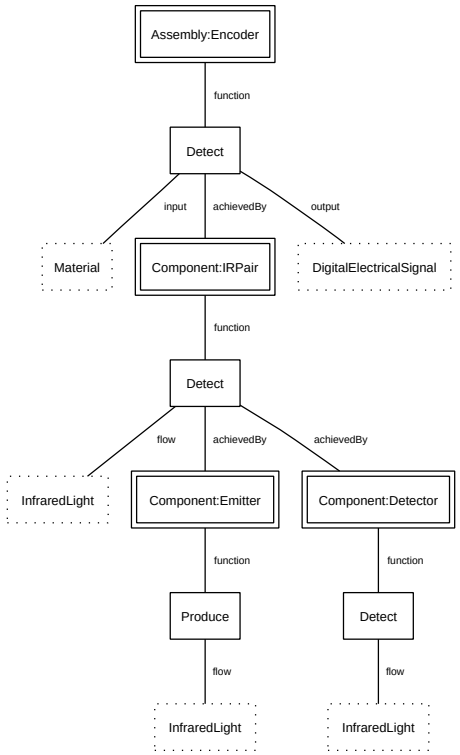
- Search: Finding designs that meet criteria
- Classification: Placing designs into a hierarchy
- Categorization: Inducing a hierarchy automatically

Representation

Function and flow signatures: DL-oriented function modeling approach

- **Simple DL core ontology (~13 statements)**
  - **Function, flow, and artifact classes**
  - **Relations between them**
- **Non-conservative descriptive extensions**
  - **~75 functions, ~50 flows**
  - **Based on Functional Basis/NIST SBF**
  - **Conservatively domain extensible**

Break-Beam Encoder

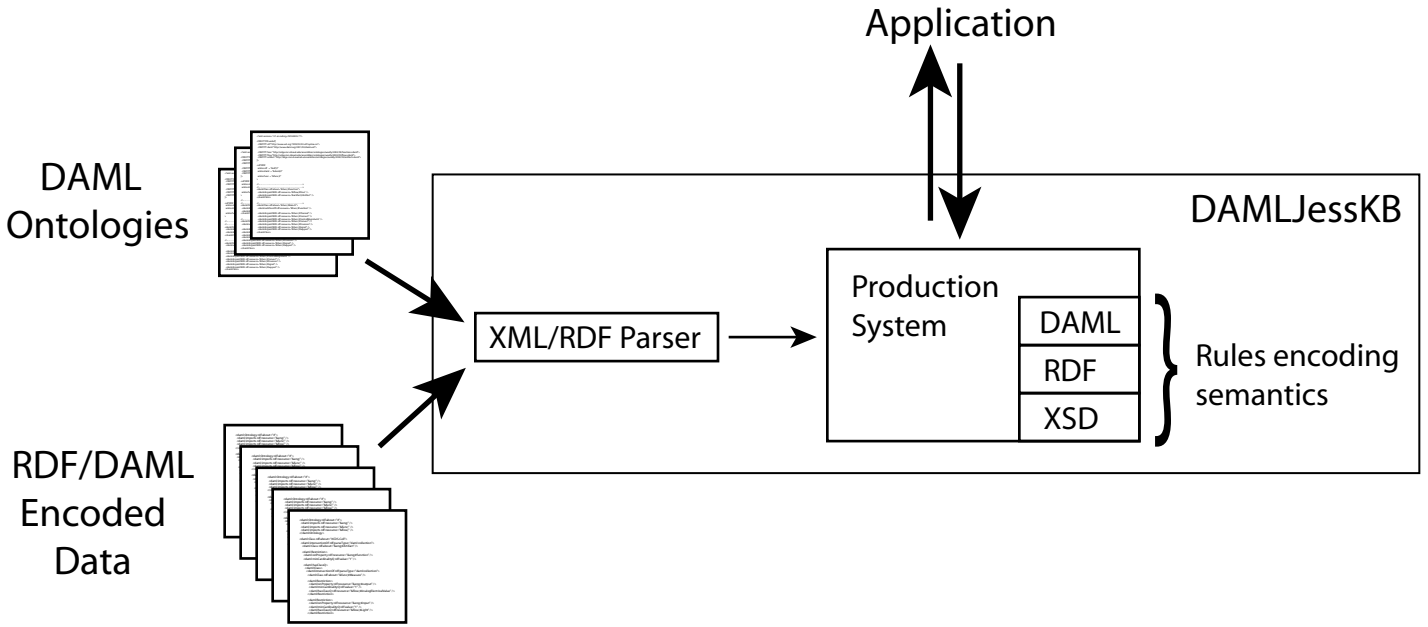


F & F Signature

Reasoning: DAMLJessKB (OWLJessKB)

DAMLJessKB: expert system-based description logic reasoner

- **RDF XML documents are converted to triples in KB**
- **Rules in KB implement RDF(S), XSD, and DAML semantics**
- **Applications query for information/apply application-specific reasoning**



Simple Example: `rdfs:subClassOf`

Necessary implication entailed by RDF-S semantics:

$$\forall a,b,i \ \langle \texttt{rdfs:subClassOf}\ a\ b\rangle \wedge \langle \texttt{rdf:type}\ i\ a\rangle \supset \langle \texttt{rdf:type}\ i\ b\rangle$$

Implementation in Jess' rule language:

```
;;-----------------------------------------------------
(defrule rdfs-subclass-instances
  "An instance of a subclass is an instance of the parent class."

  (triple (predicate "http://www.w3.org/2000/01/rdf-schema#subClassOf")
     (subject ?child)
     (object ?parent))
  (triple (predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (subject ?instance)
     (object ?child))
=>
  (assert (triple (predicate "http://www.w3.org/1999/02/22-rdf-syntax-ns#type")
     (subject ?instance)
     (object ?parent)))
)
```

(this rule from OWLJessKB)

More Complicated Inference: Intersection Subsumption

Conjunctive class description subsumption inference:

```
(defrule intersection-of-subsumption
  "Implements subsumption between classes defined by intersectionOf elements."
  (declare (salience -50))

  (triple (predicate "http://www.w3.org/2002/07/owl#intersectionOf")
     (subject ?topClass)  (object ?topList))
  (triple (predicate "http://www.w3.org/2002/07/owl#intersectionOf")
     (subject ?botClass&~?topClass)  (object ?botList))

  ; There does not exist a member of ?topList which does not either
  ; appear in ?botlist or have a subclass in ?botList.
  (not (and (list-item ?topList ?y)
            (not (or (list-item ?botList ?y)
                     (and (list-item ?botList ?x)
                          (triple
                   (predicate "http://www.w3.org/2000/01/rdf-schema#subClassOf")
                   (subject ?x)  (object ?y)))))))

=>  (assert (triple (predicate "http://www.w3.org/2000/01/rdf-schema#subClassOf")
     (subject ?botClass)  (object ?topClass))))
```

(this rule from OWLJessKB)

Datatype Reasoning

Literals are encapsuated in `daml:Datatype` objects

- **Enables a consistent interface for rules, querying, typing**

XSD Datatypes are encoded in RDF as subclasses of `rdfs:class`

- **Enables classification of literals; subsumption reasoning, e.g.:**

```
(defrule mininclusive-subclassing
  (PropertyValue http://www.w3.org/1999/02/22-rdf-syntax-ns#type
    ?dt1 http://www.daml.org/2001/03/daml+oil#Datatype)
  (PropertyValue http://www.w3.org/2000/10/XMLSchema#minInclusive ?dt1 ?anon1)
  (PropertyValue http://www.w3.org/1999/02/22-rdf-syntax-ns#value ?anon1 ?value1)

  (PropertyValue http://www.w3.org/1999/02/22-rdf-syntax-ns#type
    ?dt2&~?dt1 http://www.daml.org/2001/03/daml+oil#Datatype)
  (PropertyValue http://www.w3.org/2000/10/XMLSchema#minInclusive ?dt2 ?anon2)
  (PropertyValue http://www.w3.org/1999/02/22-rdf-syntax-ns#value ?anon2 ?value2)

  (test (and (integerp ?value1) (integerp ?value2) (>= ?value1 ?value2)))
=>
  (assert (PropertyValue http://www.w3.org/2000/01/rdf-schema#subClassOf ?dt1 ?dt2)))
```

(this rule from DAMLJessKB)

Analysis—Theoretical

Major properties:

- **Sound**—modulus closed world assumption
  - **Often useful** to assume/not require explicit closure **in practice**
  - Need to do thorough analysis/proof; **empirical evidence for now**
- **Incomplete**—handles most inferences likely to be encountered
  - Could be complete?
  - Need to strongly characterize coverage
  - **Configurability**—tailor to performance/reasoning needs
- **Complexity**—performance seems good, but...
  - What is Jess' complexity? Are results for Rete still applicable?
  - Can bounds be made tighter for this reasoning?
- **Equivalence**—icky
  - **Not a problem** in terms of class, property extensions
  - Messy for intensional/instance equivalency, e.g. `owl:sameClassAs`, `owl:sameIndividualAs`

Analysis—Practical

DAMLJessKB: useful, capable

- Handles most of the commonly used inferences
- Performance acceptable, better in OWLJessKB
- Java interface & Jess backend:solid application framework
- Open-source; supported & in active development

Jess: extremely powerful

- Commercial quality, government supported
- Excellent Java interaction; useful scripting language
- Free license for research; source released to licensees
- Very well supported & in active development
  - Upcoming: Improved API; debugging tools and rule editor

Comparison to "proper" DL reasoners, other OWL/DAML inference engines?

Summary

This talk has presented:

- **Design repositories: Application of a wide range of DL inferences**
- **DJKB/OJKB: Practical, in use, Semantic Web reasoning tools**

Topics for future thought:

- **Database backend—one way to address scalability**
- **Configurable reasoning**
  - **What does that mean in terms of interoperability?**
- **Working with rules (e.g. OWLRules)**
- **Non-standard DL reasoning (msc, lcs)**

In Closing...

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More information:

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Questions?