Applications of Description Logics
Application Areas

Terminological KR and Ontologies
- DLs initially designed for terminological KR (and reasoning)
- Natural to use DLs to build and maintain ontologies

Semantic Web
- **Semantic** markup will be added to web resources
  - Aim is “machine understandability”
- Markup will use **Ontologies** to provide common terms of reference with clear semantics
- Requirement for web based ontology language
  - Well defined semantics
  - Builds on existing Web standards (XML, RDF, RDFS)
- Resulting language (DAML+OIL) is **based on a DL** (*SHI*Q)
- DL **reasoning** can be used to, e.g.,
  - Support ontology design and maintenance
  - Classify resources w.r.t. ontologies
Application Areas II

- **Configuration**
  - *Classic* system used to configure telecoms equipment
  - Characteristics of components described in DL KB
  - Reasoner checks validity (and price) of configurations

- **Software information systems**
  - LaSSIE system used DL KB for flexible software documentation and query answering

- **Database applications**

- ...
Database Schema and Query Reasoning

- DLR (n-ary DL) can capture semantics of many conceptual modelling methodologies (e.g., EER)
- Satisfiability preserving mapping to SHIQ allows use of DL reasoners (e.g., FaCT, RACER)
- DL Abox can also capture semantics of conjunctive queries
  - Can reason about query containment w.r.t. schema
- DL reasoning can be used to support
  - Schema design, evolution and query optimisation
  - Source integration in heterogeneous databases/data warehouses
  - Conceptual modelling of multidimensional aggregation
- E.g., I.COM Intelligent Conceptual Modelling tool (Enrico Franconi)
  - Uses FaCT system to provide reasoning support for EER
I.COM Demo
Terminological KR and Ontologies

- General requirement for medical terminologies
- Static lists/taxonomies difficult to build and maintain
  - Need to be very large and highly interconnected
  - Inevitably contain many errors and omissions
- Galen project aims to replace static hierarchy with DL
  - Describe concepts (e.g., spiral fracture of left femur)
  - Use DL classifier to build taxonomy
- Needed expressive DL and efficient reasoning
  - Descriptions use transitive/inverse roles, GCIs etc.
  - Very large KBs (tens of thousands of concepts)
    - Even prototype KB is very large (≈3,000 concepts)
    - Existing (incomplete) classifier took ≈24 hours to classify KB
    - FaCT system (sound and complete) takes ≈60 seconds
Reasoning Support for Ontology Design

- DL reasoner can be used to support design and maintenance
- Example is OilEd ontology editor (for DAML+OIL)
  - Frame based interface (like Protegé, OntoEdit, etc.)
  - Extended to clarify semantics and capture whole DAML+OIL language
    ➤ Slots explicitly existential or value restrictions
    ➤ Boolean connectives and nesting
    ➤ Properties for slot relations (transitive, functional etc.)
    ➤ General axioms
- Reasoning support for OilEd provided by FaCT system
  - Frame representation translated into $\mathcal{SHIQ}$
  - Communicates with FaCT via CORBA interface
  - Indicates inconsistencies and implicit subsumptions
  - Can make implicit subsumptions explicit in KB
DAML+OIL Medical Terminology Examples

E.g., DAML+OIL medical terminology ontology

- Transitive roles capture transitive partonomy, causality, etc.
  
  Smoking $\sqsubseteq \exists$causes.Cancer and Cancer $\sqsubseteq \exists$causes.Death
  
  $\Rightarrow$ Cancer $\sqsubseteq$ FatalThing

- GCIs represent additional non-definitional knowledge
  
  Stomach-Ulcer $\doteq$ Ulcer $\sqcap \exists$hasLocation.Stomach and Stomach-Ulcer $\sqsubseteq \exists$hasLocation.Lining-Of-Stomach
  
  $\Rightarrow$ Ulcer $\sqcap \exists$hasLocation.Stomach $\sqsubseteq$ OrganLiningLesion

- Inverse roles capture e.g. causes/causedBy relationship
  
  Death $\sqcap \exists$causedBy.Smoking $\sqsubseteq$ PrematureDeath
  
  $\Rightarrow$ Smoking $\sqsubseteq$ CauseOfPrematureDeath

- Cardinality restrictions add consistency constraints
  
  BloodPressure $\sqsubseteq \exists$hasValue.(High $\sqcup$ Low) $\sqcap \leq 1$hasValue and
  
  High $\sqsubseteq \neg$Low
  
  $\Rightarrow$ HighLowBloodPressure $\sqsubseteq \bot$
OilEd Demo