Applications of Description Logics

Application Areas I

- 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** ($\mathcal{SHIQ}$)
  - DL **reasoning** can be used to, e.g.,
    - Support ontology design and maintenance
    - Classify resources w.r.t. ontologies

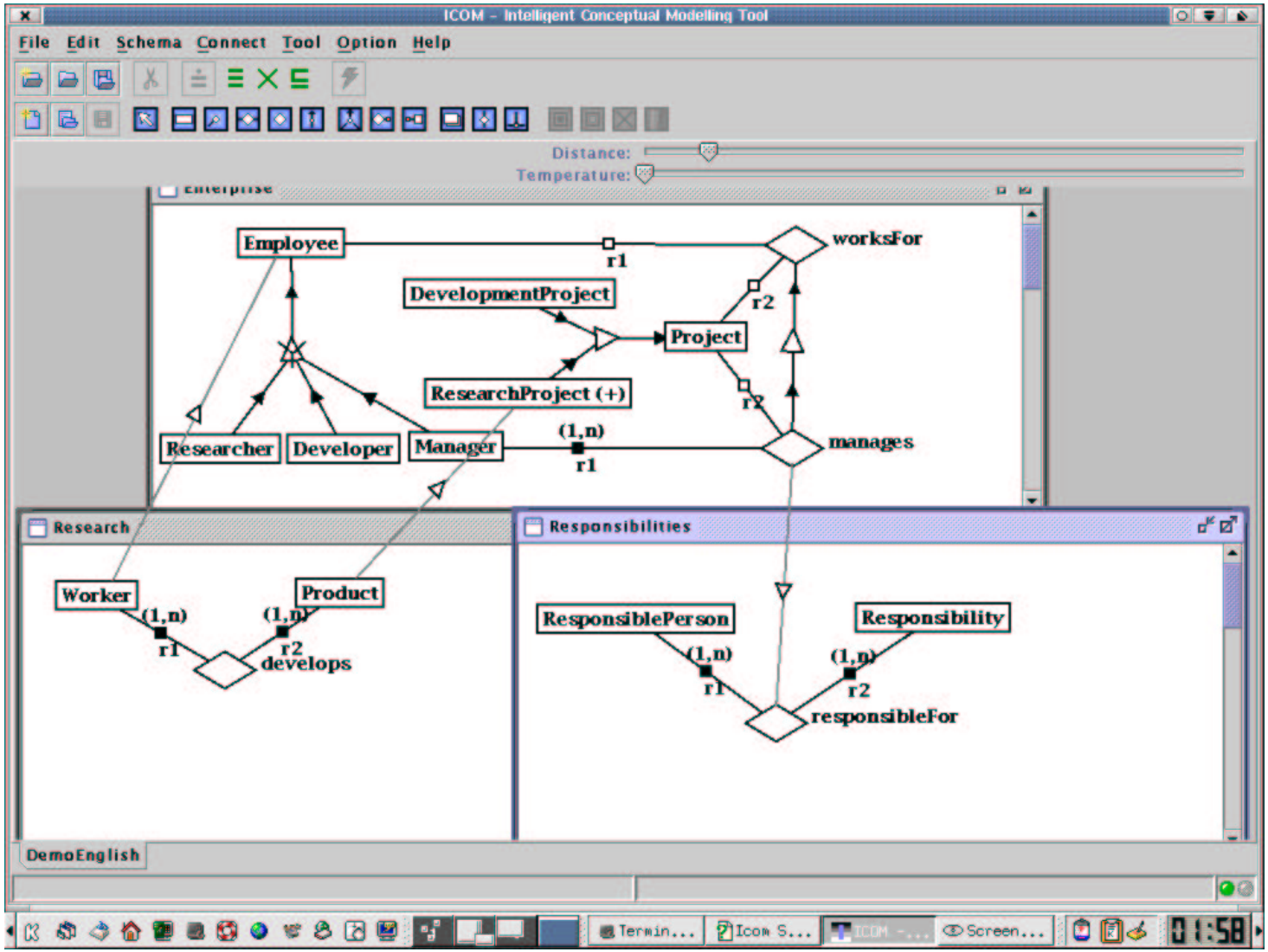
Application Areas II

- 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

- $\mathcal{DLR}$ (n-ary DL) can capture semantics of many conceptual modelling methodologies (e.g., EER)
- Satisfiability preserving mapping to $\mathcal{SHIQ}$ 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


ICOM - Intelligent Conceptual Modelling Tool
File Edit Schema Connect Tool Option Help
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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 ($\approx$3,000 concepts)
    - Existing (incomplete) classifier took $\approx$**24 hours** to classify KB
    - FaCT system (sound and complete) takes $\approx$**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.

  $\mathsf{Smoking} \sqsubseteq \exists \mathsf{causes}.\mathsf{Cancer}$ plus $\mathsf{Cancer} \sqsubseteq \exists \mathsf{causes}.\mathsf{Death}$
  $\Rightarrow \mathsf{Cancer} \sqsubseteq \mathsf{FatalThing}$

- GCIs represent additional non-definitional knowledge

  $\mathsf{Stomach\text{-}Ulcer} \doteq \mathsf{Ulcer} \sqcap \exists \mathsf{hasLocation}.\mathsf{Stomach}$ plus
  $\mathsf{Stomach\text{-}Ulcer} \sqsubseteq \exists \mathsf{hasLocation}.\mathsf{Lining\text{-}Of\text{-}Stomach}$
  $\Rightarrow \mathsf{Ulcer} \sqcap \exists \mathsf{hasLocation}.\mathsf{Stomach} \sqsubseteq \mathsf{OrganLiningLesion}$

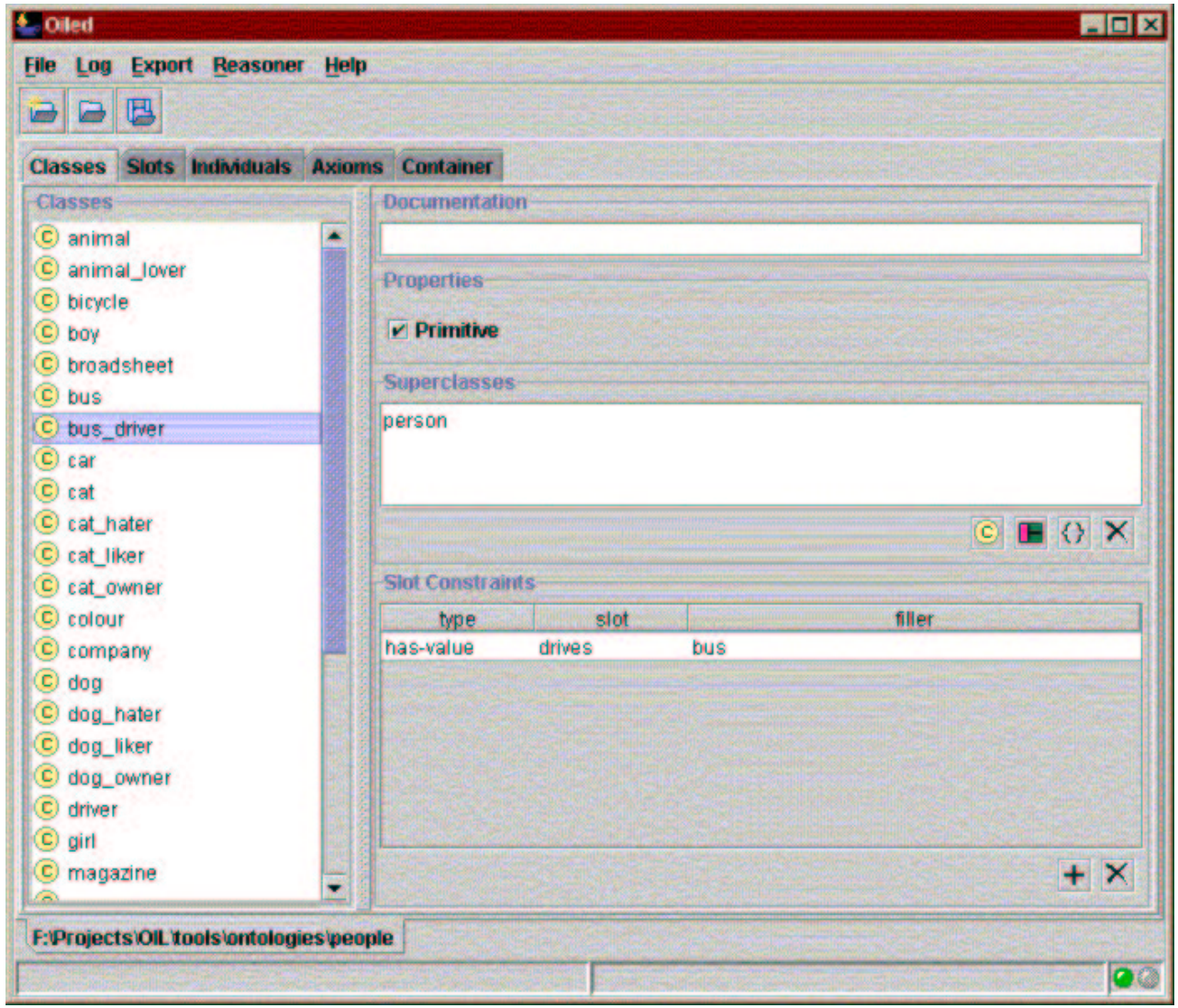
- Inverse roles capture e.g. causes/causedBy relationship

  $\mathsf{Death} \sqcap \exists \mathsf{causedBy}.\mathsf{Smoking} \sqsubseteq \mathsf{PrematureDeath}$
  $\Rightarrow \mathsf{Smoking} \sqsubseteq \mathsf{CauseOfPrematureDeath}$

- Cardinality restrictions add consistency constraints

  $\mathsf{BloodPressure} \sqsubseteq \exists \mathsf{hasValue}.(\mathsf{High} \sqcup \mathsf{Low}) \sqcap \leqslant 1 \mathsf{hasValue}$ plus
  $\mathsf{High} \sqsubseteq \neg \mathsf{Low} \Rightarrow \mathsf{HighLowBloodPressure} \sqsubseteq \bot$

OilEd Demo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File Log Export Reasoner Help
Classes Slots Individuals Axioms Container
Classes
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boy
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cat_owner
colour
company
dog
dog_hater
dog_liker
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