

# Description Logics and Databases

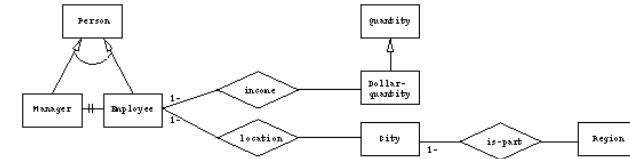
(Acknowledgement: Enrico Franconi)

Relational algebra: Relational theories in DL

DL as a query language for Data Bases:

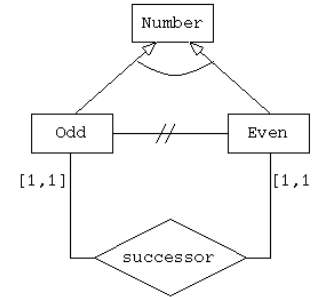
Reasoning over queries is decidable;

Extensions: Incomplete information; querying with a conceptual schema



## The Entity-Relationship (ER) Conceptual Data Model

The Entity-Relationship (ER) model is the most common semantic data model for database design.



## Mapping an ER Schema in a DL Theory

- An ER conceptual schema can be expressed in a suitable description logic theory.
- The models of the DL theory correspond with legal database states of the ER schemata.
- Reasoning services such as satisfiability of a schema or logical implication can be performed by the corresponding DL theory.
- A description logic allows for a greater expressivity than the original ER framework in terms of full disjunction and negation, and entity definitions by means of both necessary and sufficient conditions.

- Relations are *reified* in the description logic theory, i.e., they become concepts with  $n$  special feature names denoting the  $n$  arguments of the  $n$ -ary relation.
- The relation INCOME becomes a concept with the two features:
  - *incomer* – relating to the first argument of the relation, i.e., an employee,
  - *incoming* – relating to the second argument of the relation, i.e., a dollar quantity.
- *incomer, incoming, locator, place, whole, and part* are functional roles.

## Advantages of DL for Conceptual Modeling

- “Ontological” organization
- Consistency checking
- Data entry
- Views organization
- Schema refinement
- Inter-schema organization

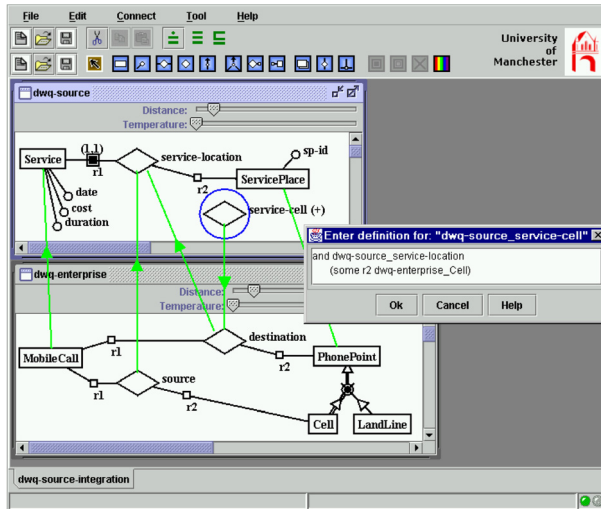
$\text{INCOME} \sqsubseteq \text{incomer} : \text{Employee} \sqcap \text{incoming} : \text{Dollar} - \text{quantity}$   
 $\text{LOCATION} \sqsubseteq \text{locator} : \text{Employee} \sqcap \text{place} : \text{City}$   
 $\text{IS - PART} \sqsubseteq \text{part} : \text{City} \sqcap \text{whole} : \text{Region}$   
 $\text{Employee} \sqsubseteq \text{Person} \sqcap \exists \text{incomer}^{-1} . \text{INCOME} \sqcap \exists \text{locator}^{-1} . \text{LOCATION}$   
 $\text{Manager} \sqsubseteq \text{Person} \sqcap \neg \text{Employee}$   
 $\text{Person} \sqsubseteq \text{Manager} \sqcup \text{Employee}$   
 $\text{Dollar} - \text{quantity} \sqsubseteq \text{Quantity}$   
 $\text{City} \sqsubseteq \exists \text{part}^{-1} . \text{IS - PART}$

## Advantages of DL for Querying

- Query validation
- Query generalization
- Query organization
- Query refinement
- Intensional query processing
- Query optimization

## i.com: A Tool Supporting Conceptual Design (EER)

. . . integrated with a powerful description logics server



## Some References

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 IEEE Transactions on Knowledge and Data Engineering,  
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Calvanese, D., Lenzerini, M., Nardi, D.:  
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 Saake, G.  
 Dordrecht: Kluwer, 1998.

## Outlook

- Description Logics and Logics  
 Propositional Dynamic and Temporal Modal Logics
- Mereology: Parts and Wholes  
 Applications, e.g. Configuration
- Geometric Modelling (Concrete Domain Extensions)  
 Applications, e.g. NC Production Planning
- Representation of Time and Space; Constraints
- Vague Knowledge and Probabilistic Reasoning;  
 Bayes Networks
- Non-Monotonic Reasoning  
 Belief Revision; Default Theories; Reason Maintenance