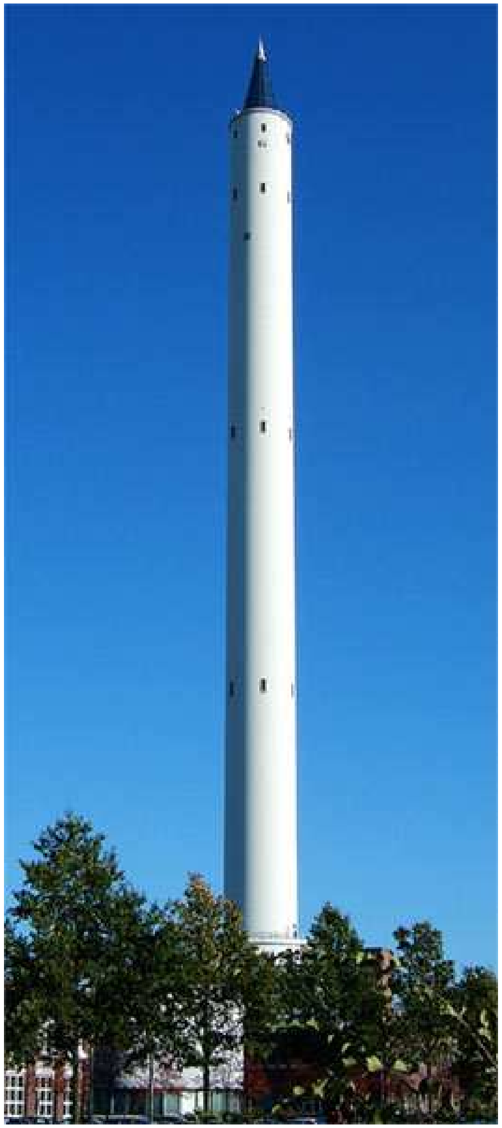


Integrationsformalismen

Semantische Datenintegration Seminar@Uni-Bremen

Oğuzhan Topsakal

June 20th, 2005

Outline

- Integration Formalism
- Types of Formalism Approaches
  - Rule-based Approach
  - Context Transformation Approach
- Global as a View (GAV)
- Local as a View (LAV)
- An Example for Rule Based: TSIMMIS
- An Example for Context Transformation: Farquar et al.

Integration Formalism & Its Types

Describes the mechanisms about how the heterogonous information from different information sources is combined in order to make a global view

- Rule Based Approaches
  - TSIMMIS at Stanford University
- Context Based Approaches
  - Formalizing Context (McCarthy et al.)
  - CARNOT System (Collet et al.)
  - COIN System (Goh et al.)
  - Integrating Sources Using Context Logic (Farquhar et al.)

Rule-based Approaches

Approaches for generating a mediated schema

- Global as a View (GAV)
- Local as a View (LAV)

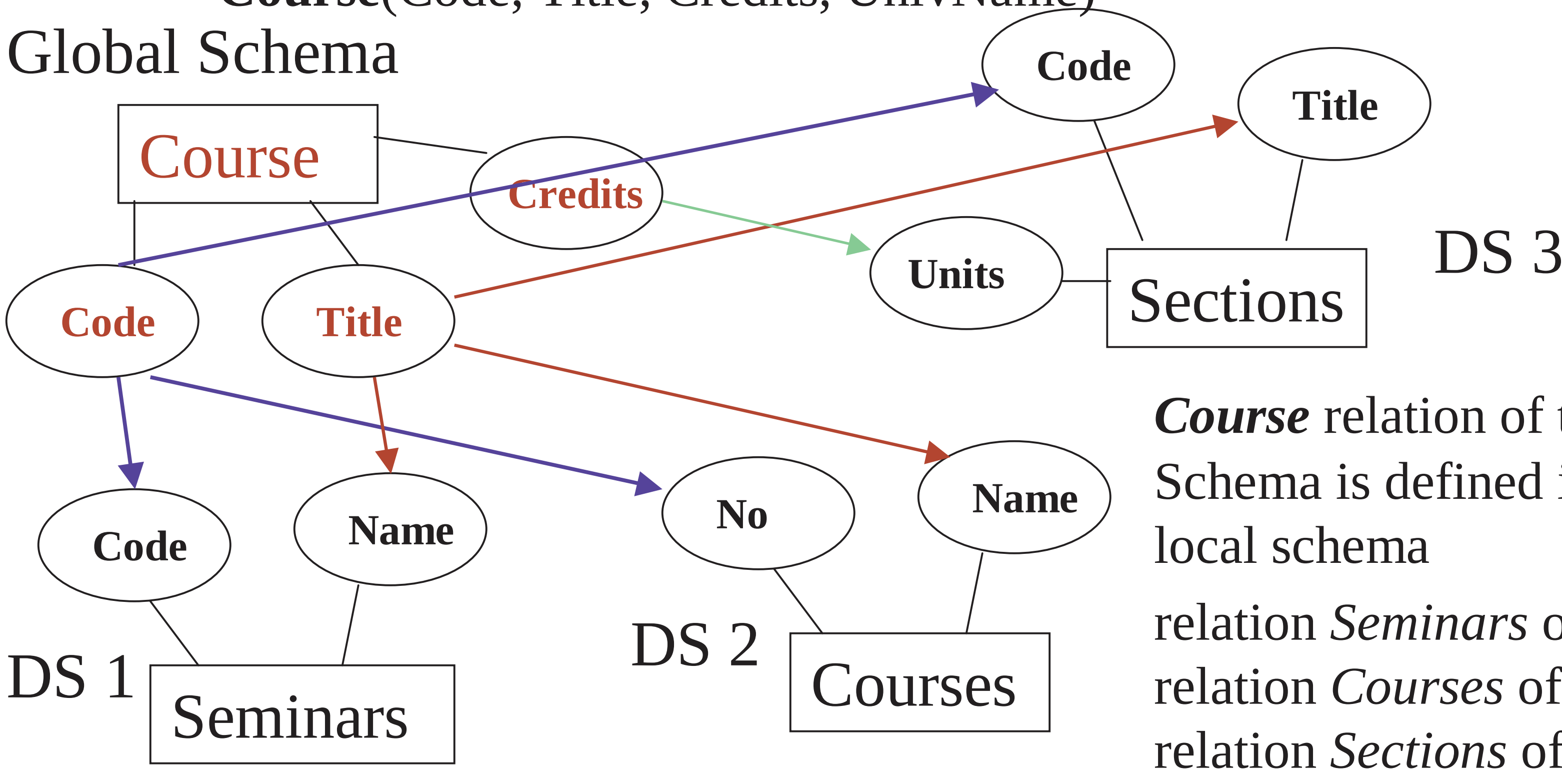
Global as a View (GAV)

The schema elements of the global schema are defined over the schema elements of the local schemas (Query-centric)

- An Example Using GAV approach
  - Garcia-Molina et al. 1997 (TSIMMIS project)

Creating the Global Schema for GAV Approach

Course(Code, Title, Credits, UnivName)



Course relation of the Global Schema is defined in terms of local schema

relation *Seminars* of DS1,
relation *Courses* of DS2, and
relation *Sections* of DS3 forms

Course(..) => DS1, DS2, DS3

Local as a View (LAV)

The schema elements of the local schemas are defined over the schema elements of the global schema (View-centric)

Related database problems:

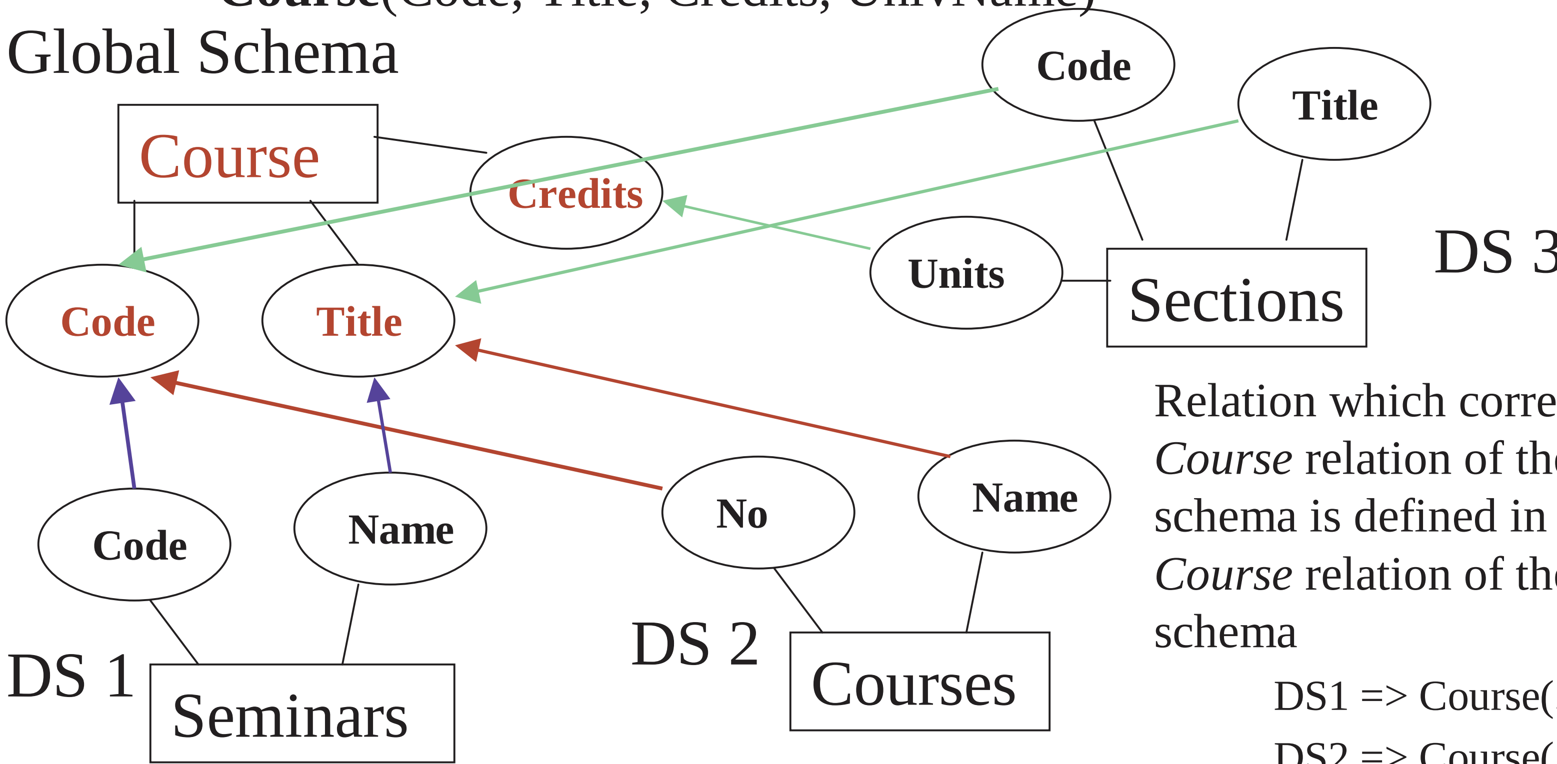
– Query optimization

– Maintaining physical data independence

– Data warehouse design

Creating the Views for LAV Approach *

Course(Code, Title, Credits, UnivName)



Relation which corresponds to *Course* relation of the global schema is defined in terms of *Course* relation of the global schema

DS1 => Course(..)

DS2 => Course(..)

DS3 => Course(..)

*Colors and direction of arrows change when compared to GAV example

Examples for GAV and LAV Approaches by Using THALIA Data

- **THALIA** (**T**est **H**arness for the **A**ssessment of **L**egacy information **I**ntegration **A**pproaches) is a publicly available testbed and benchmark for testing and evaluating integration technologies.
- THALIA provides data sources representing University course catalogs from computer science departments around the world.
- For a better understanding of GAV and LAV approaches, we provide examples by using THALIA data.
  - URL of THALIA: http://www.cise.ufl.edu/project/thalia.html

Global Schema & Local Schemas*

Suppose we have the following global (mediated) schema:

Course(CourseCode, Title, Desc, Prereq, Credits, UnivName)

Instructor(InstCode, Name, CourseCode, Email)

Location(CourseCode, Room, Building)

Time(CourseNo, Day, Hour)

Local Schemas of Universities:

DS1: Arizona_University(Code, Time, Day, Place, Instructor) **---** Only Graduate Level

DS2: Bremen_University(Code, Instructor, Title, Room) **---** Only In MZH Building

DS3: Carnegie_Mellon_University(Code, Title, Day, Time, Units)

DS4: University_of_Florida(Code, Title, Prereq, Description, Credits, Instructor, Day, Period, Building, Room) **---** Only Courses with Prereq

**** Global and Local Schemas are simplified for a clear example***

Query Answering by GAV Approach

Course(CourseCode, Title, Desc, Prereq, Credits, UnivName) => DS1, DS2, DS3 **,DS4**

Instructor(InstCode, Name, CourseCode, Email) => DS1, DS2 **,DS4**

Location(CourseCode, Room, Building) => DS1 **,DS4**

Time(CourseNo, Day, Hour) => DS1, DS3 **,DS4**

Query1: *List the Codes of Courses given on Monday*

Q(CourseNo, "Monday", Hour) **:- Time(**CourseCode, "Monday", Hour) =>
DS1(Code,Time,"Monday",Place,Instructor) , DS3(Code,Title,"Monday",Time,Units)

DS1: Arizona_University(Code, Time, Day, Place, Instructor) **---** Only Graduate Level

DS2: Bremen_University(Code, Instructor, Title, Room) **---**In MZH Building

DS3: Carnegie_Mellon_University(Code, Title, Day, Time, Units) – Only Weekends

DS4: University_of_Florida(Code, Title, Prereq, Description, Credits, Instructor, Day, Period, Building, Room) --- Only Courses with Prereq

Query Answering by LAV Approach

Arizona_University(Code, Time, Day, Place, Instructor) => Course(..), Instructor(..), Location(..), Time(..), ^ (UnivName = ‘Arizona’) ^ (CourseCode > ‘500’)

Bremen_University(Code, Instructor, Title, Room) => Course(..), Instructor(..), Location(..) ^ (Building = ‘MZH’)

Carnegie_Mellon_University(Code, Title, Day, Time, Units) => Course(..), Time(..)

University_of_Florida(Code, Title, Prereq, Description, Credits, Instructor, Day, Period, Building, Room) => Course(..), Instructor(..), Location(..), Time(..) ^ Prereq <> null

Query1: *List the Codes of Courses given on Monday*

Time(CourseNo, “Monday”, Hour) => Arizona_University(), Canigie_Mellon_University(), University_of_Florida(..)

Course(CourseCode, Title, Desc, Prereq, Credits)

Instructor(InstCode, Name, CourseCode, Email)

Location(CourseCode, Room, Building)

Time(CourseNo, Day, Hour)

Comparison of GAV and LAV

- In Global as a View (GAV)
  - Reformulating the query in terms of the sources is easier (just needs unfolding of the query)
  - Adding a new source is harder. Requires redefinition of the global schema.
- In Local as a View (LAV)
  - Reformulating the query is harder.
  - Adding new source is easier (just need to express the new source as a view of the global schema)
  - It is easier to specify rich constraints on the contents of a source.

TSIMMIS Approach - Outline

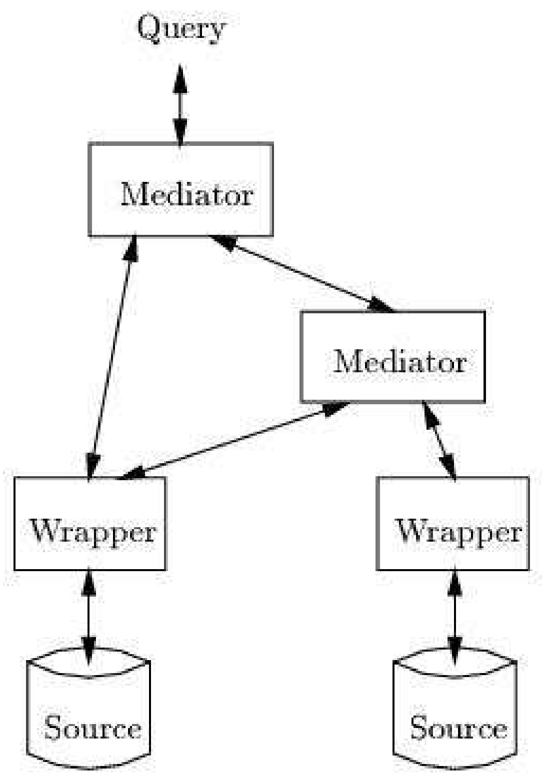
- Goal and Overview of TSIMMIS
- Object Exchange Model (OEM)
- Mediator Specification Language (MSL)
- Wrapper Generation by rules
- Mediator Generation by rules

TSIMMIS Approach

- TSIMMIS stands for "**T**he **S**tanford-**I**BM **M**anager of **M**ultiple **I**nformation **S**ources"
- The TSIMMIS Project aims
  - To develop tools
  - To provide a framework

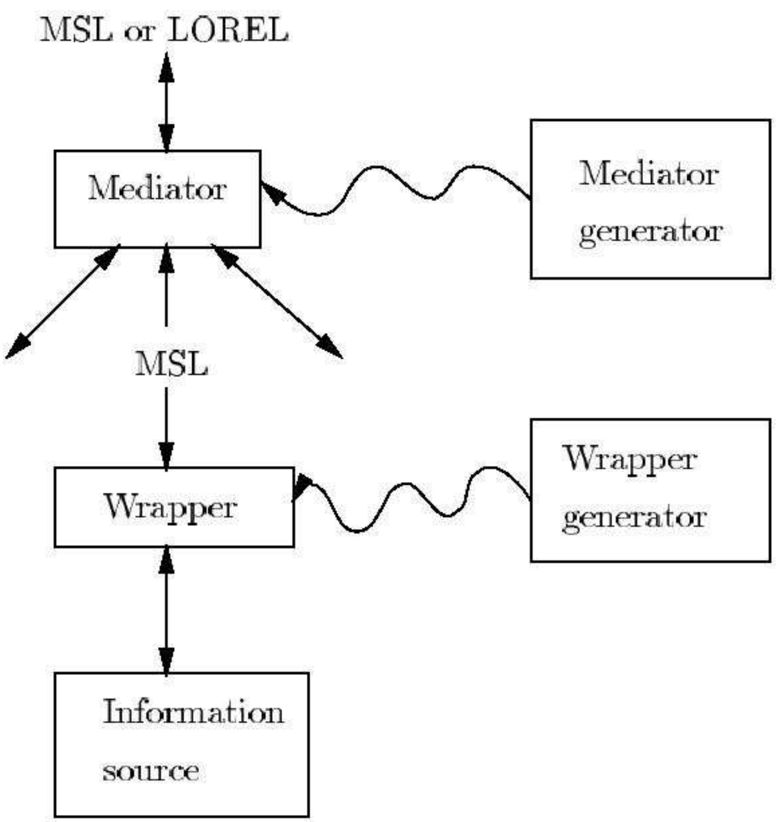
  To assist humans to facilitate the rapid integration of heterogeneous information sources
  - Not to perform fully automated information integration

Requirements of a Mediator Architecture



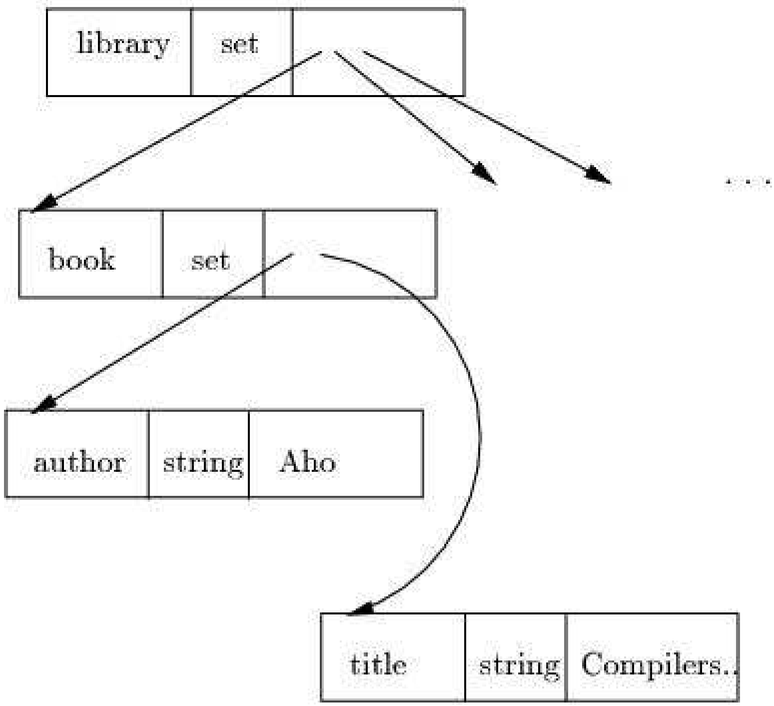
- A common data model
- A common query language that allows
  - new mediators to join
  - new sources to provide input
- Tools to make the creation of new mediator systems easier

Components of TSIMMIS



- OEM data model
- MSL or LOREL query query language
- Mediator and Wrapper Generator Tools

Object Exchange Model (OEM)



Components:

[OID | label | type | value]

ObjectID: Need not to be persistent

Label: Defines the object

Type: Either set or an atomic type

Value: Either an atomic value or a set of objects.

Mediator Specification Language

An example of a rule written in MSL:

<booktitle X> :-

<library {<book {<title X> <author "Aho">}> }> @s1

- Triangular brackets associate labels with their values.
- Curly brackets groups members of a set. This set is the value of an object that has a type set.
- The object pattern in the body is matched against the object structure of the source s1
- The variable **X** binds to the value of the *title* subobjects of *book* objects that have an *author* subobject with the value *'Aho'*

Wrapper Generation Example

The wrapper generator takes a set of templates of the form:

MSL template

// action //

Example:

```
<books X> :-
   <library {X: <book {<title X> <author $AU>}> }>@s1
   // sprintf(lookup-query,'find author %s',$AU) //
```

- The wrapper examines a query and compares it to the patterns in its specification file.
- If the query matches a pattern with some string in place of the parameter $AU, then the associated action would be executed, with that string in place of the parameter.

Context Logic for Integration

- Context Logic
  - Extension of First Order Logic

    c` : ist(c, p)
- Idea
  - Define each information source as a context
  - Integrate the sources by lifting to a wider context

Research on Information Integration with Context Logic

- Formalizing Context (McCarthy et al.)
  - Defines context logic, lifting axioms
  - Gives an example for integrating databases
- CARNOT system (Collet et al.)
  - Defines articulation axioms which translate statements which are true in a source to statements which are meaningful in the Cyc knowledgebase
- COIN system (Goh et al.)
  - Forms a formal, logical specification of Context Interchange System with three components: Domain model, Elevation Axioms, Context Axioms
- Integrating Sources Using Context Logic (Farquhar et al.)
  - Translate relational DB tables into First Order Logic
  - Use lifting axioms of Context Logic to make implicit assumptions explicit

Integrating Information Sources Using Context Logic (Farquar et al.)

- Their goal is to enable
  - Meaningful integration across multiple sources
  - Users to access to complete power of an individual source
  - Taking advantage of their familiarity with a source
- Their approach
  - Reduces the up-front cost of integration
  - Expresses and resolves semantic conflicts
  - Provides incremental integration

Types of Context According to Farquar et al. Approach

- Information Source Context
  - Direct translation of DB schema into assertions in first order logic
  - Done automatically but no semantic conflict is resolved
- Semantic Context
  - Lifting axioms are added manually to make the implicit assumptions explicit
- Integration Context
  - Contains axioms that lift sentences from several semantic contexts

Example: Product Database - Representing in First Order Logic

***Product* table:**

name	char	key
size	int	
cost	int	

name	***size***	***cost***
Television_1	14	256
Simm_1	256	14

***ProductType* table:**

name	char	key
type	char	

name	***type***
Television_1	television
Simm_1	memory chip

Information Source Context

(∀ x,y,z product(x, y, z) ⇒ string(x) & integer(y) & integer(z))

relation(product) & arity(product, 3) & primary-key(product, 1)

(∀ x,y,z product_type(x, y) ⇒ string(x) & string(y))

relation(product_type) & arity(product, 2) & primary-key(product_type, 1)

Example: Product Database – Problems with Representation

***Product* table:**

name	char	key
size	int	
cost	int	

name	***size***	***cost***
Television_1	14	256
Simm_1	256	14

***ProductType* table:**

name	char	key
type	char	

name	***type***
Television_1	television
Simm_1	memory chip

Problems with representing a DB schema in logic

- **Attributes may be used polymorphically (Ex: size attribute can hold size in different units)**
- **Values need not have a unique denotation (Ex: The number 256 appears in both size and cost columns)**

Solution is to use

- **Existential quantification & Renaming**
- **Context Logic (Adding Lifting Axioms)**

Example: Product Database – Adding Lifting Axioms

Information Source Context

($\forall$ x,y,z product(x, y, z) $\Rightarrow$ string(x)
& integer(y) & integer(z))

relation(product) & arity(product, 3)
& primary-key(product, 1)

($\forall$ x,y,z product_type(x, y) $\Rightarrow$ string(x)
& string(y))

relation(product_type) & arity(product, 2)
& primary-key(product_type, 1)

+ Lifting Axioms = Semantic Context

ist (SC1, product_type(x, y))
$\Leftrightarrow$ **ist**(IS1, product_type(x, y))

ist (SC1,
$\exists$ y',z'
(product(x, y', z')
& magnitude(y', natural-size-units (x))=y
& magnitude(z', us-dollar) = z))
$\Leftrightarrow$ **ist**(IS1, product(x, y, z)))

ist (SC1,
natural-size-units(x) = bit*1024
$\Leftarrow$ product-type(x, memory-chip))

ist (SC1, natural-size-units(x) = inch
$\Leftarrow$ product-type(x, television))

Integration Context

- Defined after constructing the information source context and semantic context
- Contains axioms that lift sentences from several semantic contexts
- Several Approaches are possible
  - Global Schema Approach
  - Federated Database Approach
  - Peer to peer Approach

Benefits of Using Context Logic

- Integrate new information sources incrementally
- Share assumptions without making them explicit
- Exploit ontologies
- Provide a richer model of integration

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Fragen ?

Vielen Dank für Ihre Aufmerksamkeit!