Data integration (Heterogeneous data sources)

Technologies for Information Systems
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Exercise

There are 3 data sources with different schemas and data models
- UNIVERSITY-DB (DS1)
  - Relational data source
- TAX-POSITION (DS2)
  - XML data source
- COMPUTER-SCIENCE (DS3)
  - Object-oriented data source

Differently from previous exercises, we are dealing with heterogeneous data sources
- Different data models

Exercise - main steps

In the presence of heterogeneous data sources, we need to change some steps of the integration approach:
1. Schema analysis and identification of the sources data models
2. Reverse engineering (conceptual models)
3. Identification and resolution of conflicts
4. Conceptual models integration
5. Choice of the target data model (for global conceptual schema translation)
6. Source schemata translation to the target data model (by means of adapters)
7. Conceptual model translation
8. Definition of data views (mappings)

UNIVERSITY-DB (DS1)

DEPARTMENT(dept-code, dept-name, budget)
RESEARCH_STAFF(email, name, dept-code, s-code)
SCHOOL_MEMBER(email, name, school, year)
SESSION(s-code, session-name, length, room-code)
ROOM(room-code, seats-number, notes)

N.B.:
- School members are both research staff members and students
- Sessions are intended as courses
- Each session is related to only one research staff member
- People names are encoded as "name$surname"

TAX-POSITION (DS2)

```
<!ELEMENT listOfStudents (student*)>
<!ELEMENT student (name, s-code, school-name, email, tax-fee)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT s-code (#PCDATA)>
<!ELEMENT school-name (#PCDATA)>
<!ELEMENT email (#PCDATA)>
<!ELEMENT tax-fee (#PCDATA)>
```

N.B.:
- Assume the content of **s-code** as key

COMPUTER-SCIENCE (DS3)

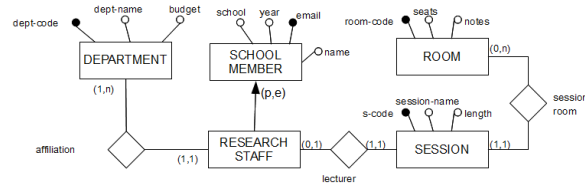
CS_PERSON (first-name, last-name)
PROFESSOR:CS_PERSON (belongs_to:DIVISION, rank)
STUDENT:CS_PERSON (year, takes:set<COURSE>, rank, email)
DIVISION (code, description, address:LOCATION)
LOCATION (city, street, number, country)
COURSE (course-name, taught-by:PROFESSOR)

Data model identification

- DS1: relational
- DS2: XML
- DS3: Object Oriented

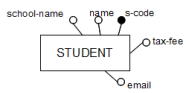
Reverse engineering

DS1 – conceptual schema



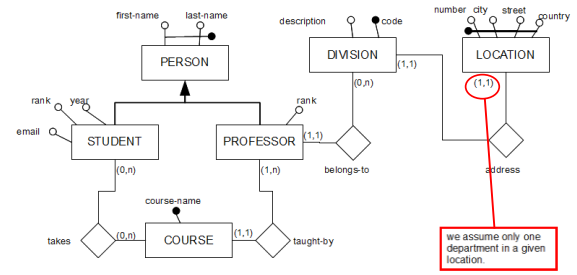
Reverse engineering

DS2 – conceptual schema



Reverse engineering

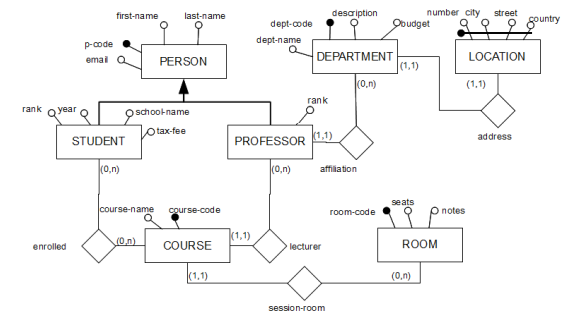
DS3 – conceptual schema



Conflict analysis

- synonyms:
  - department ↔ division
  - course ↔ session
  - research staff ↔ professor
  - school member ↔ person
  - student is a subset of person
- location ↔ room
- cardinality conflicts:
  - cardinality conflict between professor and course
    - DS1: relationship session (course) - research staff (professor): one to one
    - DS3: relationship course - (professor): one to many
- key-conflicts:
  - person
    - DS1: email → p-code
    - DS2: s-code → p-code
    - DS3: (first name, last-name) → p-code

GS conceptual schema



GS logical schema

Choice of the target data model
- We select the relational data model

GS logical schema

GS.PERSON(p-code, first-name, last-name, email, role, year, rank, school-name, tax-fee, dept-code)
GS.COURSE(course-code, course-name, p-code, room-code)
GS.ENROLLED(p-code, course-code)
GS.ROOM(room-code, seats, notes)
GS.DEPARTMENT(dept-code, dept-name, description, budget)
GS.LOCATION(street, number, city, country, dept-code)

Source schemata translation

•DS1
- •no translation needed

•DS2
- •DS2.STUDENT(s-code, name, school-name, tax-fee)

•DS3
- •DS3.PERSON(first-name, last-name, role, year, email, division-code, rank)
- •DS3.COURSE(course-name, professor-first-name, professor-last-name)
- •DS3.TAKES(student-first-name, student-last-name, course-name)
- •DS3.DIVISION(code, description)
- •DS3.LOCATION(street, number, city, country, division-code)

Source schemata translation

•DS1

DEPARTMENT(dept-code, dept-name, budget)
RESEARCH_STAFF(email, name, dept-code, s-code)
SCHOOL_MEMBER(email, name, school, year)
SESSION(s-code, session-name, length, room-code)
ROOM(room-code, seats-number, notes)

•DS2
- •DS2.STUDENT(s-code, name, school-name, tax-fee)

•DS3
- •DS3.PERSON(first-name, last-name, role, year, email, division-code, rank)
- •DS3.COURSE(course-name, professor-first-name, professor-last-name)
- •DS3.TAKES(student-first-name, student-last-name, course-name)
- •DS3.DIVISION(code, description)
- •DS3.LOCATION(street, number, city, country, division-code)

Logical mappings

Suppose that the sources' schemata are very stable and there exists only the given sources in the system.
What kind of integration strategy do you propose?

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GAV: Global as view

Logical mappings

CREATE VIEW **GS.PERSON** (p-code, first-name, last-name, email, role, year, rank, school-name, tax-fee, dept-code) AS

SELECT email, f1(name), f2(name), email, "research-staff", year, NULL, school, NULL, dept-code
FROM DS1.RESEARCH_STAFF, DS1.SCHOOL_MEMBER
WHERE DS1.RESEARCH_STAFF.email=DS1.SCHOOL_MEMBER.email

UNION

SELECT email, f1(name), f2(name), email, "student", year, NULL, school, NULL, NULL
FROM DS1.SCHOOL_MEMBER
WHERE email NOT IN (SELECT email FROM DS1.RESEARCH_STAFF)

UNION

SELECT s-code, f1(name), f2(name), email, "student", NULL, NULL, school-name, tax-fee, NULL
FROM DS2.STUDENT

Logical mappings

UNION

SELECT concat(first-name, last-name), first-name, last-name, email, role, year, rank, NULL, NULL, division-code
FROM DS3.PERSON

- f1(.) --> returns the first part of the name (that we assume to be the only first name)
- f2(.) --> returns the second part of the name
- concat(.,.) --> concatenates the first and the last name to build a valid key

Logical mappings

UNION

SELECT concat(first-name, last-name), first-name, last-name, email, role, year, rank, NULL, NULL, division-code
FROM DS3.PERSON

- f1(.) --> returns the first part of the name (that we assume to be the only first name)
- f2(.) --> returns the second part of the name
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We need to perform the same steps for each entity in the global schema

Adapters – DS2

DS2
- We need an adapter able to offer a relational view over the XML database
  - e.g., by mixing the OO language and XQuery

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- The following piece of code will generate the java-inspired code for adding to a result set the result of the GAV mappings between GS.PERSON and DS2.STUDENT

```
for $x in doc("tax-positions.xml")/listOfStudents/student
return resultSet.add({$x/s-code}, myfunct.f1({$x/name}),
myfunct.f2({$x/name}), email, “student”, null, null, {$x/school-name},
{$x/tax-fee}, null);
```


Adapters - DS3

DS3
- We need an adapter able to offer a relational view over the Object-Oriented database

- The following piece of code will generate the java-inspired code for adding to a result set the result of the GAV mappings between GS.PERSON and DS3.PERSON

Adapters - DS3

```
for each person {
 if (person instanceOf professor) {
      resultSet.add(professor.getFirstName()+professor.getLastName(),
      professor.getFirstName(), professor.getLastName(), null, “professor”,
      null, professor.getRank(), null, null,
      professor.getDivision().getDivisionCode());
 } else {
      resultSet.add(student.getFirstName()+student.getLastName(),
      student.getFirstName(), student.getLastName(),student.getEmail(),
      “student”, student.getYear(), student.getRank(),null, null, null);
 }
}
```