photo de fond supprimée

[MoVES] Meeting - May 25th, Namur

The Computer Science Faculty of Namur

- The University of Namur
  - member of the Académie Louvain
  - 5,000 students
  - 6 faculties

- The Computer Science Faculty
  - 16 full time academics
  - 50 researchers
  - Research fields :
    - Information system engineering
    - Database engineering
    - Human-Computer interfaces
    - Software quality
    - Multimedia
    - Organization theory
    - Programming
    - Decision support systems
    - Mobile networks
    - ICT and Society
    - Security
    - *etc.*

photo de fond supprimée

The PRECISE group

- **P**recise is **RE**search **C**enter in **I**nformation **S**ystems **E**ngineering

- Research Interests
  - modelling and methods
  - database engineering
  - requirements engineering
  - Interoperability, reengineering and evolution
  - quality and measures
  - CASE and meta-CASE tools

- Team
  - 6 full time academics
    - Vincent ENGLEBERT
    - Naji HABRA
    - Jean-Luc HAINAUT
    - Patrick HEYMANS
    - Michael PETIT
    - Pierre-Yves SCHOBBENS
  - 27 Researchers and collaborators

photo de fond supprimée

The PRECISE group

- *Goal*: to develop models (formalisms, languages), techniques, methodologies and tools for the engineering of Information systems
- *Information systems*: wide-scope, large-scale and multi-paradigm applications considered in their organizational context; software and data are major components of IS.
- Six transversal research axes
- Each axis is inter-disciplinary
- Each project contributes to one or several axes

- PReCISE is open and adaptive

The PRECISE group

- Modelling and methods

  the common resources on which the other axes are based

- Database engineering

  addressing the specific data component of IS

- Requirements engineering

  the early stage of any design process

- Interoperability, reengineering and evolution

  coping with application domain evolution and its impact of all the IS components

- Quality and measures

  focusing on a major dimension of engineering artefacts and processes

- CASE and meta-CASE tools

  indispensable support of all engineering activities

Partner

- **IMRU Research Group (Louvain School of Management/ University of Namur)**

- Theme: **Web Service Composition**
  - Web Service Communities
  - Context-based and multi-type policy approach for Web service composition
  - Modelling and Developing Self-Healing Web Services Using Aspects
  - Policies for Context-driven Transactional Web Services
  - Dynamic Web Service Composition within a Service-Oriented Architecture
  - Dynamic Requirements Specification for Adaptable and Open Service-Oriented Systems

- Team
  - Prof. Stéphane Faulkner
  - Prof. Philippe Thiran
  - Dr Sattanathan Subramanian
  - Ivan Jureta (PhD Student)
  - Stéphane Dehousse (PhD Student)

- Web: http://www.fundp.ac.be/facultes/eco/departements/gestion/recherche/centres/imru/

Presentations

1. Model-based Engineering of Evolving Data-intensive Systems
2. Model-based Engineering of Software Product Lines
3. A Flexible MetaCase Environment to support Domain-Specific Visual Languages
4. Measuring the Quality of Programs and Models to Support their Evolution
5. Business IT Alignment

Model-based Engineering of Evolving Data-intensive Systems

Computer Science Faculty
University of Namur, Belgium

1. Introduction
2. GER and specializations
3. Transformations
4. Main DB engineering processes
5. CASE tools
6. Evolution & coevolution
7. Evolution of relational database applications
8. Legacy database migration
9. LIBD contribution to MoVES

1. Introduction

Presentation in two parts

- transversal resources: GER, transformations, DB life cycle and CASE tools (J-L Hainaut)
- contribution to MoVES: database and database application evolution (A. Clève)

Is DB engineering MDE compliant?

Database engineering basically is model-driven (MDE) and transformational from its early days:

- abstract *vs* physical levels: *Information Algebra*, CODASYL, CACM, 1962
- the concept of multilevel design is ancient: Senko's 4-level NIAM (1974), 3-level MERISE (draft 1974), Chen's ERA model (1976), ANSI/Sparc framework 1978; ISO/TC97/SC5 framework (1982)

Is DB engineering that important?

- DB are at the core of Information systems (e.g., entreprise/management applications), that form 70% of the world software portfolio.
- DB and application programs most often are strongly linked: even slightest changes in the DB schema may imply changes in the application code
- Badly designed and maintained DB induce severe problems in application program design and maintennce

Contribution of PReCISE in DB engineering

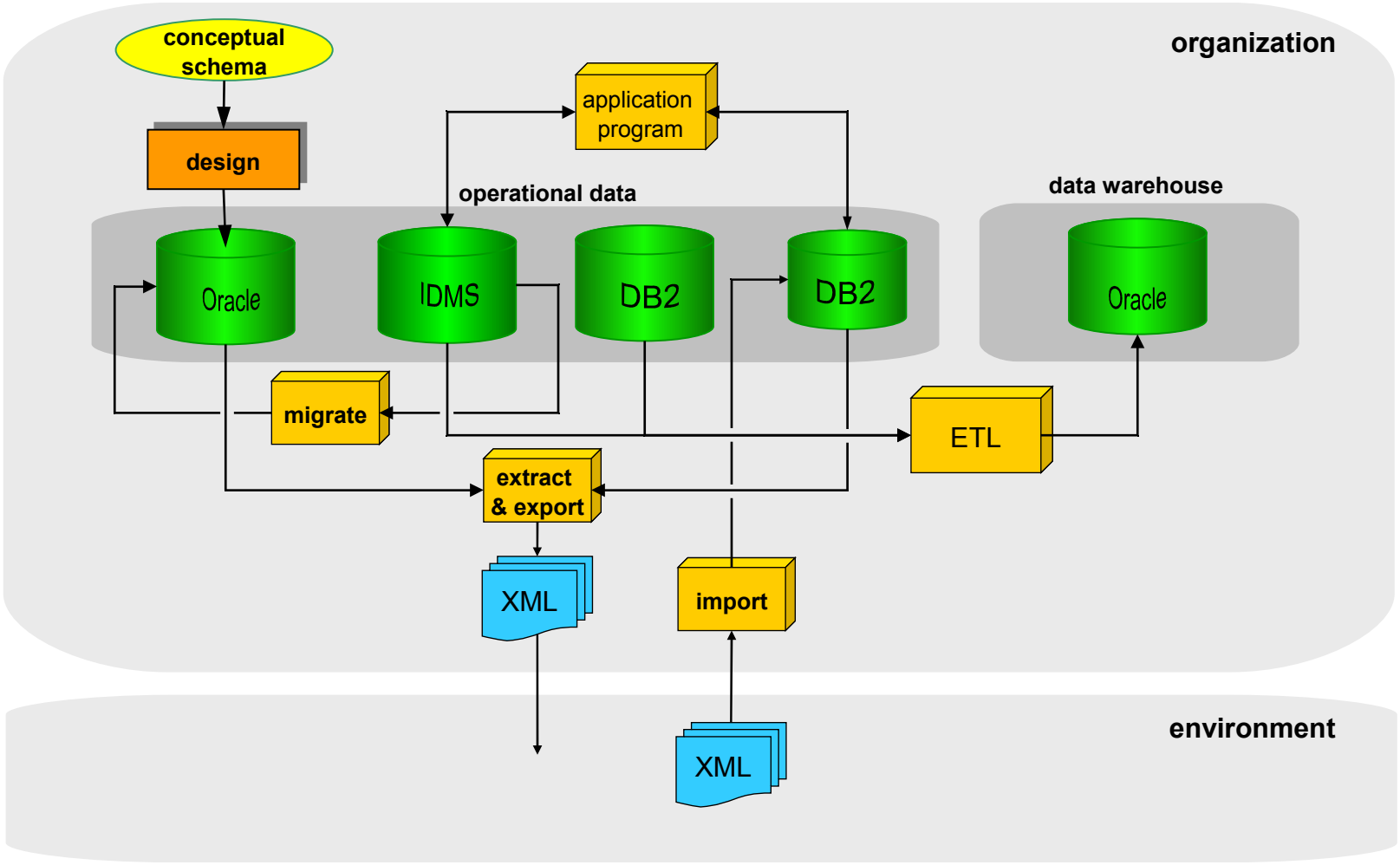
- LIBD (Laboratory of DB application engineering) a member of PReCISE
- models, techniques, methodologies and tools for DBE
- emphasis of complex processes: reverse engineering, evolution, maintenance, migration, integration
- multi-paradigm approaches (genericity)
- main recent results
  - generic data structure model (GER), transformational framework
  - methodologies for complex engineering processes (reverse engineering, migration, evolution, integration)
  - DB-MAIN CASE tool,
  - ReveR: spin-off of the LIBD (marketing and evolution of the methodologies and tools)
  - . . . + 5 PhD theses

Contribution of PReCISE / LIDB to MoVES

- model-driven processes
- transformational approach
- database evolution / migration
- coevolution of DB/programs

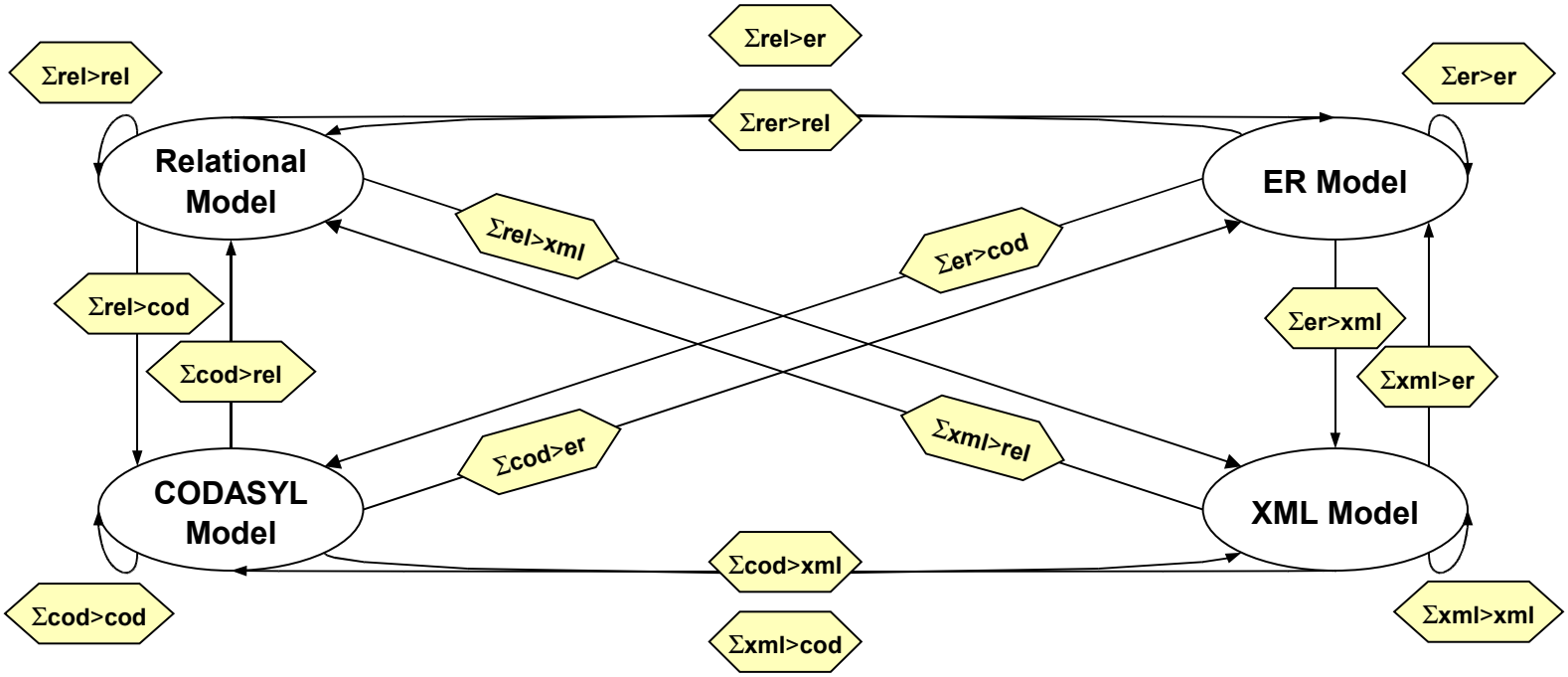
2. GER and specializations

Problem: *dealing with multiple models*



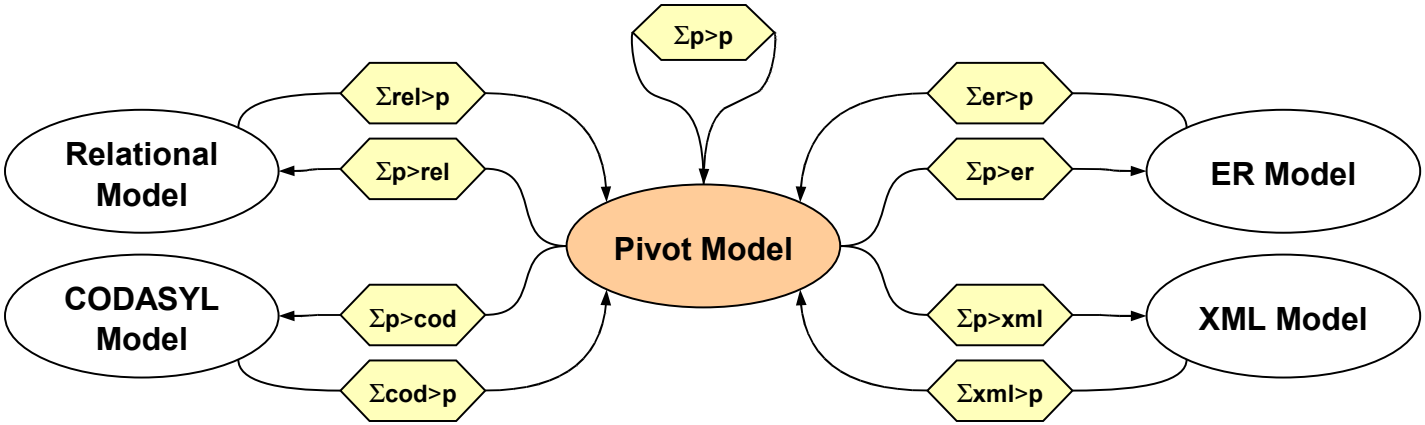
Problem: *dealing with multiple models*

Considering all the inter-model and intra-model conversions, the organization requires *N x N different mappings (= 16)*.



Problem: *dealing with multiple models*

The usual answer: *introducing a pivot model*.
Considering all the inter-model and intra-model conversions, the organization requires *2 x N + 1 different mappings (= 9)*.



Problem: *dealing with multiple models*

Our answer: pivot model = Generic Entity-Relationship model (GER)

- abstract union of all operational (practically used) information/database models
- Encompasses several paradigms: ER, UML, SQL, CODASYL, IMS, file structures, XML, etc.
- Encompasses several levels of abstraction: conceptual, logical, physical, external
- formal semantics (based on NF^2 relational theories)
- sound basis for building transformational frameworks (all inter-model transformations becomes intra-model transformations)
- operational models defined by specialization rules
  - ➢ selection
  - ➢ renaming
  - ➢ assembly rules (structural constraints)

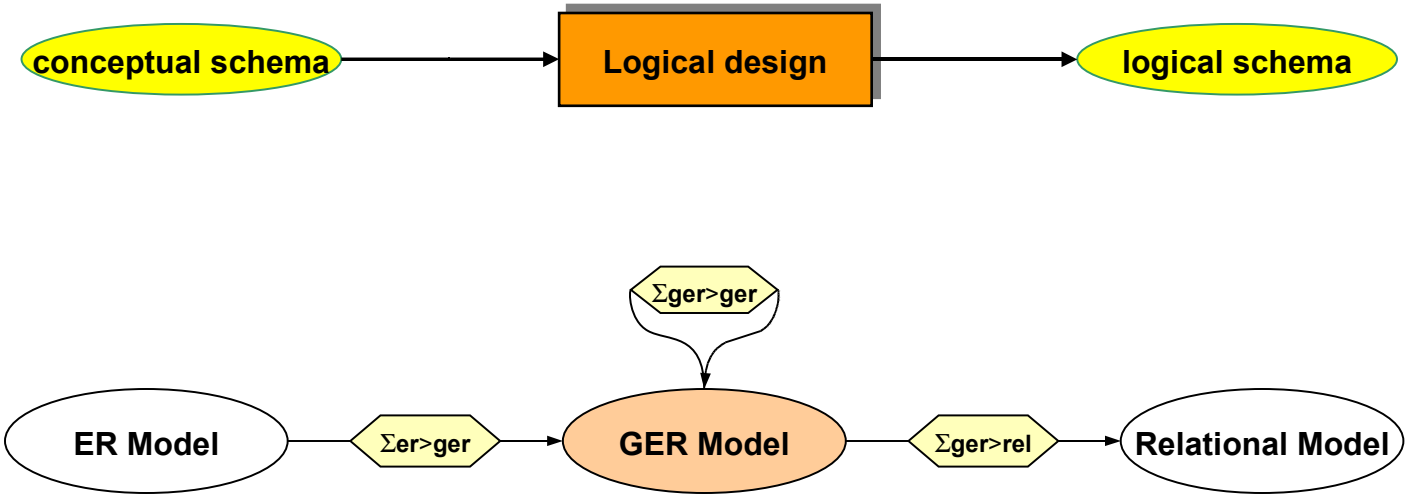
Problem: *dealing with multiple models*

Example of an operational model: SQL2 relational model

relational constructs	GER constructs	assembly rules
database schema	schema	
table	entity type	an entity type includes at least one attribute
domain	simple domain	
nullable column	single-valued and atomic attribute with cardinality [0-1]	
not null column	single-valued and atomic attribute with cardinality [1-1]	
primary key	primary identifier	a primary identifier comprises attributes with cardinality [1-1]
unique constraint	secondary identifier	
foreign key	reference group	the composition of the reference group must be the same as that of the target identifier
SQL names	GER names	the GER names must follow the SQL syntax

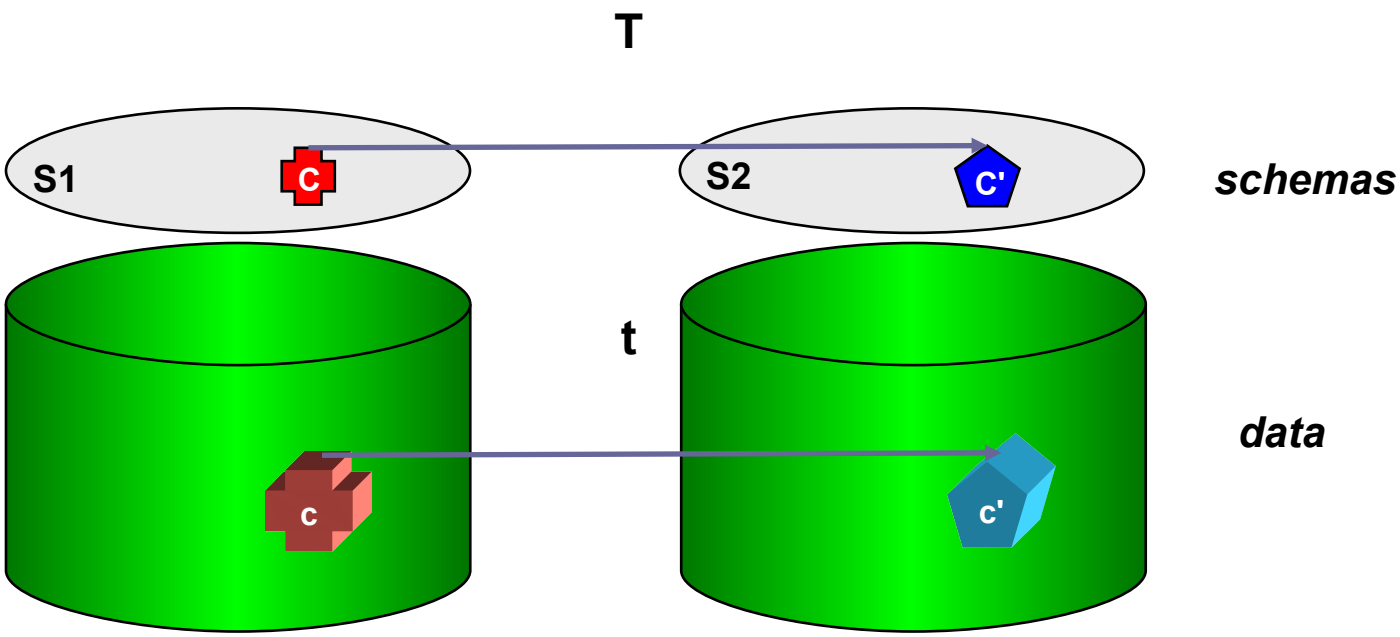
Problem: *dealing with multiple models*

Example: *relational logical design*.



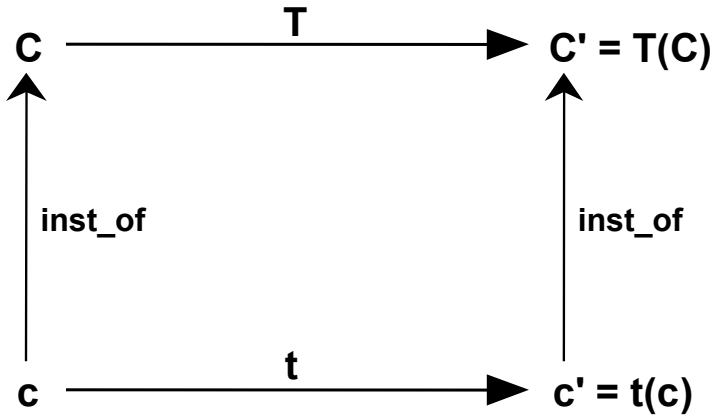
3. Transformations

A transformation T replaces a construct C in a schema S1 with another construct C', leading to schema S2



A transformation Σ is defined by two mappings T and t

$$\Sigma = \langle T, t \rangle$$



T: *structural mapping = syntax of* Σ

t: *instance mapping = semantics of* Σ

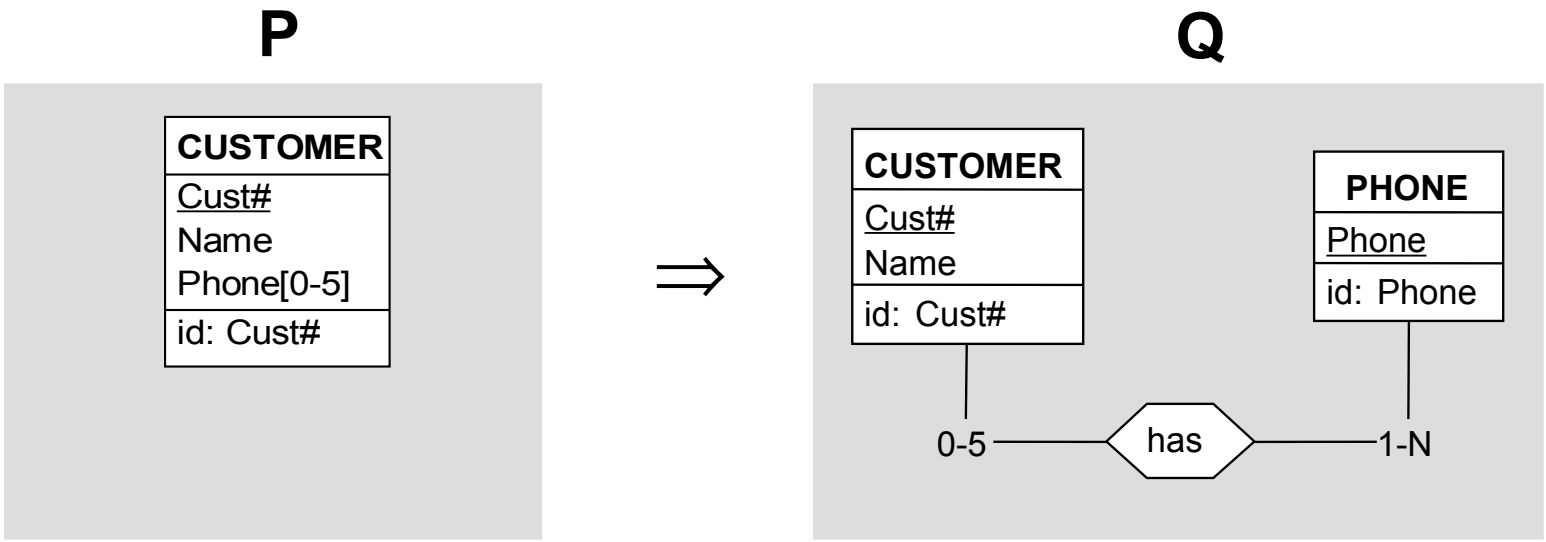
Structural mapping T can be specified with two predicates:

P: minimal pre-condition on the source constructs

Q: maximal post-condition on the target constructs

$$\Sigma = \langle T,t \rangle = \langle P,Q,t \rangle$$

The structural mapping of a transformation can be defined graphically:



Semantics-preserving transformations

- both constructs/schemas have the same information contents
- *examples*: mutation transformations
- property formally defined
- possible to prove that an arbitrary transformation is SP

Non semantics-preserving transformations

- loss of semantics or addition of (spurious) semantics
- *example*: set attribute ⇒ array attribute
- often empirical
- often used in refinement (logical/physical design)

Elementary semantics-preserving transformations

- mutation (*trans-gender*) transformations (attribute ↔ entity type, entity type ↔ relationship type, etc.)
- simplification transformation (ISA hierarchies, non-set constructs, etc.)
- others

Complex semantics-preserving transformations

- compound transformations: $\Sigma_{12} = \Sigma_2 \circ \Sigma_1$
- predicate-driven transformations: Σ (p)
- model-driven transformations: $\text{schema}_{M1} \Rightarrow \text{schema}_{M2}$

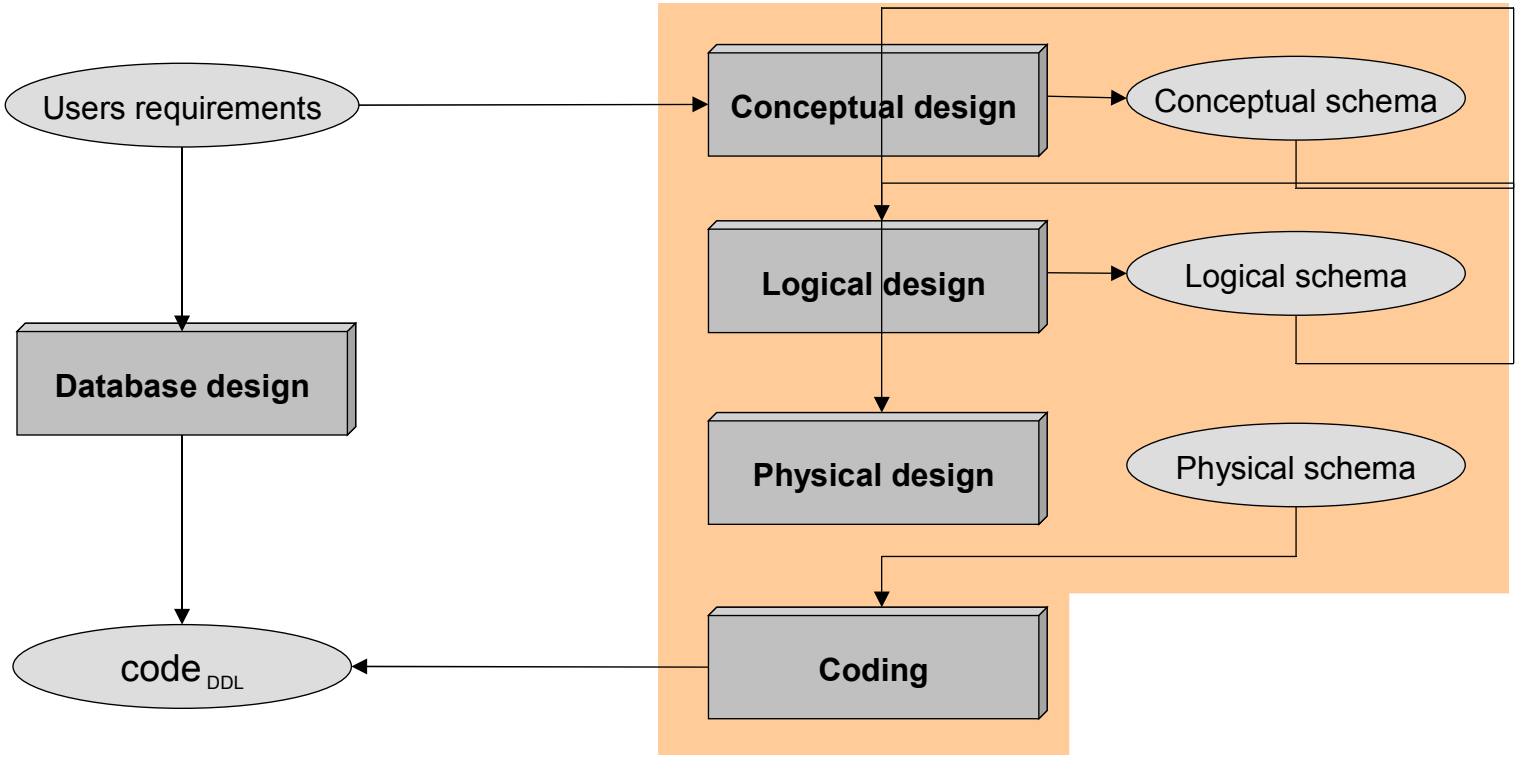
4. Main database engineering processes

4. Main database engineering processes (life cycle)

- **Forward engineering**
- **Reverse engineering**
- **Reengineering**
- **Migration**
- **Integration**
- **Evolution**

Forward engineering

Design and implementation of a new database from users requirements



Reverse engineering

Recovering the technical and conceptual specifications of an existing database.

Observations: only a subset of the conceptual specifications has been implemented in the DDL code, frequent idiosyncrasies, poor design, dead parts, redundant constructs, etc.

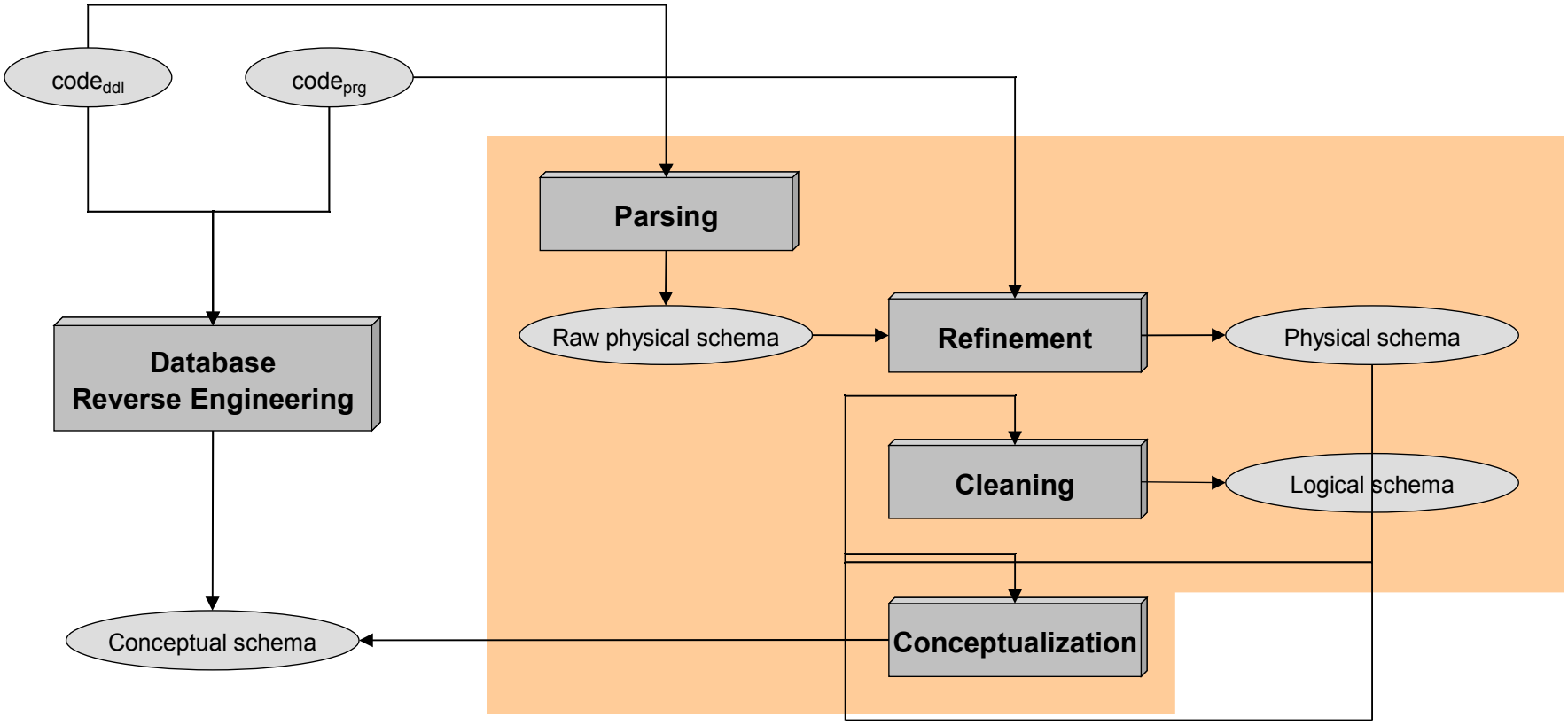
$\Longrightarrow$ analysis of various information sources: *DDL code*, *data dictionaries*, *application programs code*, *database contents*, *user interfaces*, *reports*, *program execution*, etc., to get additional information of the actual constructs.

Two main problems

- recovering implicit constructs
- interpreting physical constructs

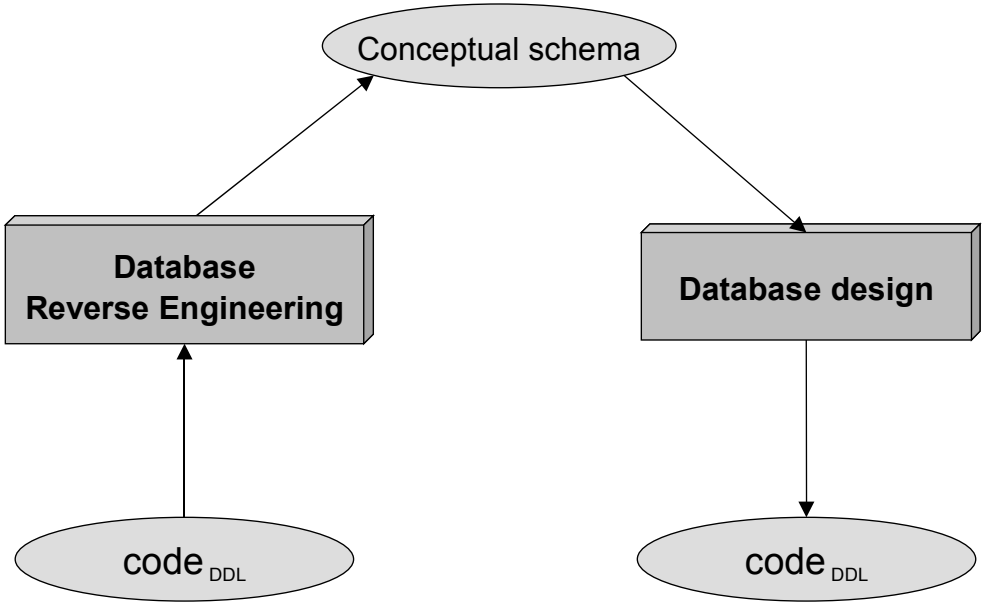
Reverse engineering

Recovering the technical and conceptual specifications of an existing database



Reengineering

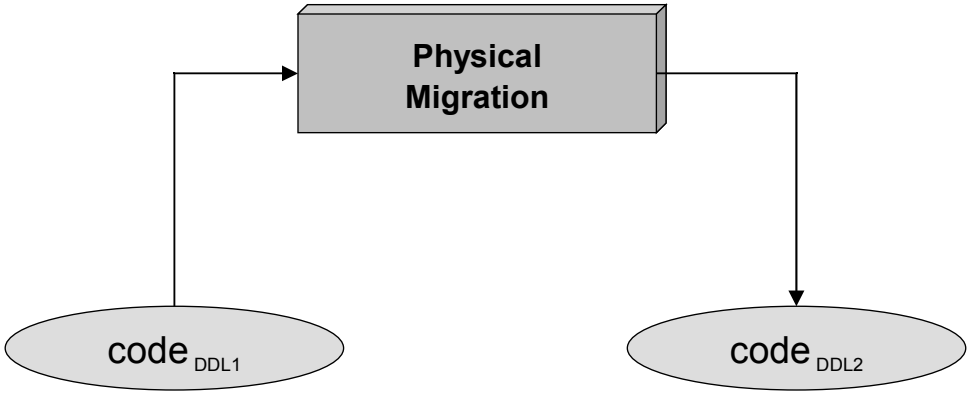
Rebuilding (*rearchitecturing*) an existing database without changing its conceptual schema



Migration

Porting an existing database to another (generally more modern) technical platform

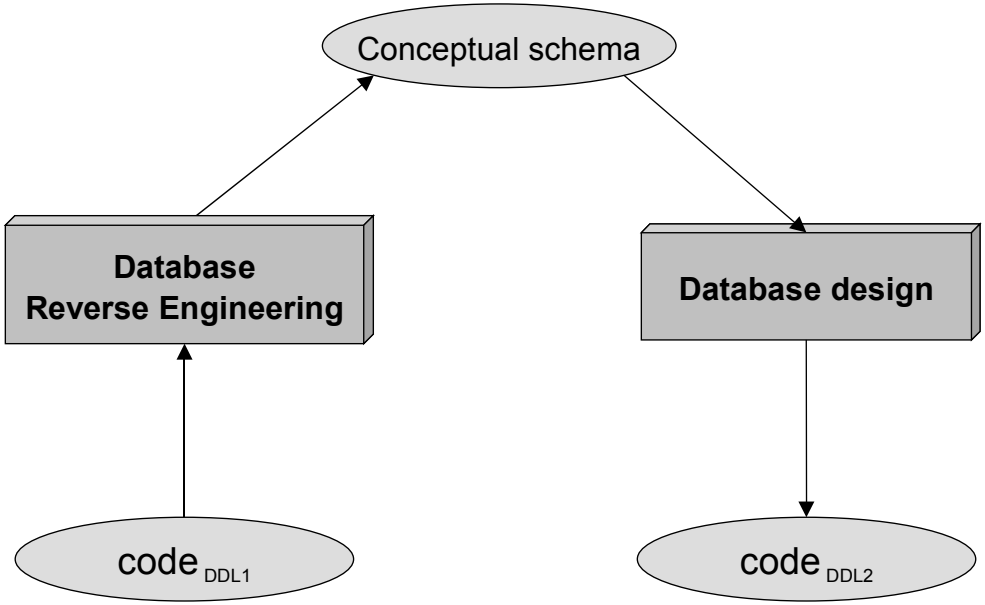
Bad approach: physical migration (straighforward, easy, cheap, unreadable, difficult to maintain)



Migration

Porting an existing database to another (generally more modern) technical platform.
Special case of evolution.

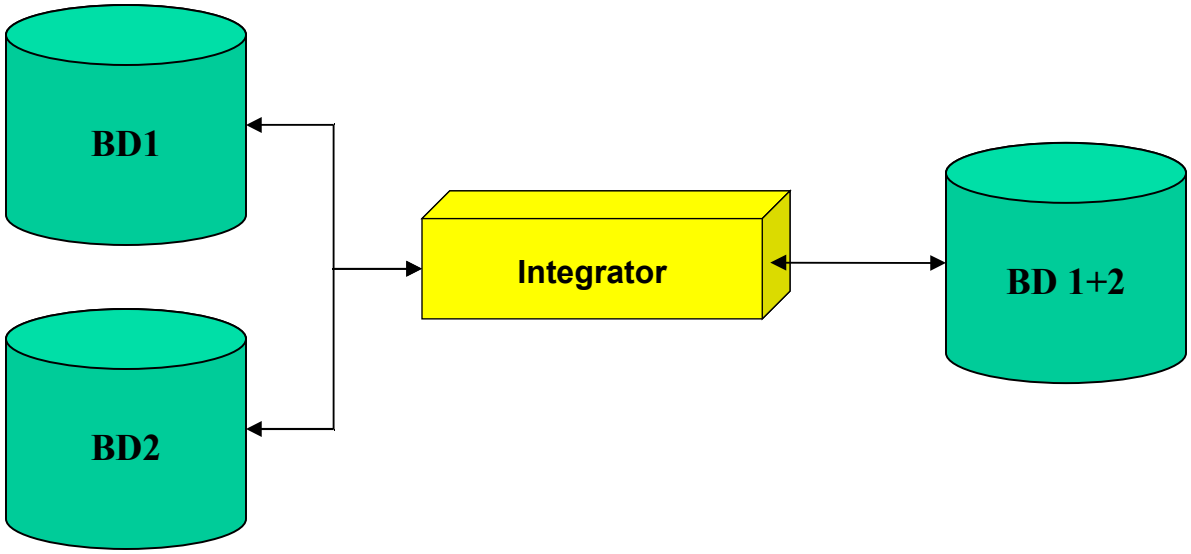
Good approach: conceptual migration (complex, expensive, clean result, easy to maintain)



Integration

Deriving a new (physical or virtual) database from a collection of independent, autonomous, and heterogeneous databases

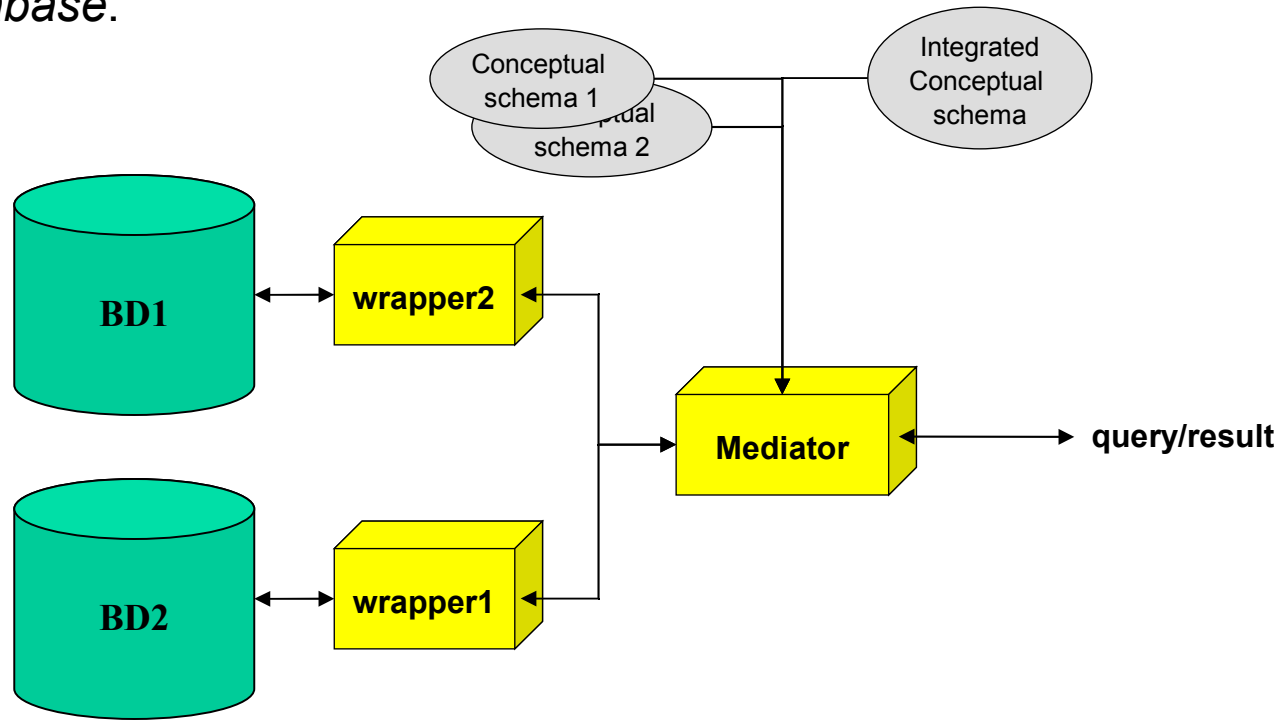
Physical database:



Integration

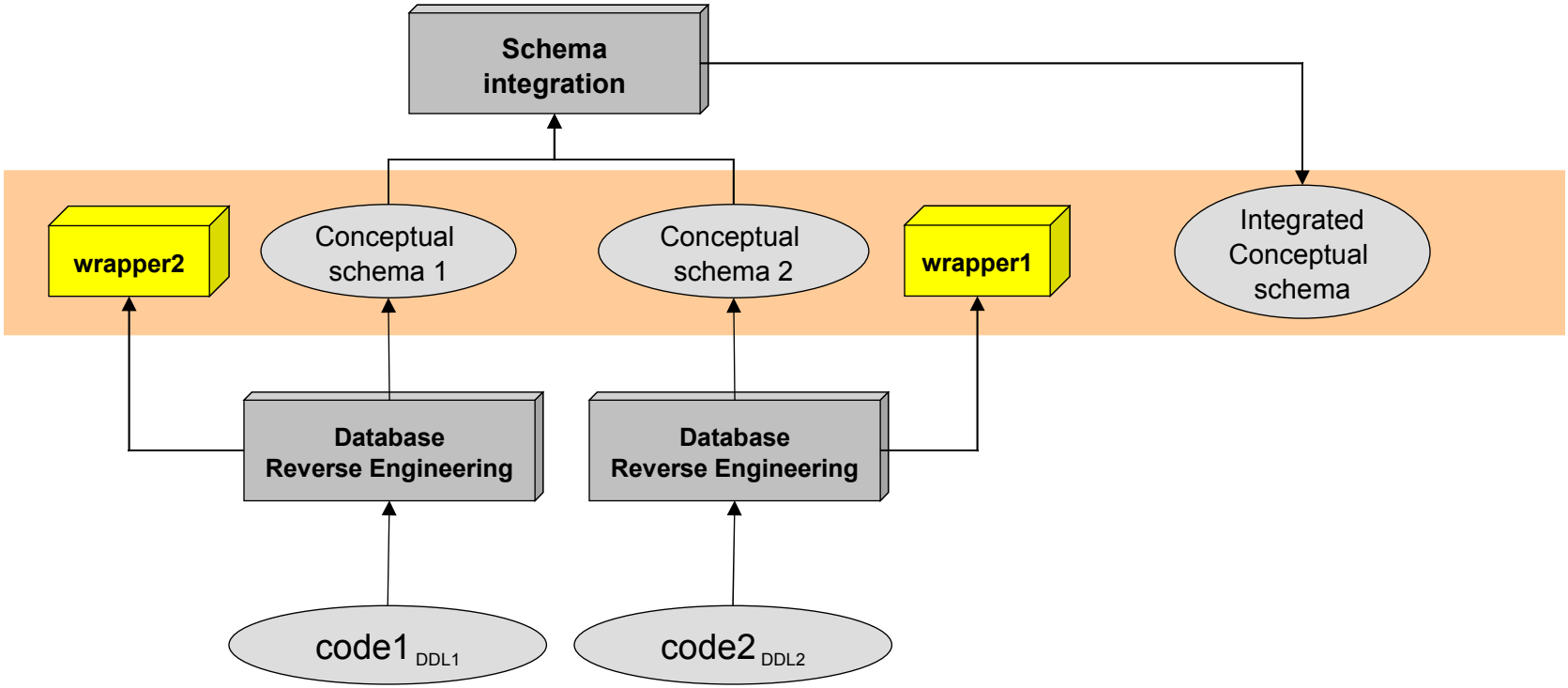
Deriving a new (physical or virtual) database from a collection of independent, autonomous, and heterogeneous databases

Virtual database:



Integration

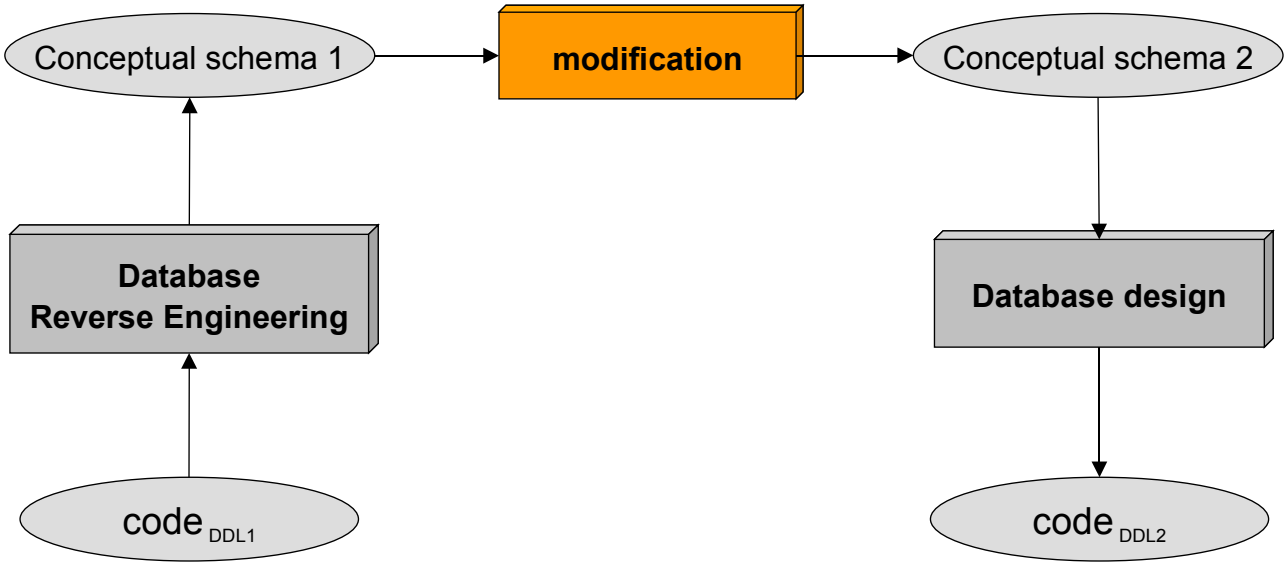
Engineering processes



Evolution

Adapting an existing database to new functional or non-fuctional requirements

Example: evolution of functional requirements



Database Engineering Processes

- Each process basically is an inter-model compound transformation
- Thanks to the GER, database engineering processes mainly are intra-model transformation
- Most processes are semantics preserving transformations
- Formal approaches can be developed to model, develop and control Database Engineering processes

Consequences

- Properties can be proved (e.g., semantics preservation)
- Processed can be supported by tools

5. CASE tools

Observation

No methodologies can succeed without tools that support them

Requirements

- user-friendly
- performance: from small to very large complex schemas (100.000+ objects)
- modularity : basic platform + specific components
- wide spectrum: multiparadigm, multi-level
- extendable
- transformational
- DB-oriented input/output

DB-Main CASE environment

- user-friendly: various graphical/hypertext view
- performance: written in C++
- modularity : basic platform + specific components
- wide spectrum: GER
- extendable: repository + programming languages (Java, Voyager 2)
- transformational: transformation toolbox + transformation composers
- DB-oriented input/output: parsers, generators

6. Evolution & Coevolution

- Context:
  - Multi-paradigm environment (e.g., database + programs + HMI)
  - Engineering processes based on a hierarchy of abstraction levels
  - Each abstraction level comprises several coordinated artefacts, each belonging to a definite paradigm
  - Artefacts of two successive levels are linked through mapping deriving from engineering (transformational) processes
  - Each artefact has multiple (evolvable) facets
    - Intrinsic properties: name, type, structure, constraints,…
    - Additional properties: annotations, views, instance samples, statistics,…

- Evolution ➔ modification of an artefact at a given level of abstraction
- Research Methodology:
  - Identification of artefacts modification primitives
  - Modification propagation based on inter-artefact mapping
  - Study of compositionality of modification propagation
- Horizontal (intra-level) co-evolution
  - Schema change ➔ sub-schema change
  - Schema change ➔ process change
- Vertical (inter-level) co-evolution
  - Conceptual schema change ➔ logical schema change
  - Abstract process change ➔ code change

Database oriented Coevolution Scenarios

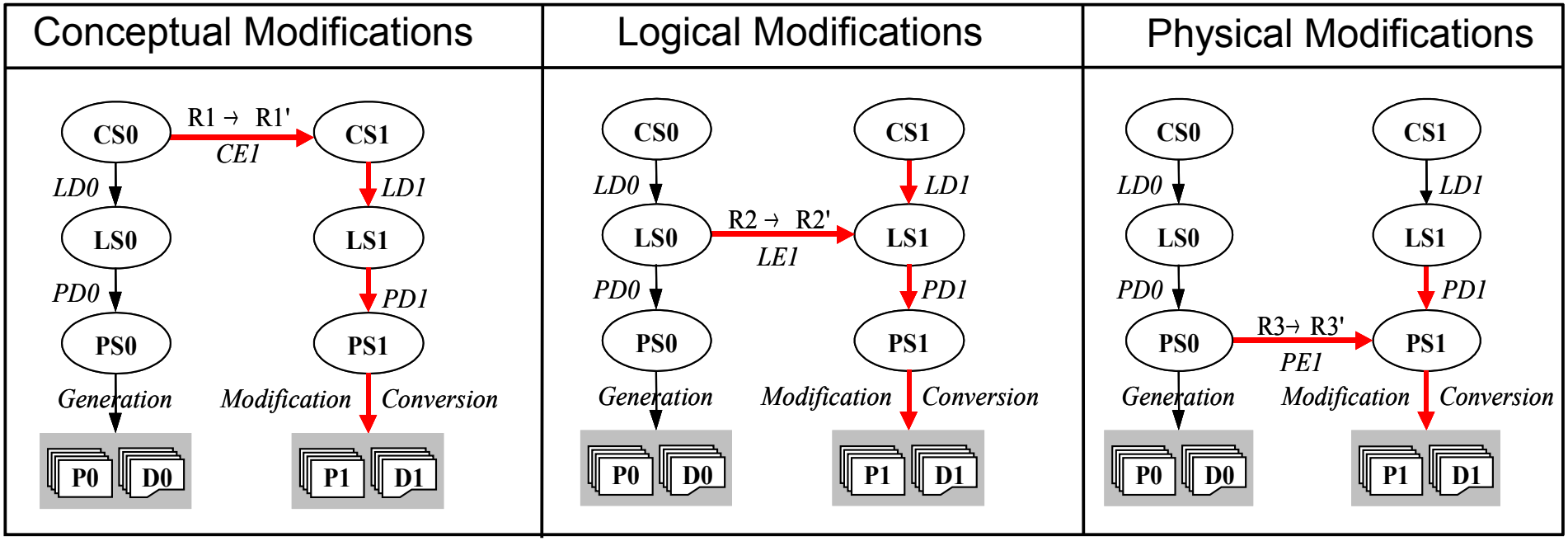
- **The conceptual schema is modified due to a change in user requirements**
  - **What about the logical schema?**
  - **What about the data instances?**
  - What about the client programs?
- **The database platform is replaced due to technological modernization**
  - What about the logical schema?
  - What about the data instances?
  - **What about the client programs?**
- The data resources of companies are merged due to corporate merging
  - How to restructure their databases?
  - How to adapt legacy programs?
  - How to develop new programs?
- The data instances change due to application domain instances evolution
  - How to record this evolution in the database?
  - How to rebuild the history of the application domain?

LIDB Experience in (co)Evolution

- Evolution of Relational Database Applications
  - J.-M. Hick PhD thesis (2001) + Biomaze project (2003-2007)
- Temporal Databases Engineering
  - TimeStamp project (1997-2001)
- Database Reverse Engineering
  - Jean Henrard PhD thesis (2003)
- Heteregeneous Database Federation
  - InterDB project & Ph. Thiran PhD thesis (2003)
- Taxonomies Evolution
  - Quetelet.net project (2003-2007)
- Legacy Database Migration
  - RIStart project (2004-2008)

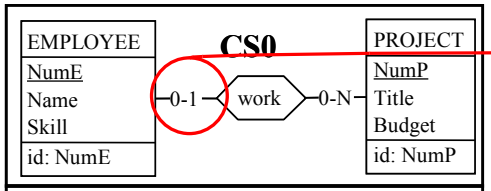
7. Evolution of Relational Database Applications

- Coevolutions scenarios (inter-level + intra-level)

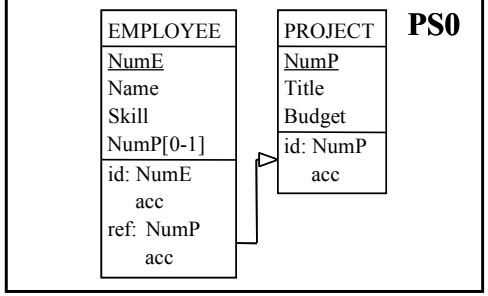


- Typology of schema transformations according to
  - the type of object involved: entity type, attribute, constraint …
  - the nature of the modification: creation, destruction, restructuring, renaming …
  - the (non-)preservation of different properties: type, semantics, …

7. Evolution of Relational Database Applications

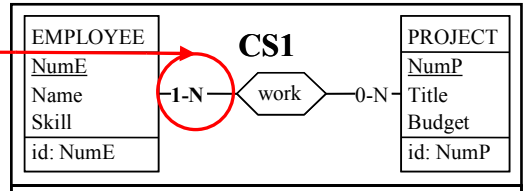



```
LD0 + PD0 =
<(EMPLOYEE,{NumP})<-
            RT-to-FK(work)>
```

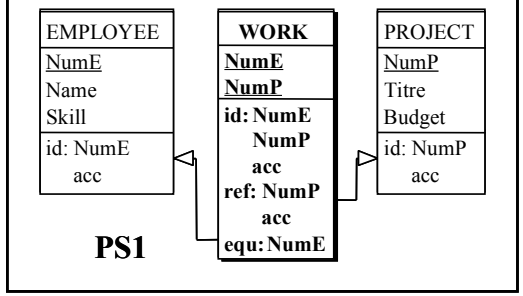



```
CE1 = <(work,EMPLOYEE)<-
       modify-Role(work,EMPLOYEE,1-N)>
```

```
PE1 =
<WORK<-FK-to-ET(EMPLOYEE,{NumP})
 fkproject<-create-FK(WORK,{NumP},
                {PROJECT.NumP})
 fkemployee<-create-FK(WORK,{NumE},
                {EMPLOYEE.NumE},equal)>
```




```
LD1 + PD1=
<(WORK,{wp,we})<-RT-to-ET(work)
 (WORK,{NumP})<-RT-to-FK(wp)
 (WORK,{NumE})<-RT-to-FK(we)>
```



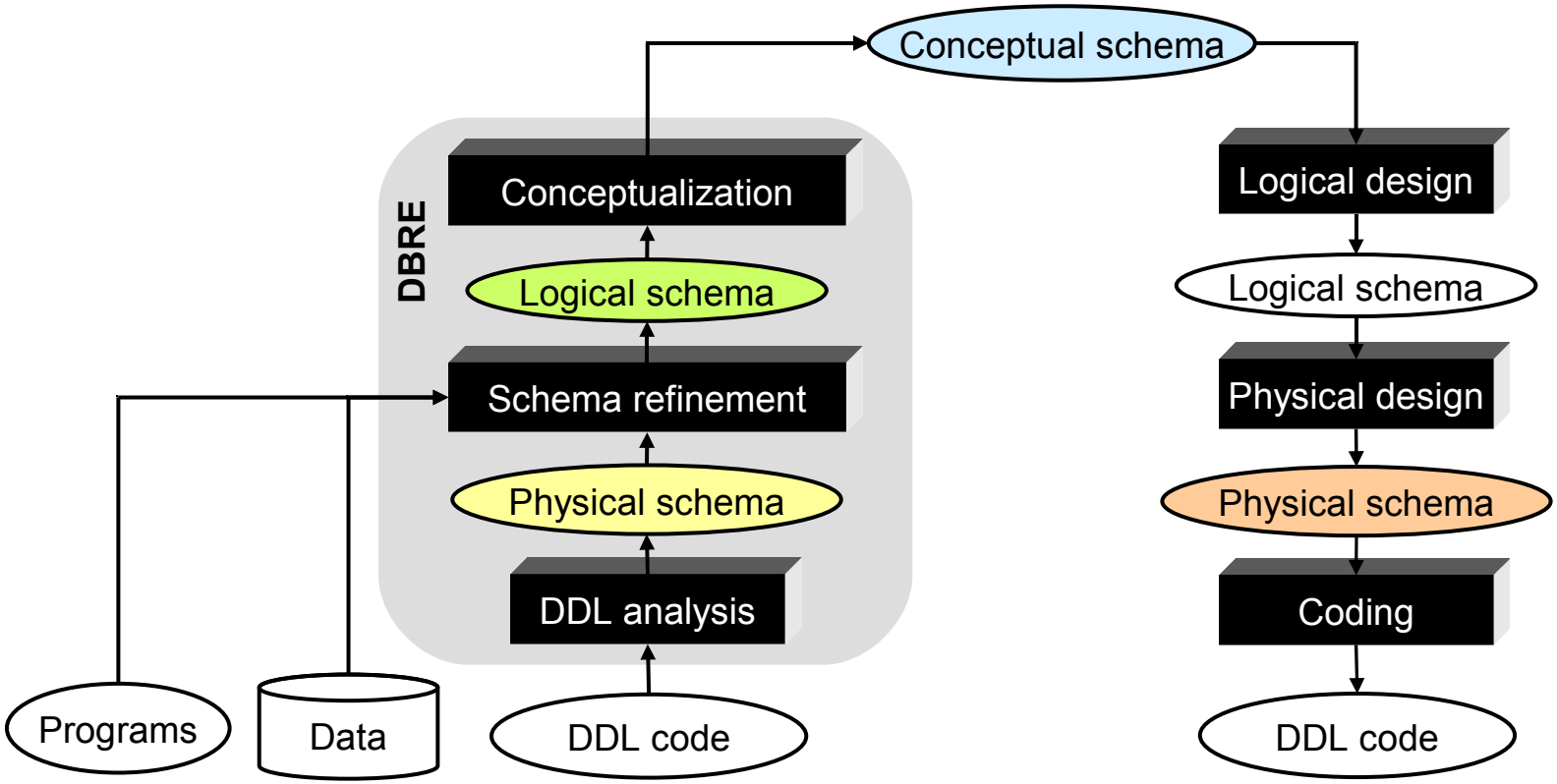

```
-- Check new constraint:
SELECT * FROM EMPLOYEE WHERE NumP is NULL;
-- 1. WORK <- FK-to-ET(EMPLOYEE,{NumP})
  -- Create table WORK :
  CREATE TABLE WORK (NumP NUMERIC(5) NOT NULL,NumE NUMERIC(5) NOT NULL,CONSTRAINT IDWORK PRIMARY KEY(NumP,NumE));
  CREATE UNIQUE INDEX IDXWORK ON WORK (NumP,NumE);
  CREATE INDEX IDXPROJECT ON WORK (NumP);
  -- Instance transfert:
  INSERT INTO WORK (NumP,NumE) (SELECT Nump,NumE FROM EMPLOYEE);
  -- Delete column NumP of table EMPLOYEE:
  ALTER TABLE EMPLOYEE DROP NumP;
-- 2. fkproject <- create-FK(WORK,{NumP},{PROJECT.NumP})
ALTER TABLE WORK ADD CONSTRAINT FKPROJECT FOREIGN KEY (NumP) REFERENCES PROJECT (NumP);
-- 3. fkemployee <- create-FK(WORK,{NumE},{EMPLOYEE.NumE},equal)
ALTER TABLE WORK ADD CONSTRAINT FKEMPLOYEE FOREIGN KEY (NumE) REFERENCES EMPLOYEE (NumE);
ALTER TABLE EMPLOYEE ADD CONSTRAINT EQWORK CHECK(EXISTS(SELECT * FROM WORK WHERE WORK.NumE = EMPLOYEE.NumE));
```

8. Legacy Database Migration

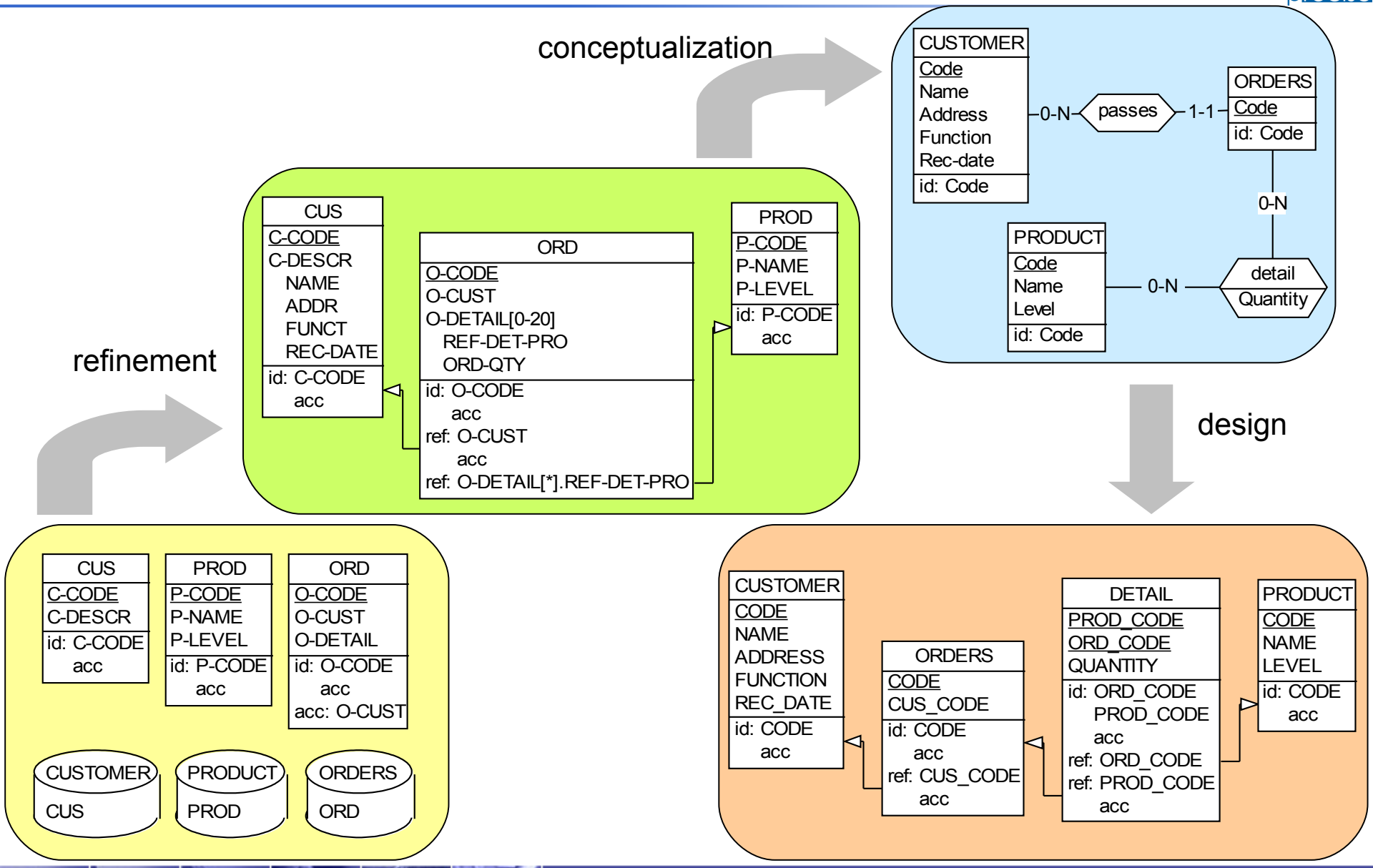
- Migration = particular case of evolution
  - Source and target schema convey the same information content
  - ➔ Automated program conversion is easier
- Propagation at the program level to preserve
  - Structural consistency: use the target database structure
  - Language consistency: use the target data manipulation language
- RIStart approach: combination of generative & transformational techniques
  - Schema conversion through database reverse engineering (DBRE)
  - Wrapper-based program conversion

Schema Conversion through DBRE

- Recover the complete conceptual schema
  - enriched with implicit structures and constraints elicited through program and data analysis
- Design the target schema through standard methodology

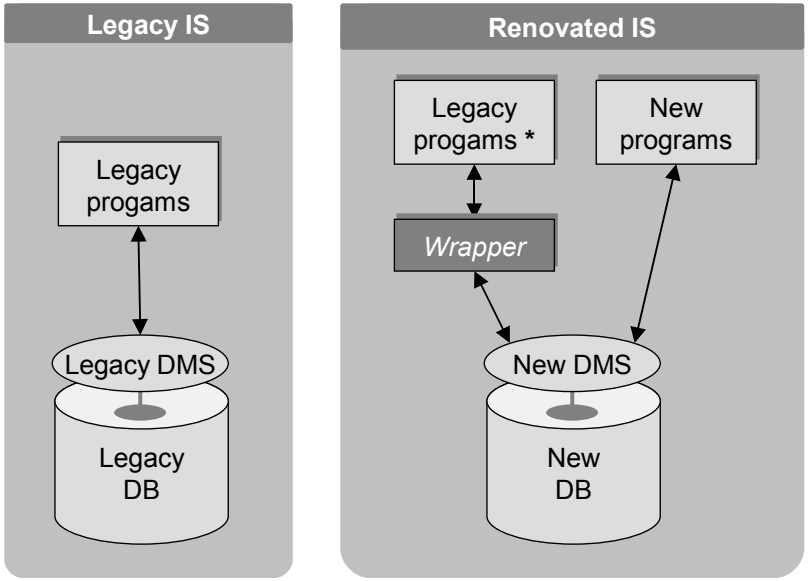


8. Legacy Database Migration



Wrapper-based Program Adaptation

- Wrapper
  - simulates the legacy data management system (COBOL, CODASYL)
  - on top of the new database (Oracle, DB2,...)



- Wrapper generated from
  - source-to-target schema mappings
  - source-to-target DML translation rules
    - COBOL-to-SQL & CODASYL-to-SQL

Industrial Application

- Migration project by Rever s.a.
- Legacy system running on a Bull Mainframe (GCOS8)
- 2300 COBOL programs, over 2 million LOC
- Goal =
  - migrate a legacy database (CODASYL-IDS/II) to a relational platform (DB2)
  - while preserving the functionalities of the application programs
- Methodology
  - DBRE-based schema conversion
  - Wrapper-based program conversion

Industrial Application

- DBRE-based program conversion

	Physical	Refined	Conceptual	Relational
# ent. types	231	231	156	171
# rel. types	213	213	90	0
# attributes	648	11 157	2 176	2 118
max # att./ent.	8	104	61	94

- Close to fully-automated program conversion
  - 98% of source code files automatically converted
  - 92% of IDS/II primitives automatically converted

	Migrated	Manually transformed
# programs	669	17
# copybooks	3 917	68
# IDS/II verbs	5 314	420

9. LIBD contribution to MoVES

9. LIBD contribution to MoVES

- WP2: Modelling languages and Restructuring
  - Modelling language
    - Multiple models, multiple abstraction levels
  - Transformational/MDE approach to restructuring
- WP4: Consistency checking & Coevolution
  - Typology of consistency relationships
  - Classification of coevolution scenarios
  - Impact analysis in a coevolution context
  - Classification of propagation strategies
  - Automated evolution propagation
    - Generative & transformational techniques

+ possible contributions to other WPs

photo de fond supprimée

University of Namur

http://www.fundp.ac.be

Computer Science Faculty

http://www.info.fundp.ac.be

PRECISE group

http://www.software-engineering.be/