ICA | INFORMATICA COMMUNICATIE ACADEMIE

Fact-Oriented Modeling in ERM and FCO-IM

Jan Pieter Zwart
Group Model-Based Information Systems
HAN University of Applied Sciences

HAN University of Applied Sciences

University

33.000 students, 2.500 staff

62 bachelor, 19 master programs in 4 faculties, 26 institutes

39 research groups

Faculty, Institute

Faculty of Engineering. Institute: ICA

Academy of Communication and Information Technology

7 bachelor programs

3 research groups

1600 students, 120 teaching staff

2016: 650 first-year students

Dean: Ir. Ing. Peter Koburg

HAN University of Applied Sciences

Research group

Model-Based Information Systems (M-BIS)

Headed by: Prof. Dr. Stijn Hoppenbrouwers

Expertise:

- Development of model-based methods and techniques
- Collaborative modeling approaches
- Metadata management
- Business intelligence
- Courses, consultancy

HAN University of Applied Sciences

ICA: 7 programs for Bachelor of ICT, 4 years each.

In year 2:

Semester: Information Systems Engineering

Courses:

- Requirements
- Database Implementation
- **Data Modeling and Relational Database Design**

Fact-Based ERM: developed 2015-2016 for the last course.

HAN University of Applied Sciences

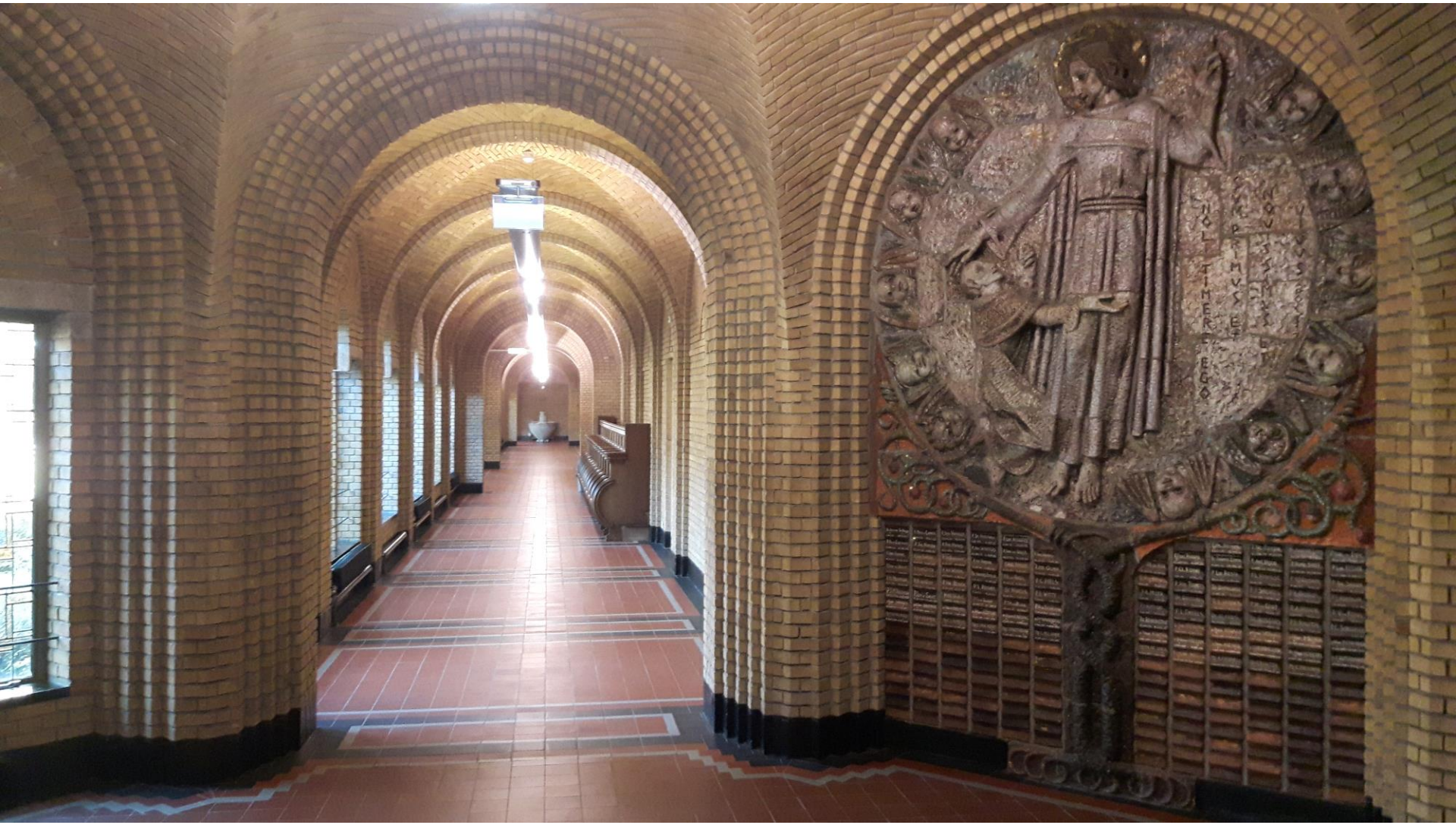
A few colleagues at the HAN:

Chris Scholten MSc, Senior Lecturer

Dineke Romeijn MSc, Lecturer

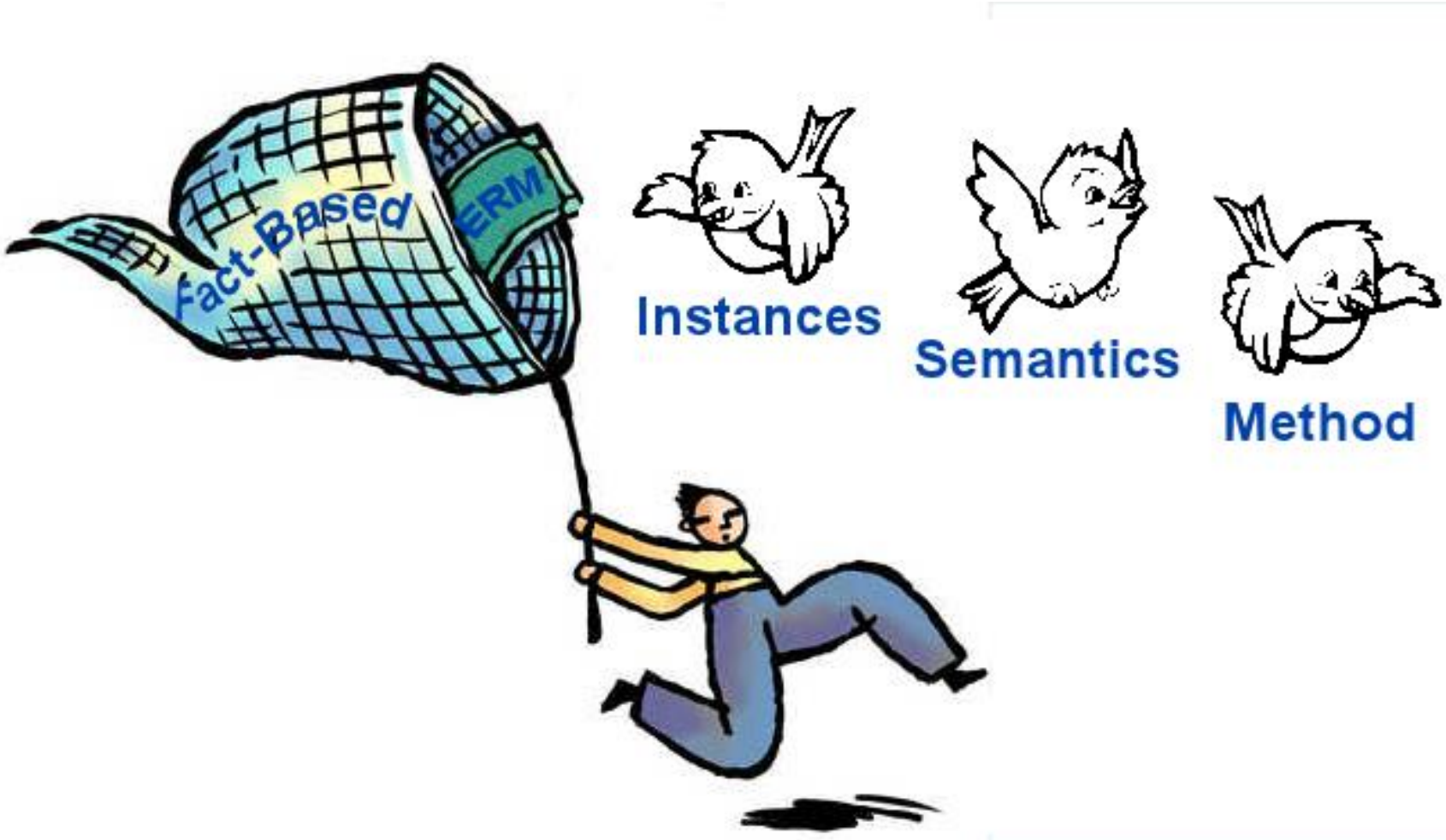
Marco Engelbart, MSc, Senior Lecturer


ALBERTINUM



Killing three birds with one stone

Catching three birds with one net



Fact-Oriented Modeling (FOM)

- **Fact-based vs Attribute-based modeling**
- **Problems in classic ER models**
  - Only type level
  - No semantics
  - No method
- **Verbalizing example facts helps modelers**
- **Method to draw up an ER model**
- **Better FOM technique: FCO-IM and CaseTalk**
- **Experiences and conclusion**

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Fact-Based vs Attribute Modeling

Central point:

The fact–oriented/based perspective offers a valuable extra viewpoint to supplement the traditional entity / attribute viewpoint.

Fact-Based vs Attribute Modeling

Reservation Request Part: Attribute/Entity perspective:

- Table: models an **entity type**: a kind of thing in the UoD
- Columns: model **attributes**: properties of the entity type

Attribute Dom:RRno PK, NN	Attribute Dom:Seqno PK, NN	Attribute Dom:Perfno NN	Attribute Dom:Number NN
Reservation Request	**Res. Req. Part**	**Performance**	**# Seats**
3456	1	256	2
3456	2	277	6
5555	1	277	3
…	…	…	…

Focus: the **atoms** of information, not the molecules

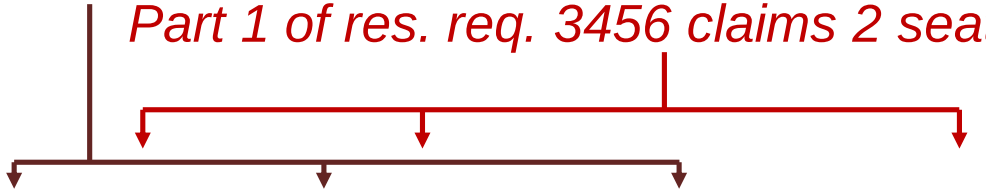
Fact-Based vs Attribute Modeling

Reservation Request Part: Elementary Fact perspective:

- Table contains **facts**: groups of atttributes that belong together

Part 1 of res. req. 3456 concerns performance 256.

Part 1 of res. req. 3456 claims 2 seats.



Reservation Request	Res. Req. Part	Performance	# Seats
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…	…	…	…

Focus: the **molecules** of information, not the atoms

Fact-Based vs Attribute Modeling

A few pros and cons of these perspectives:

	Entity, Attribute	Elementary Facts
Pros	• Easy for trivial properties • Techniques widespread (ERM, UML, …) • Many big software tools	• Natural units of info • Good for complex data str. • Semantics clear • Good methods • Metamodel simple
Cons	• No natural units of info • Impracticable for complex data structures • Semantics not included • No good method • Metamodel clumsy	• More elaborate • Techniques in niche (FCO-IM, ORM, CogNIAM) • Few supporting tools (CaseTalk, NORMA, …)

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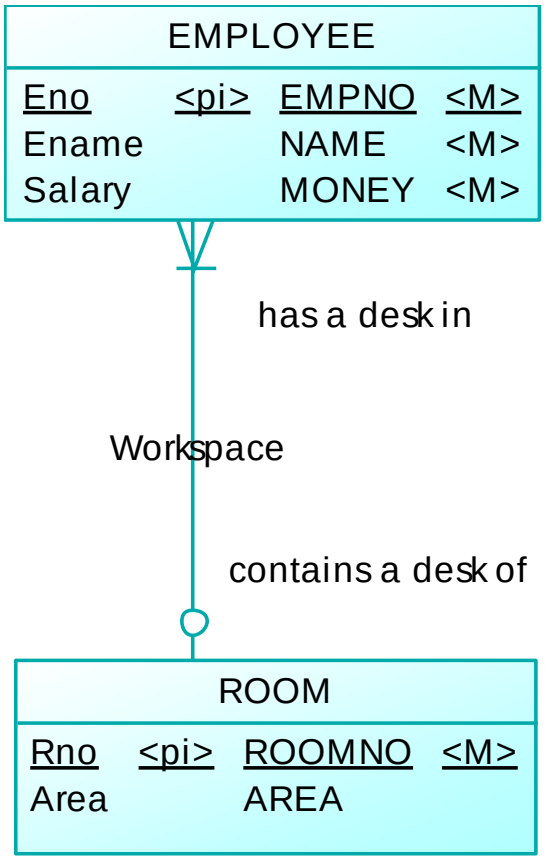
Problems in classic ER models

Fact-oriented modeling aims to expand classic ERM with:

- Fact-based perspective
- Semantics
- Instance level
- Systematic technique

Here's why:

Problems in classic ER models



Is this model correct?

At least some semantics is modeled:
the meaning of the RT is clear

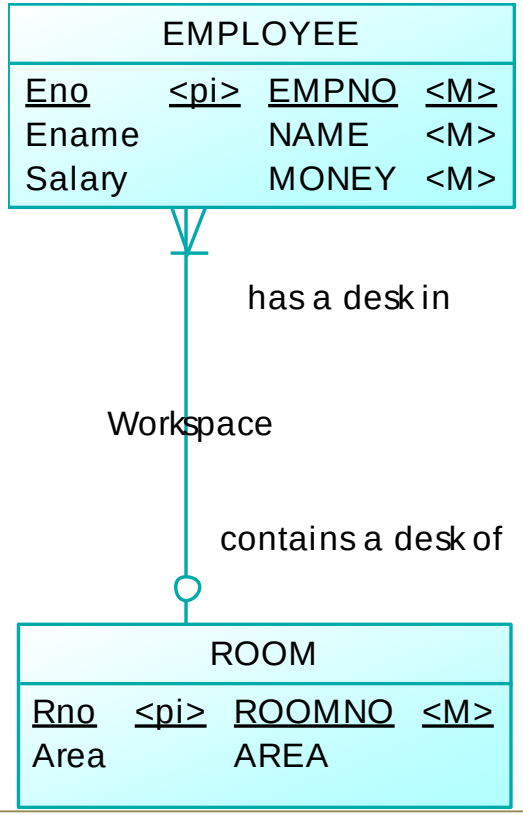
But Salary (per year? per month)?

What is Area? Size? Part of building?

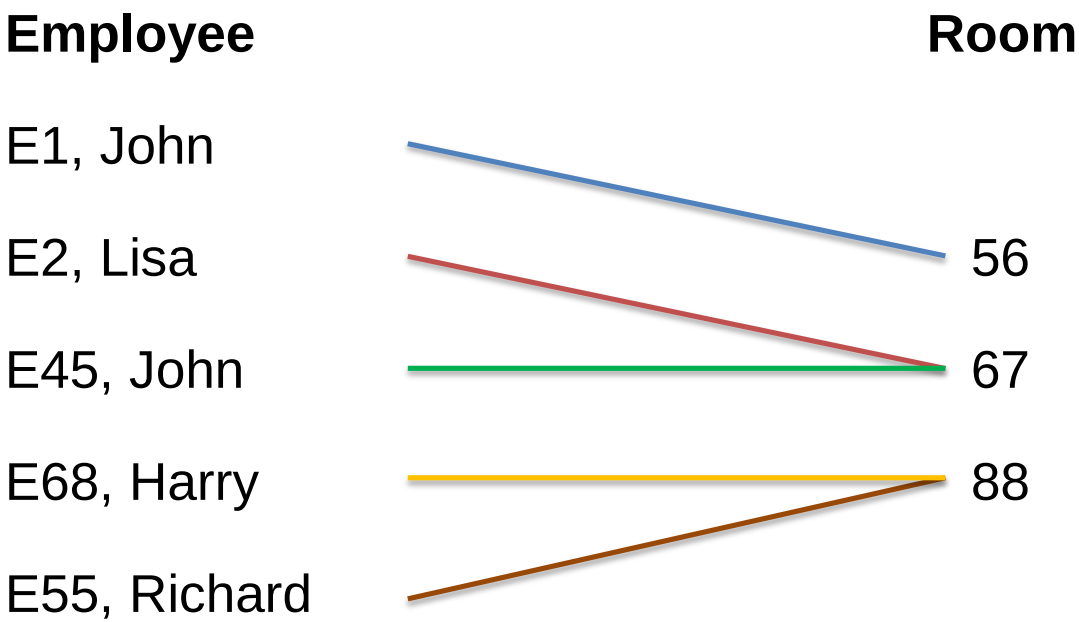
Abstract model: difficult to check.

Types and instances

Type level

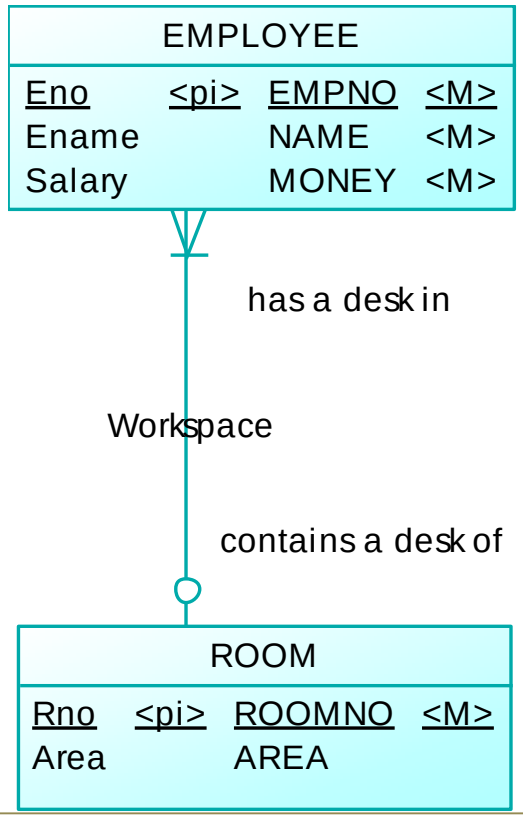


Instance level



Semantics, types and instances

Type level



A classic ERM diagram shows only the type level

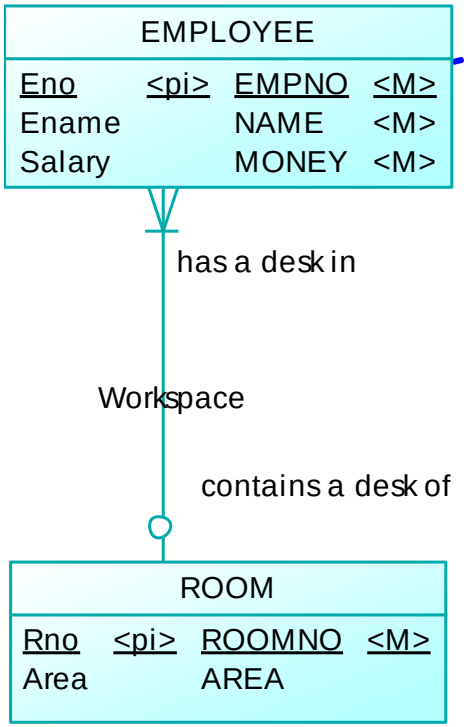
This suffices for simple everyday ETs and Atts (but many Atts are not simple at all)

However, for unfamiliar contexts
and/or complex data structures
this is not enough to understand the model

Adding the **semantics** (meaning) and **examples of instances** to the diagram can greatly help to validate the model (is it correct?)

Semantics, types and instances

Type level



Semantics and instance level

Employee <Eno> is called <Ename>.
Employee <Eno> earns a salary
of € <Salary> per month.

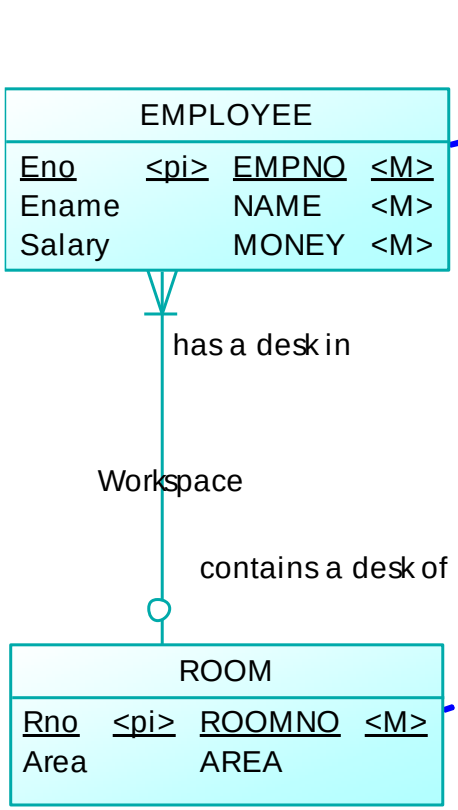
E1	E2	E45
John	Lisa	John
3000	5000	2400

Fact-Based ERM diagram with predicates and populations

Predicate: represents exactly one type of fact

Semantics, types and instances

Type level



Semantics and instance level

Employee <Eno> is called <Ename>.
Employee <Eno> earns a salary of € <Salary> per month.

E1	E2	E45
John	Lisa	John
3000	5000	2400

Room <Rno> offers an area per person of <Area> m2.

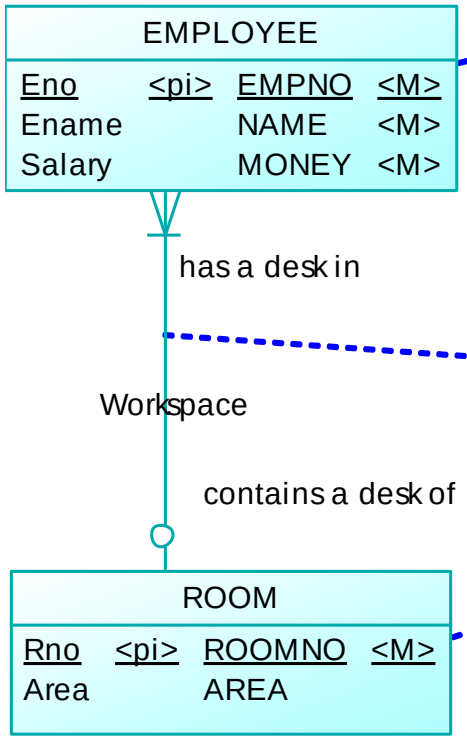
56	67
10.3	8.4

Fact-Based ERM diagram with predicates and populations

Predicate: represents exactly one type of fact

Semantics, types and instances

Type level



Semantics and instance level

Employee <Eno> is called <Ename>.
Employee <Eno> earns a salary of € <Salary> per month.

E1	E2	E45
John	Lisa	John
3000	5000	2400

Employee <Eno> occupies a desk in room <Rno>.

E1	E2	E45
56	67	67

Room <Rno> offers an area per person of <Area> m2.

56	67
10.3	8.4

Fact-Based ERM diagram with predicates and populations

Predicate: represents exactly one type of fact

Fact type:
either <pi>+Att combination
or non-dependent RT

Population: concrete illustration
Substitute values into blanks

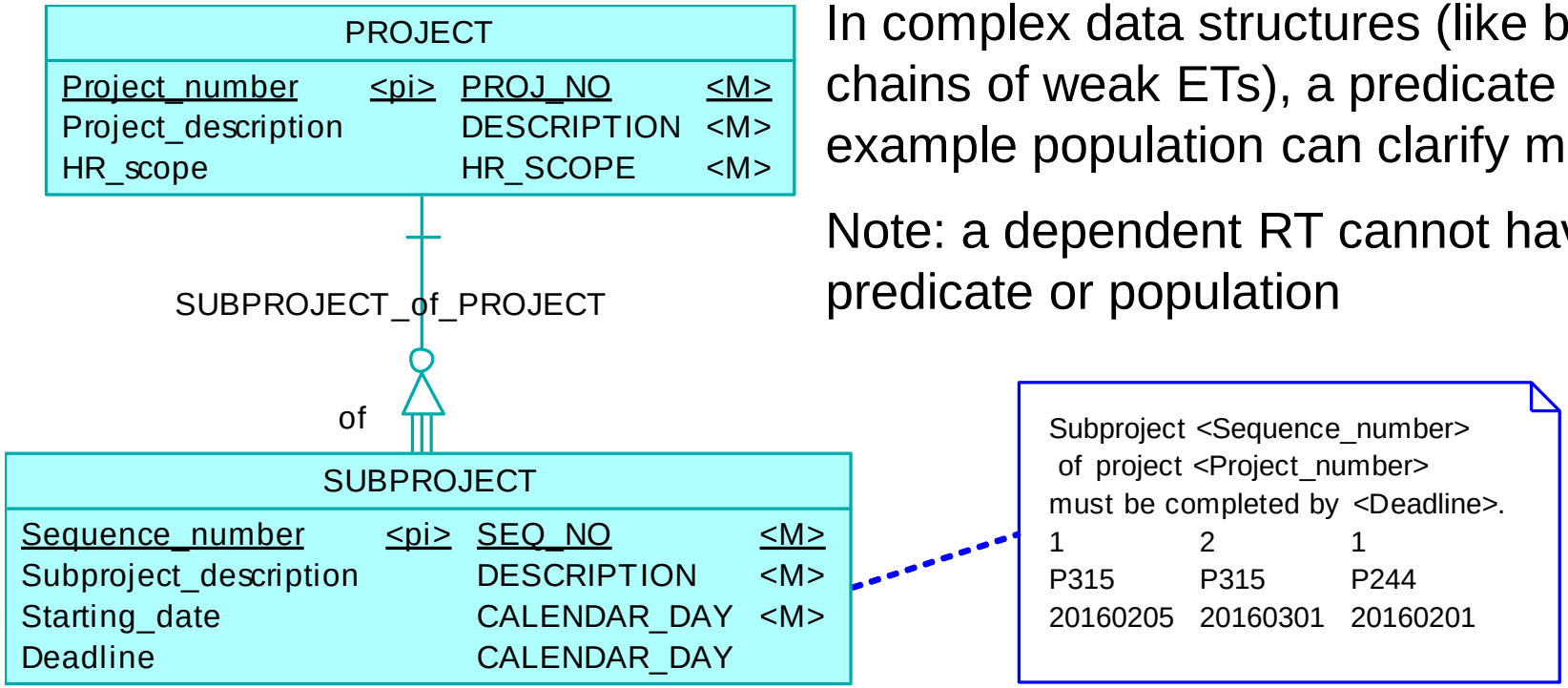
In practice: do this only for unclear Atts and RTs

Types and instances, weak ET

Here is a simple example of a weak ET (only one <pi>+Att fact type is shown)

In complex data structures (like branching chains of weak ETs), a predicate and example population can clarify much

Note: a dependent RT cannot have a predicate or population



Problems in classic ER models

Three main problems with classic ERM:

- Only abstract type level is modeled
  - Impossible to validate abstract model
- Semantics (of complete facts) not modeled
  - Data Dictionary: absent, or only ET and Att.
  - Semantics highly valued in practice
- No good modeling method
  - Most textbooks show WHAT to model
  - No textbook shows HOW to model

Here: attempt to solve all problems using **verbalizations of concrete examples of facts**

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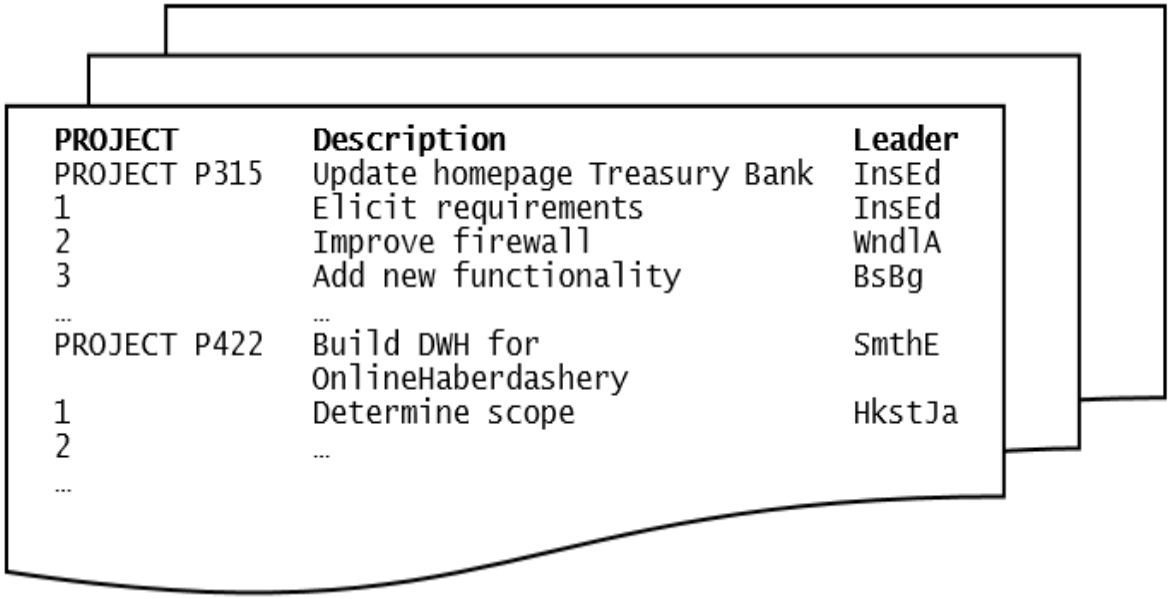
Examples of verbalizations



PROJECT	Description	Leader
PROJECT P315	Update homepage Treasury Bank	InsEd
1	Elicit requirements	InsEd
2	Improve firewall	WndlA
3	Add new functionality	BsBg
…	…	
PROJECT P422	Build DWH for OnlineHaberdashery	SmthE
1	Determine scope	HkstJa
2	…	
…		

Employee InsEd manages project P315.

The description of subproject 2 of project P315 is: Improve firewall.

Subproject 2 of project P315 is led by employee WndIa.

Why use verbalizations of facts?

Verbalizations of elementary facts:

- Are on the concrete instance level
  - Domain expert and modeler: common ground
  - Validation by domain expert is easy
- Capture the semantics of the data
  - Main issue in practice (>60% of design time)
- Are independent of modeling technique
  - Do not change in model transformations:
  - ORM, ERM, UML, Rel, …: same verbalizations
- Offer a valuable alternative viewpoint
  - Natural units of information

How do verbalizations help a modeler?

Verbalizing concrete examples of facts:

- Makes the modeler understand the data
- Is done in constant dialogue between modeler and domein expert
  - no ‘ivory tower’ modeling
- Enables an arcane abstract ER model to be built from familiar concrete facts
- Leads to a good and simple method to draw up an ERM diagram
- Enables easy validation of the model
- Enables adding semantics and examples to the diagram itself where convenient

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Method

Plenty of ERM textbooks tell you
WHAT to model

No ERM textbook tells you
HOW to make a good model

Fact Oriented/Based Methods
(FCO-IM, ORM, CogNIAM)
have always provided a good method

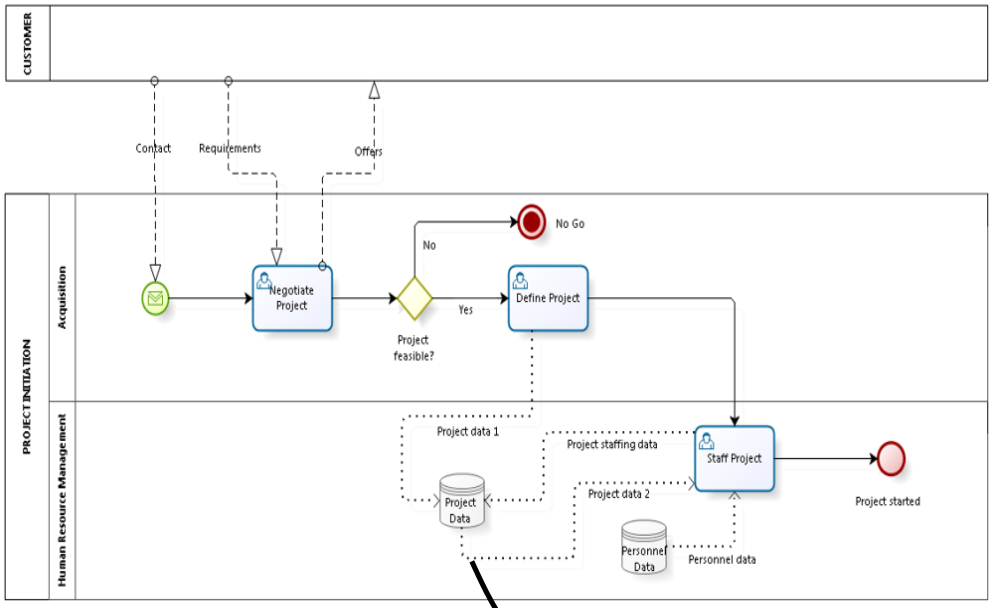
Procedure to draw up an ERD

Steps 1 and 2 are not covered in this presentation.

1. Collect concrete examples of facts
   - Use BPM as starting point
   - Make up examples if they don't exist (yet)
2. Verbalize these examples
   - With domain expert. Result: fact expressions.
   - Make the meaning as clear as possible
3. Sort expressions into Fact Types (FTs)
   - Same kind of expression: same FT
   - Order FTs with most components last
4. Analyze each FT (2 segments) and add the results to the ERD

Starting point

A process model shows data stores and flows: good sources of concrete examples of facts



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PROJECT P422	Build DWH for OnlineHaberdashery	SmthE
1	Determine scope	HkstJa
2	…	
…		

Sorting fact expressions

Expressions of the same kind belong to a Fact Type.

Expressions of the same type have components: places where the text can vary.

FT4 has 2 components

FT6 has 3 components

```
FT4
Employee InsEd manages project P315.
    "    SmthE    "       "    P422.

FT6
Subproject 1 of project P315 starts on 20160201.
     "     2  "    "    P315    "    " 20160201.
     "     3  "    "    P315    "    " 20160208.
     "     1  "    "    P422    "    " 20160101.
```

Sorting fact expressions

Procedure for sorting:

- Place expressions of the same kind in the same Fact Type (FT)
  - 2 or 3 expressions per FT is enough
- Per FT: count the number of components
  - Component: place where text can vary
  - Highlight the components
- Order the FTs
  - FTs with the fewest components: first
  - FTs with the most components: last

Analyzing fact types

No matter how many components a FT has, it can have only 2 segments: groups of components that belong together (only 1 segment is also possible).

The cases with 2 segments are treated in slides 9-18.

There are only two possibilities for the 2 segments:

- One segment concerns an ET,
  the other segment concerns an Att of this ET
- Both segments concern ETs, with a mutual RT

The cases with 1 segment are treated in slides 19-21.

There is only one possibility for a FT with 1 segment:

- The segment concerns an ET

Analzying fact types is:
determining which segments there are,
and which ETs, Atts and RTs are involved.

Analyzing fact types

The procedure to analyze FTs will be illustrated using the following four FTs:

```
FT1:
The family name of student S17 is Johansen.
 "     "     "   "    "    T66  " Robberts.
FT2:
The course SQL is taught by Tmina.
 "     "   ERM  "    "    " Ttigo.
FT3:
The exam of the course SQL on 14/1/2016 is held in room R67.
 "    "  "   "     "   ERM  " 25/2/2016  "   "   "   "  45a.
FT4:
Student T66 scored a mark of 85 for the exam of SQL on 14/1/2016.
   "    S17   "    "   "   " 47  "   "    "   " ERM  " 25/2/2016.
```

All modeling decisions are discussed with domain experts.

Analyzing fact types: FT1 (ET+Att)

Two components.
Segments underlined.
Segments: ET + Att.
Meaningful names.

```
FT1:
The family name of student S17 is Johansen.
 "     "     "   "    "     T66  " Robberts.
                    ET STUDENT     Att Family_name
```

Identifier of STUDENT: S17 and T66 are student numbers, which are called 'Studno' according to the domain expert.

For each ET: establish its <pi> (if Att: always <M>)

```
FT1
The family name of student S17 is Johansen.
 "     "     "   "    "     T66  " Robberts.
                    ET STUDENT     Att Family_name
                    ID: Att Studno
Predicate: The family name of student <Studno>
           is <Family_name>.
```

ERD
The <pi> and <M> were checked with the domain experts. Domains for the Atts were specified also.

STUDENT			
Studno	<pi>	STUDNO	<M>
Family_name		NAME	<M>

Rules for analyzing FTs

- Mark 2 segments (or 1), and decide on
  ET + Att or ET + ET (if 1 segment: ET).
-
- If you find a new ET:
  determine its ID (primary identifier)
-
-
- Give the complete predicate
- Determine <M> for new Atts
-
-

Analyzing fact types: FT2 (ET+ET)

Two components.
Segments: ET + ET
Meaningful names
Identifier determined

```
FT2:
The course SQL is taught by Tmina.
 "      "   ERM   "    "     " Ttigo.
ET COURSE                    ET TEACHER
ID: Att Course_code          ID: Att Teacher_code
```

Add a RT between the ETs; determine its cardinalities

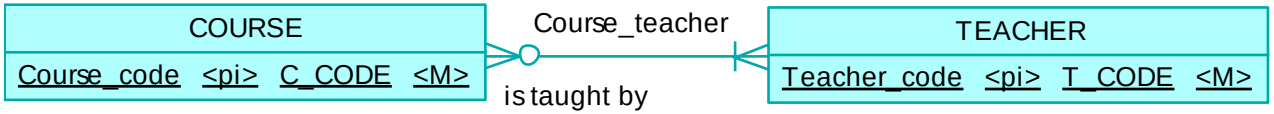
RT: explicit notation with ET-names needed in general

```
FT2
The course SQL is taught by Tmina.
 "      "   ERM   "    "     " Ttigo.
ET COURSE                    ET TEACHER
ID: Att Course_code          ID: Att Teacher_code

RT Course_teacher between COURSE and TEACHER

Predicate: The course <Course_code>
           is taught by <Teacher_code>.
```

ERD
All constraints, domains and cardinalities were determined with the domain experts



Rules for analyzing FTs

- Mark 2 segments (or 1), and decide on
  ET + Att or ET + ET (if 1 segment: ET).
-
- If you find a new ET:
  determine its ID (primary identifier)
-
- In the ET + ET case:
  add a non-dependent RT
- Give the complete predicate
- Determine <M> for new Atts
- Determine cardinalities for new RTs
-

Analyzing fact types: FT3 (weak ET)

FT3:
The exam of the course SQL on 14/1/2016 is held in room R67.
" " " " " ERM " 25/2/2016 " " " " 45a.

ET EXAM
ID: ET COURSE + Att Date
MATCH

Old ET: MATCH

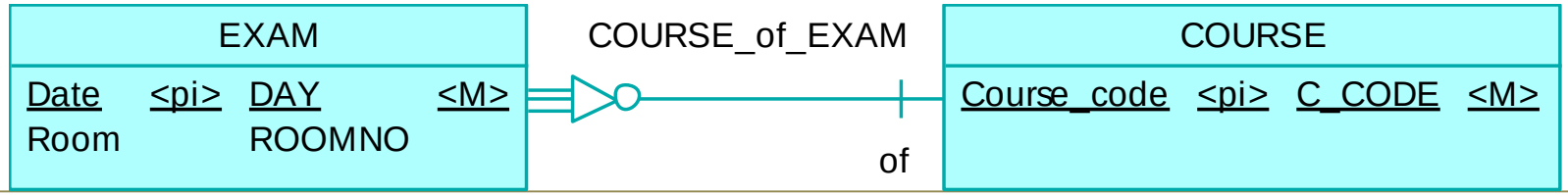
ID contains ET: EXAM is **weak ET:** add RT with dependency

Att Room

Could also be ET, if Atts for rooms were to be recorded, or a domain list would be convenient.

RT COURSE_of_EXAM between EXAM(dependent)
and COURSE

Predicate: **The exam of the course <Course_code> on <Date> is held in room <Room>.**



Rules for analyzing FTs

- Mark 2 segments (or 1), and decide on
  ET + Att or ET + ET (if 1 segment: ET).
- If you find an old ET: MATCH
- If you find a new ET:
  determine its ID (primary identifier)
- If this ID contains an ET:
  add a dependent RT to it
- In the ET + ET case:
  add a non-dependent RT
- Give the complete predicate
- Determine <M> for new Atts
- Determine cardinalities for new RTs
-

Analyzing fact types: FT4 (Complex)

```
FT4:
Student T66 scored a mark of 85 for the exam of SQL on 14/1/2016.
   "    S17   "    "   "   " 47  "   "    "   " ERM  " 25/2/2016.
                   Att Mark
```

Old ETs STUDENT and EXAM present. Mark: attribute (property) of an exam participation. So other three components must be one ET.

```
ET EXAM_PARTICIPATION
ID: ET STUDENT + ET EXAM
    MATCH        MATCH
```

ID contains 2 old ETs: 2 MATCHes

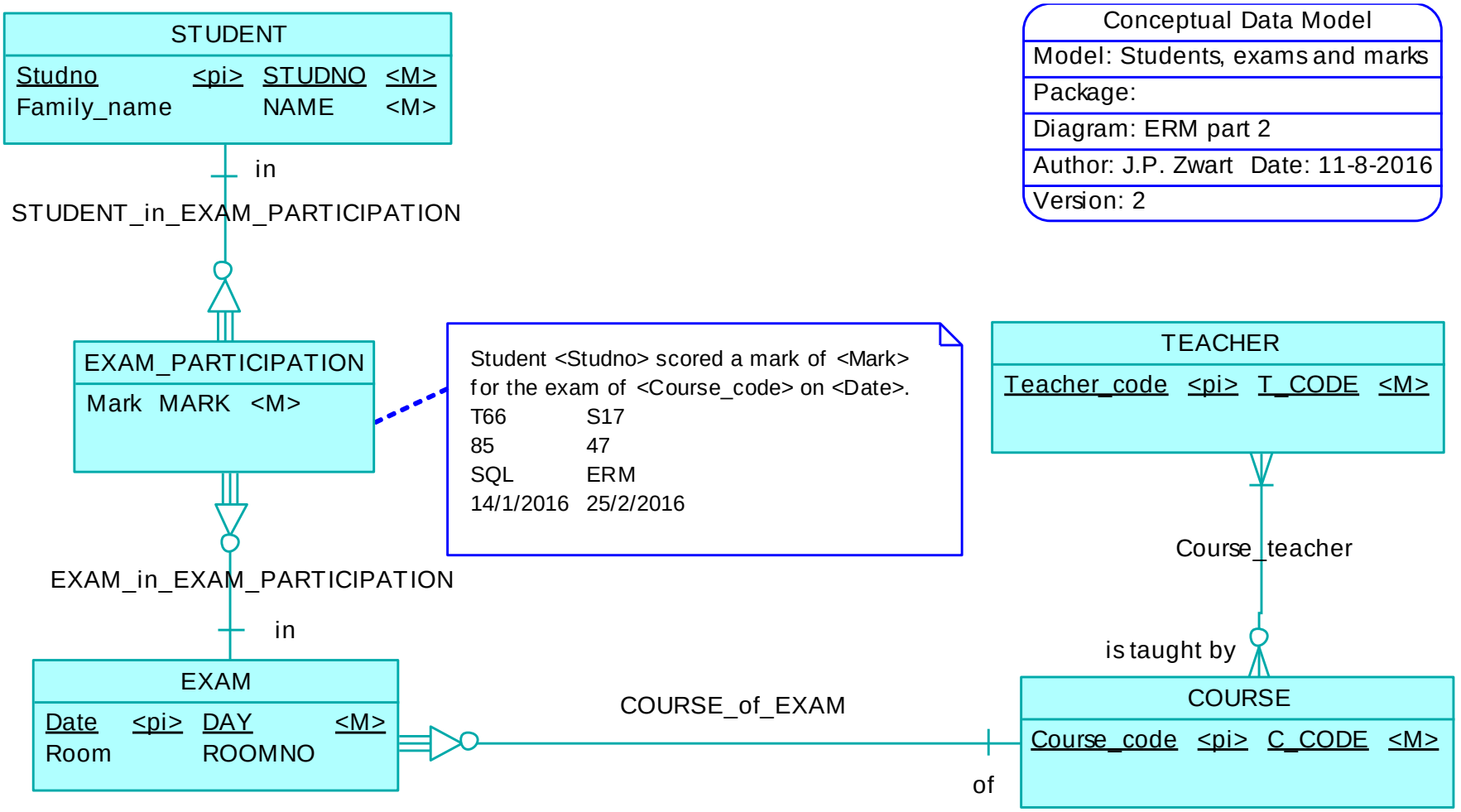
For each ET in the ID: add a dependent RT

```
RT STUDENT_in_EXAM_PARTICIPATION between
   EXAM_PARTICIPATION(dependent) and STUDENT

RT EXAM_in_EXAM_PARTICIPATION between
   EXAM_PARTICIPATION(dependent) and EXAM

Predicate: Student <Studno> scored a mark of <Mark>
           for the exam of <Course_code> on <Date>.
```

Analyzing fact types: Complete ERD



Rules for analyzing FTs

- Mark 2 segments (or 1), and decide on
  ET + Att or ET + ET (if 1 segment: ET).
- If you find an old ET: MATCH
- If you find a new ET:
  determine its ID (primary identifier)
- If this ID contains an ET:
  add a dependent RT to it
- In the ET + ET case:
  add a non-dependent RT
- Give the complete predicate
- Determine <M> for new Atts
- Determine cardinalities for new RTs
- Add predicates and populations to the diagram to make the meaning of the fact types more clear

Examples of FTs with one segment

Example 1: Domain list

Such verbalizations might be given for domain lists (departments in an organization, wards in a hospital, towns in a country, …).

Domain lists prevent typos, save users time and effort, and are easily updated by the DB admin.

```
There is a course ERM.
  "    " "    "   SQL.
```

Only one component, only one segment possible. This must then be an ET.

```
There is a course ERM.
  "    " "    "   SQL.
          ET COURSE
          ID: Att Course_code
Predicate: There is a course <Course_code>.
```

COURSE			
Course_code	<pi>	C_CODE	<M>

Examples of FTs with one segment

Suppose you know that enrollments have attributes of their own (date, status, …). Then you don't want to treat this as an ET+ET case: it will result in a Many-to-Many RT.

Instead, an empty ET for the future Atts is desired.

Example 2: Empty weak ET

Student S17 has enrolled for the course ERM.
" T66 " " " " " SQL.

Two components, only 1 segment chosen: must be ET.

Student S17 has enrolled for the course ERM.
" T66 " " " " " SQL.

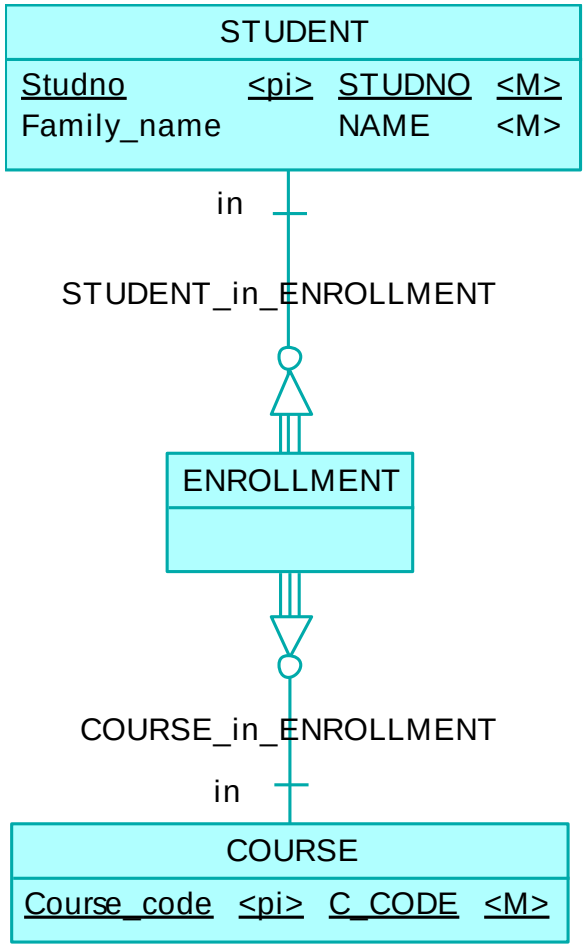
ET ENROLLMENT
ID: ET_STUDENT + ET_COURSE
MATCH MATCH

RT R_STUDENT_in_ENROLLMENT between
ENROLLMENT(dependent) and STUDENT

RT R_COURSE_in_ENROLLMENT between
ENROLLMENT(dependent) and COURSE

Predicate: **Student <Studno> has enrolled for the course <Course_code>.**

Examples of FTs with one segment



Example 2: Empty weak ET

Note:

- Attributes for ENROLLMENT can be easily added: when analyzing a verbalization like:

  ```
  The status of student S17's enrollment
  in the course ERM is: Pending.
  ```

  the ET ENROLLMENT is old, so MATCH will do.

- The rules given in slide 18 also capture the one-segment cases.

Practical recommendations

- Always work exclusively from concrete examples of facts.
- Always verbalize these facts carefully, with the possible exception of widely known simple attributes, but don't be too sloppy!
- Add predicates and/or example populations for
  - ➢ all unclear non-dependent RTs
  - ➢ all unclear <pi>+Att fact types

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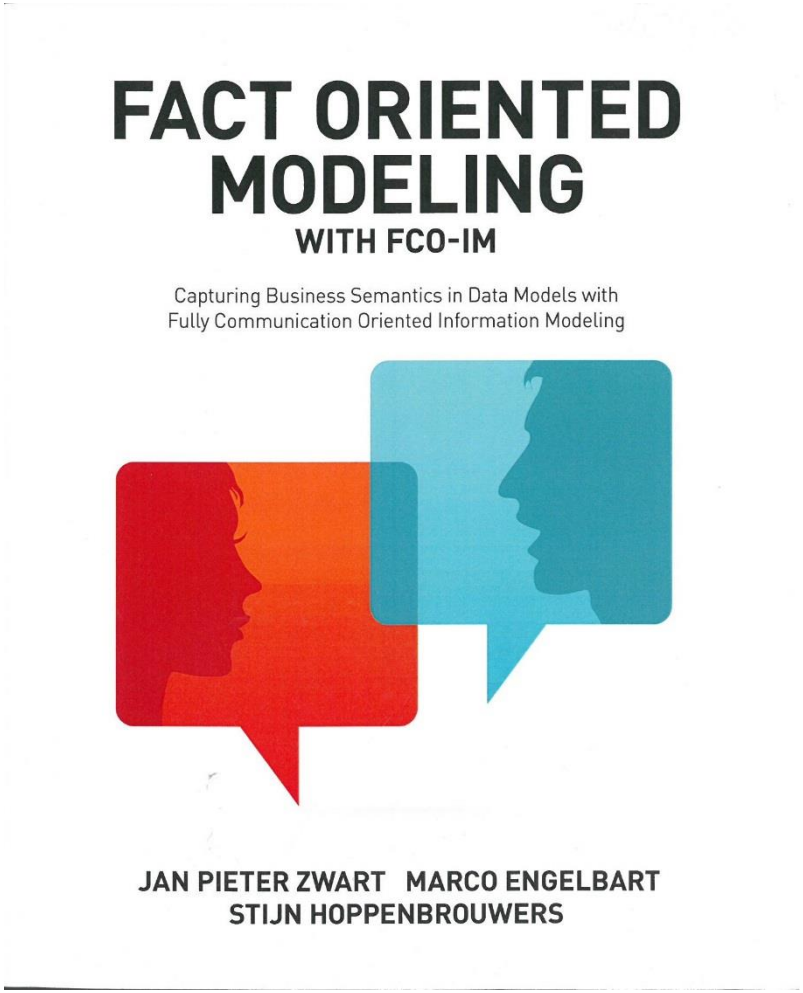
- Experiences and conclusion

FOM technique: FCO-IM



Fact Oriented Modeling with FCO-IM

Published 2015

FOM technique: FCO-IM
Tool: CaseTalk

BCP software

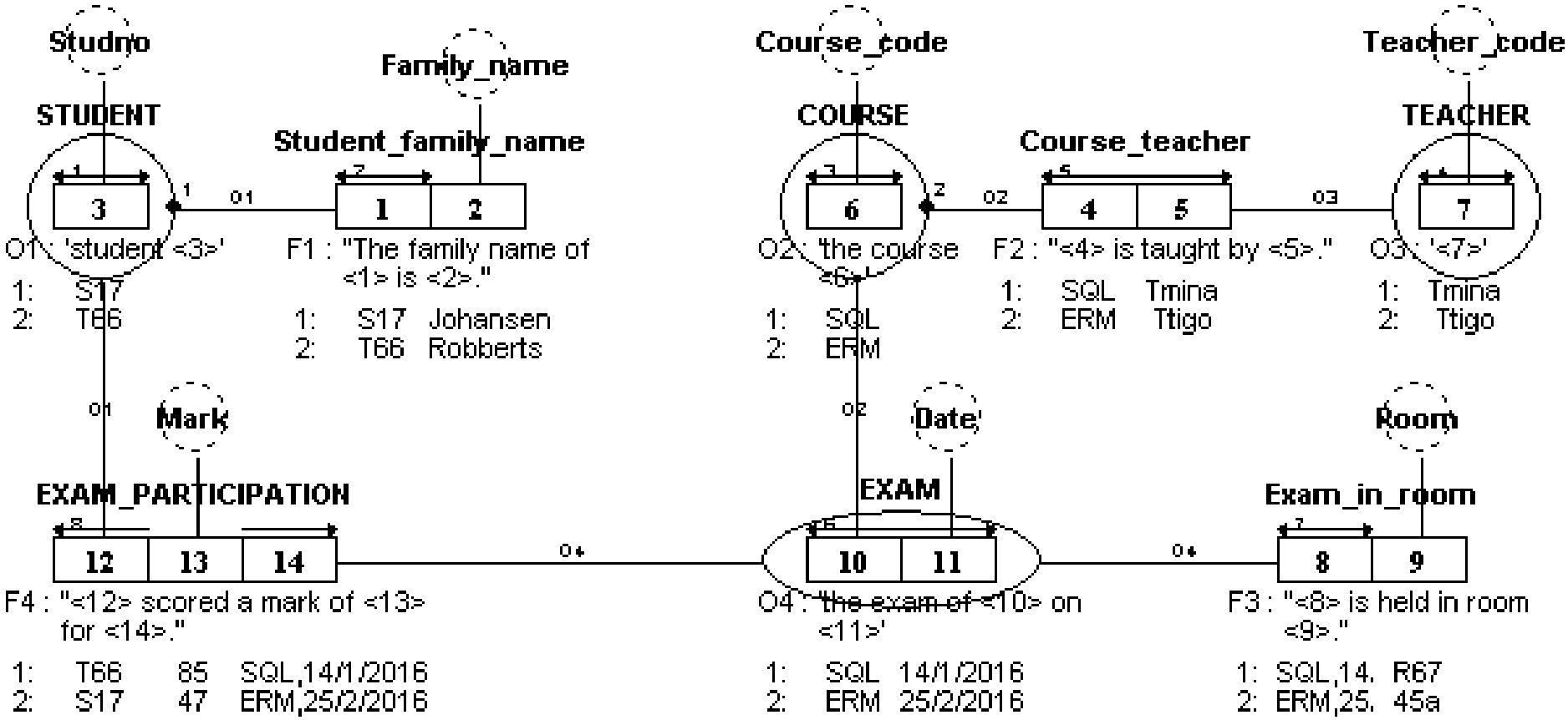
CaseTalk™

Marco Wobben

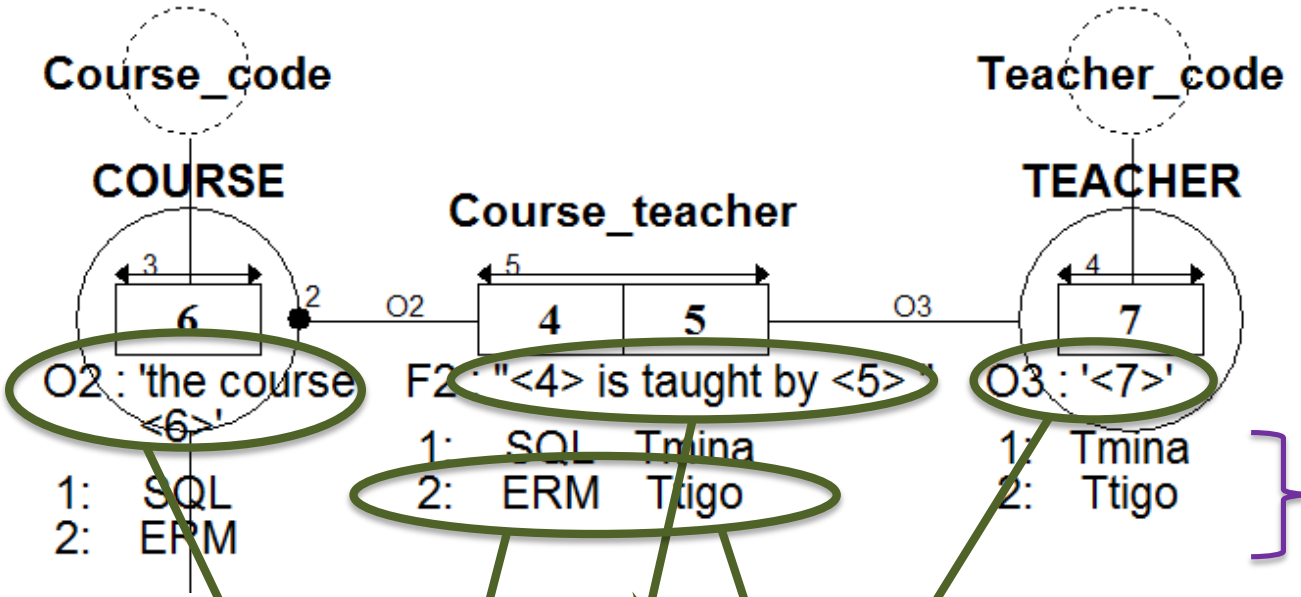
FOM technique: FCO-IM

- **FCO-IM uses the same principles**
  - Focus: complete elementary facts
  - Model is built by analyzing verbalizations of example facts
- **Method more fully worked out**
  - Verbalizations incorporated
  - Many constraint types included (uniqueness, totality, cardinality, subset, …)

FCO-IM model (in CaseTalk)



FCO-IM model (in CaseTalk)



<4> is taught by <5>

the course <6> is taught by <7>

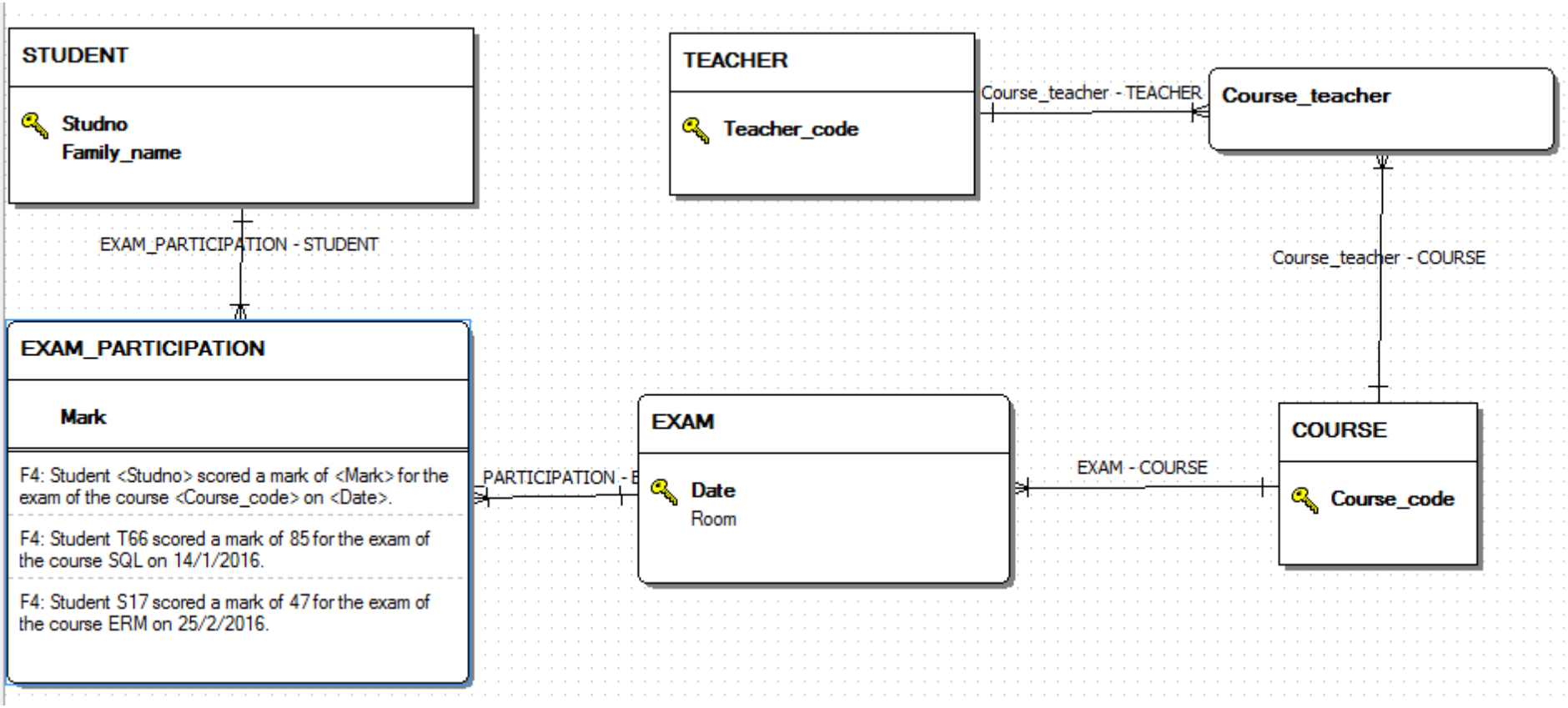
the course ERM is taught by Ttigo

Type level
Instance level
Verbalizations

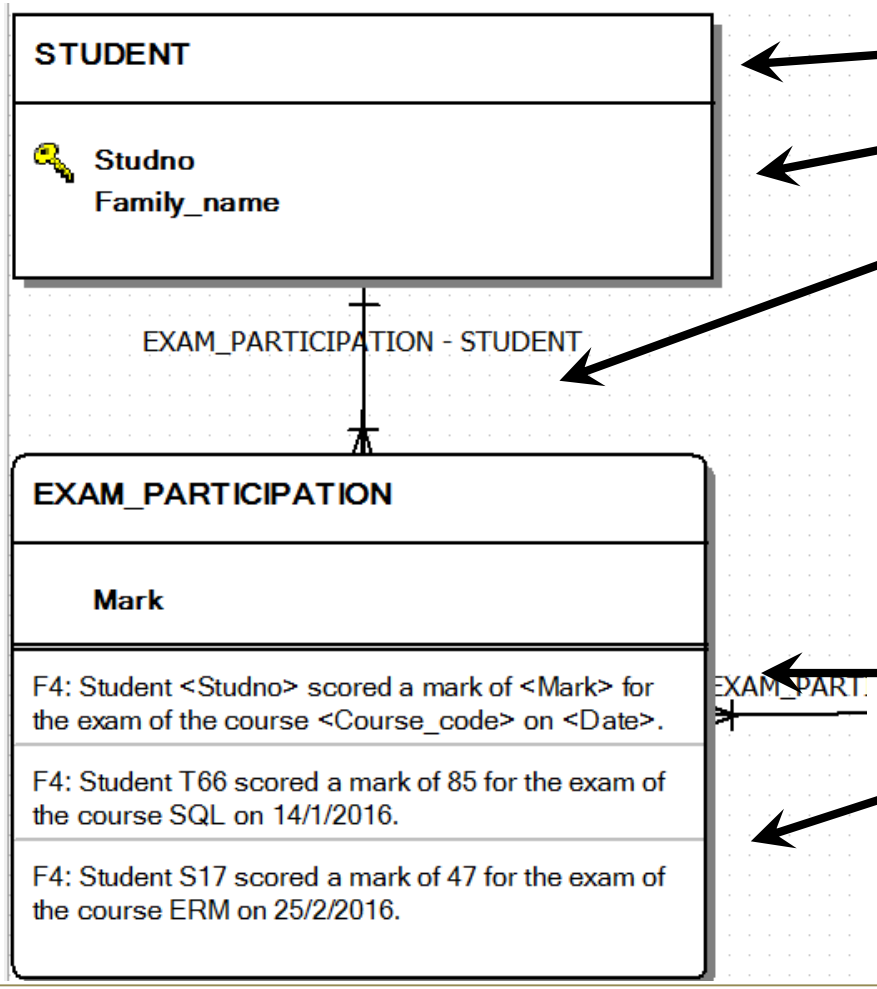
FOM technique: FCO-IM
Tool: CaseTalk

- **Automatic transformation of FCO-IM model into**
  - ERM data model
  - UML class diagrams
  - Relational database schema
  - DWH Star Schema
  - Data Vault
  - …
- **Script generation**
  - Several RDBMS platforms

ERM model (derived in CaseTalk)



ERM model (derived in CaseTalk)

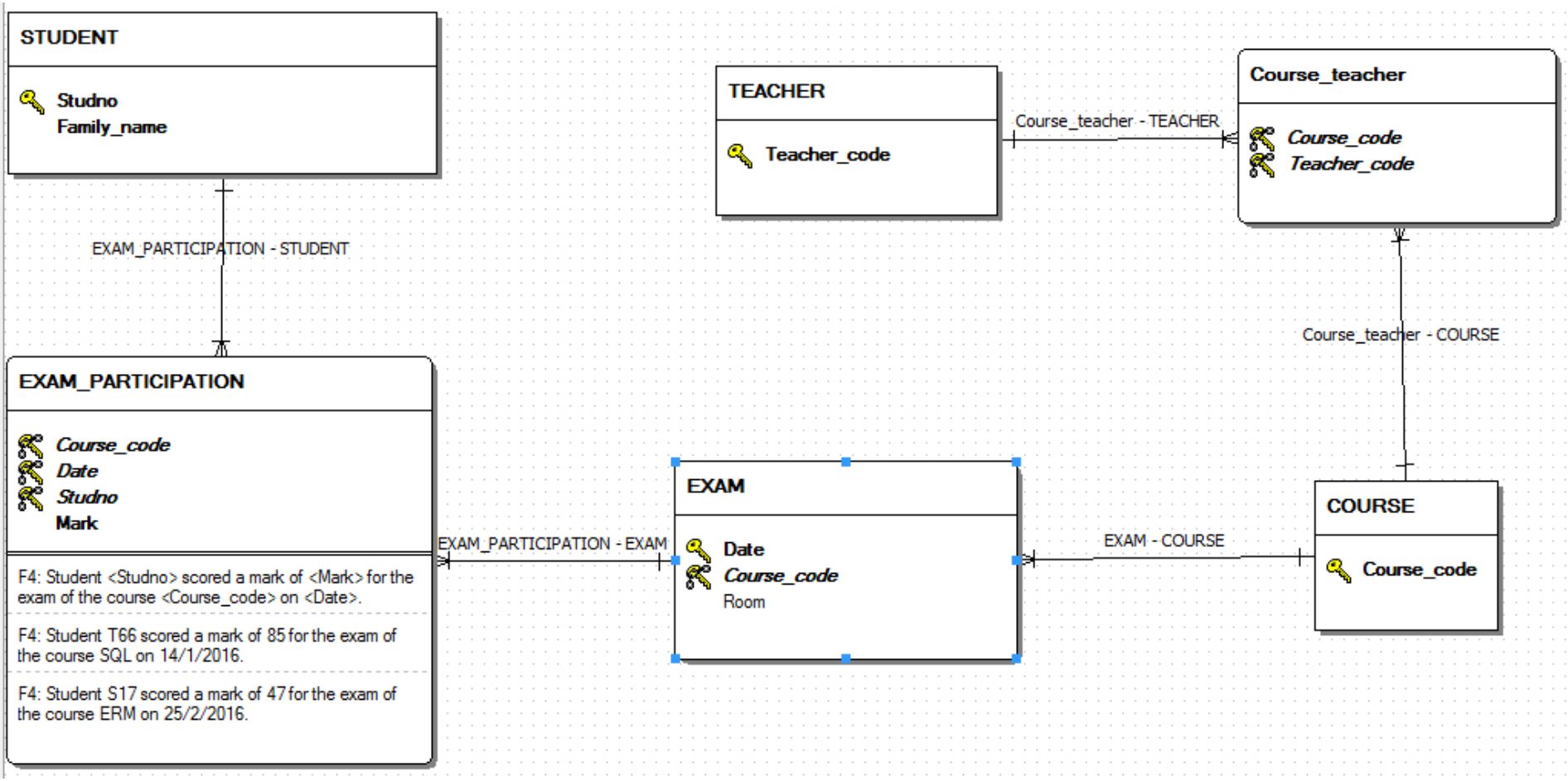


- Entity type
- Attributes
- Relationship type

Shown or hidden ad libitum:

- Predicate
- Example facts

Relational schema (derived in CaseTalk)



Fact-Oriented Modeling (FOM)

- Fact-based vs Attribute-based modeling
- Problems in classic ER models
  - Only type level
  - No semantics
  - No method
- Verbalizing example facts helps modelers
- Method to draw up an ER model
- Better FOM technique: FCO-IM and CaseTalk
- **Experiences and conclusion**

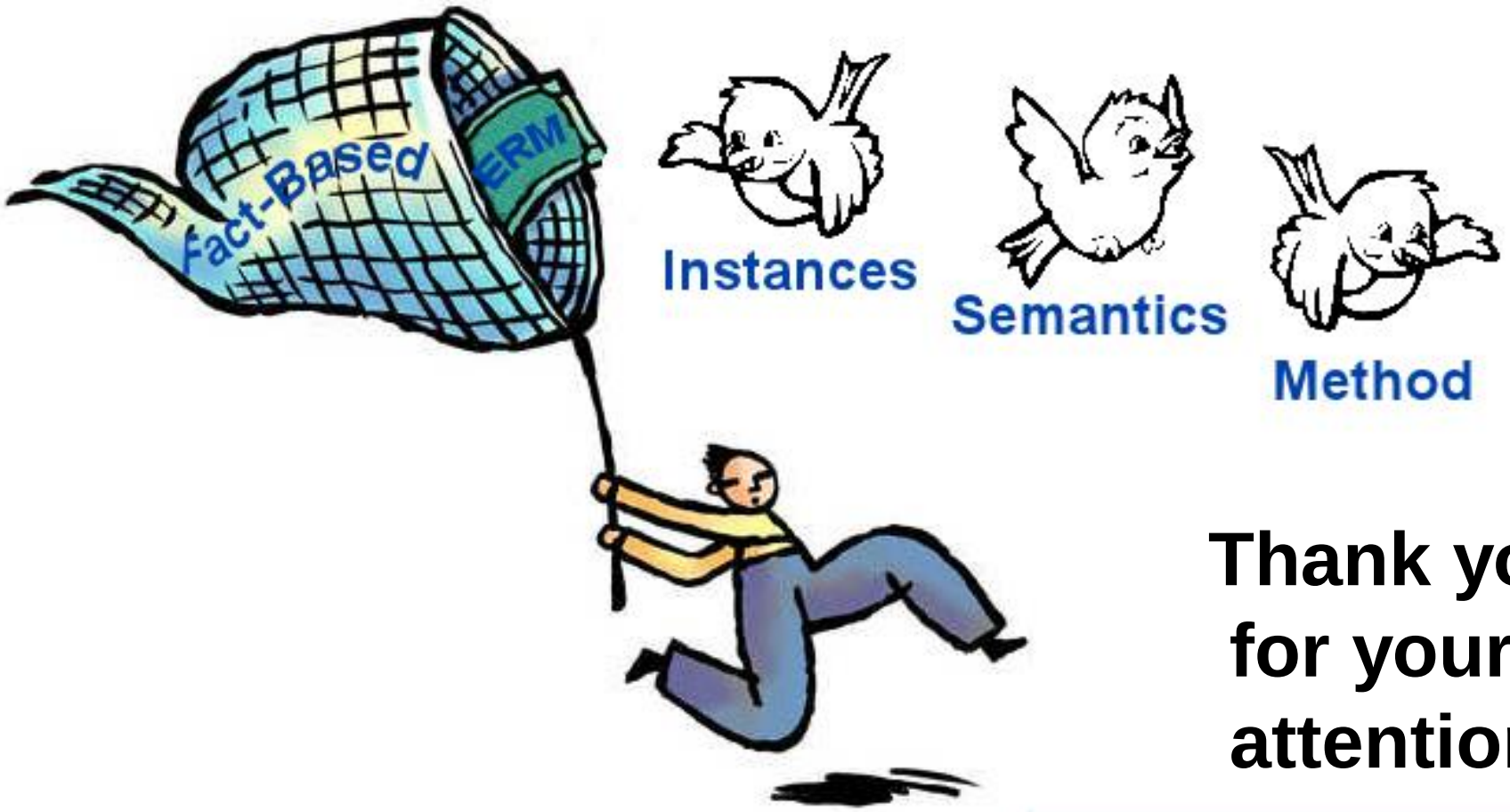
Experience with this approach in class

- Procedure: can be taught and practised well in class
- Case studies (hospital, music theater, travel agency):
  - Students were only allowed to continue
    if the verbalizations were approved by the domain expert (teacher)
  - Verbalizing takes time
  - Students understand UoD better:
    - Less jumping to (wrong) conclusions,
      and misunderstandings corrected quickly
    - Excellent way to solve semantic issues
  - Analyzing and drawing up the ERM diagram was easy after this
- Students: appreciate the ‘best of both worlds’ approach
  - For trivial attributes: why the fuss?
  - More difficult modeling: benefit is acknowledged

Conclusions

- Fact-Based viewpoint: valuable additional perspective
  - Exactly one complete fact (natural unit of information)
  - vs Entity Type (cluster of facts) or Attribute (fact fragment)
- Verbalizations of elementary facts can be used to
  - Supplement a classic ER model where convenient with instance-level examples to add clarification by illustration
  - Supplement a classic ER model where convenient with elementary fact predicates to add semantics
  - Draw up an ER model using a systematic easy-to-learn procedure telling you how to do so

Catching three birds with one net



Thank you for your attention