From Extended Entity-Relationship schemata to illustrative instances

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please visit the companion Web site:
http://mag.dsi.unimi.it/EER2instances

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Illustrative Instances

long-term research topic:

apply logic programming to automated reasoning about projects diagrams: UML and [E]ER.

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Given a set of constraints representing an EER project, generate automatically an example instance showing how the final database will (likely) look like.

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Given a set of constraints representing an EER project, generate automatically an example instance showing how the final database will (likely) look like.
Automated reasoning about project constraints: (relatively) easy to add them to our LP representation
both directions of research showcase DLV*

Informative Armstrong Data Bases (IADBs)

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Semantic sampling of existing databases through informative Armstrong databases
Information Systems, 2007.

De Marchi et al. aim to provide information about the structure of the database by letting the user inspect a suitably small instance.
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Informative Armstrong Database

A *small* instance that satisfies exactly the same functional and inclusion dependencies that were found on the given (normally large) database instance.
IADBs consist of *real tuples* that come from an input database which we want to *understand*

Literature: Armstrong Databases

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An Armstrong Database is a *global Witness* from a *relational* schema.

1. Let Σ a set of constraints over the schema
2. Let Σ^* the set of logical consequences of Σ
3. An instance Θ is an ADB if
   a. $\forall\sigma \in \Sigma^*.\ \Theta \models \sigma$
   b. $\forall\sigma \notin \Sigma^*.\ \Theta \not\models \sigma$

Example (Fagin-Vardi): ADB

$\Sigma = \{EMP \rightarrow DEPT, DEPT \rightarrow MGR\}$

Employee	Dept	Manager
Hilbert	Math	Gauss
Pythagoras	Math	Gauss
Turing	Computer Science	von Neumann
Einstein	Physics	Gauss

Table: Armstrong Relation r for Σ

Σ^* contains the FD's in Σ

The FD $MGR \rightarrow DEPT$ is not an FD in Σ^*, and indeed, r does nor obey this FD, since GAUSS is the MANAGER of two distinct departments (MATH and PHYSICS)

Example: EER schema

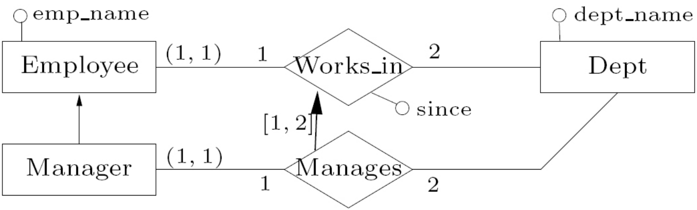
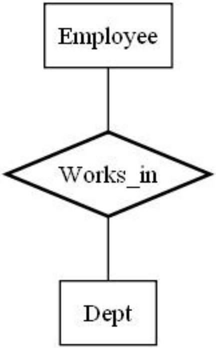


Figure: Extended Entity Relationship schema

The schema describes employees (entity EMPLOYEE) working (relationship WORKS_IN) in departments (relationship DEPT) of a firm, and managers (entity MANAGER) that are also employees, and manage (relationship MANAGES) departments. Managers who manage a department also work in the same department, as imposed by the *is-a* among the two relationships.

FROM EER to ERL




```
<!DOCTYPE erl PUBLIC "-//DSI//DTD ERL V1.2//EN" "file:./ERL/erl.dtd">
<erl id="Example1" title="Example 1 from [Cali, 2007]">

  <ent id="employee" label="Employee">
    <attr id="empname" label="emp_name" size="30" mand="true"/>
  </ent>

  <ent id="dept" label="Dept">
    <attr id="deptname" label="dept_name" type="int" mand="true"/>
  </ent>

  <rel id="worksin" label="Works_in">
    <attr id="since" label="since" type="date" mand="true"
          default="'2001-01-01'"/>
    <leg entref="employee" label="1"/>
    <leg entref="dept" label="2"/>
  </rel>

</erl>
```

A new DTD for handling *is-a* between relationship

Step-by-step generation of the logic program

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- **A..D** insert into $\pi_{\mathcal{C}}$ facts and rules that capture the structure of *a* relational schema induced by $\mathcal{C}$;
- **1..11** insert into $\pi_{\mathcal{C}}$ rules that capture two essential aspects of EER:
  - inclusion dependencies, captured by logic programming constraints (on consistency);
  - the inheritance relation between entities (resp. relationships) which is captured by normal deductive rules.

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Implemented as a ERW interface:

```
>java -cp ER2DL.jar it.unimi.dsi.erw.ERtool < my-eer-project.xml
--datalog
```

From EER to Logic Programs: Modifying [Calì 07]

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First of all, we formally define a database schema from an EER diagram. Such a database schema is defined in terms of predicates: we define a relational database schema that encodes the properties of an EER schema $\mathcal{C}$.

A. Each entity E in $\mathcal{C}$ has an associated predicate E of arity 1.

B. Each attribute A for an entity E in $\mathcal{C}$ has an associated predicate A of arity 2, associating attribute values to entity instances.

C. Each relationship R among the entities $E_1, \ldots, E_n$ in $\mathcal{C}$ has an associated predicate R of arity n.

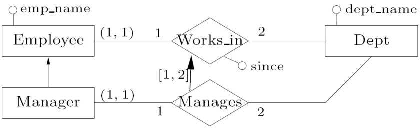
D. Each attribute A for a relationship R among the entities $E_1, \ldots, E_n$ in $\mathcal{C}$ has an associated predicate A of arity n + 1, associating attribute values to n-tuples of entity instances.

Cont'd

Given a database schema R for an EER schema $\mathcal{C}$, Calì gives a semantics to each construct of the EER model by specifying what databases (i.e. extension of the predicates of R) satisfy the constraints imposed by the constructs of the EER diagram.

EER construct	**Relational constraint**
attribute $A/2$ for an entity E	$A[1] \subseteq E[1]$
attribute $A/(n+1)$ for a relationship R/n	$A[1,\ldots,n] \subseteq R[a,\ldots,n]$
relationship R with entity E as i-th component	$R[i] \subseteq E[1]$
mandatory attribute $A/2$ of entity E	$E[1] \subseteq A[1]$
mandatory attribute $A/(n+1)$ of relationship R/n	$R[1,\ldots,n] \subseteq A[1,\ldots,n]$
functional attribute $A/2$ of entity E	$key(A) = \{1\}$
functional attribute $A/(n+1)$ of a relationship R/n	$key(A) = \{1,\ldots,n\}$
is-a relation between entities E_1 and E_2	$E_1[1] \subseteq E_2[1]$
is-a relation between relationships R_1 and R_2, where components $1,\ldots,n$ di R_1 correspond to components $j_1,\ldots,j_n$ of R_2	$R_1[1,\ldots,n] \subseteq R_2[j_i,\ldots,j_n]$
mandatory participation as c-th component of an entity E in a relationship R	$E[1] \subseteq R[i]$
functional participation as c-th component of an entity E in a relationship R	$key(R) = \{c\}$

Our method, By Example



manager/1,
employee/1,
dept/1,
works_in/2,
manages/2,
emp name/2,
dept name/2,
since/3

Manager[1] ⊆ Employee[1]
Manages[1] ⊆ Employee[1]
Manages[2] ⊆ Dept[1]
Works_In[1] ⊆ Employee[1]
Works_In[2] ⊆ Dept[1]
Manages[1,2] ⊆ Works_In[1,2]

Step **A..D**:

Step A.
```
employee(emp).
manager(man).
dept(dept).
```

Step B.
```
emp_name(emp,emp_name).
dept_name(dept,dept_name).
```

Step C.
```
works_in(emp,dept).
manages(man,dept).
```

Step D.
```
since(emp,dept,since).
```

Step **1..11**:
capture special constraints (*FDs*, *IDs* e *KDs*).

Example 1: Defining the constraints

Step 1: emp_name[1] ⊆ employee[1]:

```
:- emp_name(Emp, Emp_name),
   not employee(Emp).
```

Step 2: since[1,2] ⊆ works_in[1,2]:

```
:- since(Emp, Dept, Since),
   not works_in(Emp, Dept).
```

Step 3: works_in[1] ⊆ employee[1]:

```
:- works_in(Emp, Dept), not employee(Emp).
```

Step 4: employee[1] ⊆ emp_name[1]:

```
:- employee(Emp), not
   emp_name(Emp, emp_name_of(Emp)).
```

Step 5: works_in[1,2] ⊆ since[1,2]:

```
:- works_in(Emp, Dept), not
   since(Emp, Dept, works_in_since(Emp, Dept)).
```

Step 6: does not apply to this example (it would simply generate a key constraint)

Step 7: does not apply to this example (it would simply generate a key constraint)

Step 8: Each manager is also an employee:

```
employee(Man) :- manager(Man).
```

Step 9: Each occurrence of Manages is also an occurrence of Works_in:

```
works_in(Emp, Dept) :- manages(Emp, Dept).
```

Step 10: employee[1] ⊆ works_in[1]:

```
:- employee(Emp),
   not participates(Emp, works_in, 1).
participates(Emp, works_in, 1) :-
            dept(Dept), works_in(Emp, Dept).
participates(Dept, works_in, 2) :-
            employee(Emp), works_in(Emp, Dept).
```

Step 11: key(works_in) = employee[1]:

```
:- works_in(Emp1, Dept1),
   works_in(Emp2, Dept2),
   Emp1 = Emp2,
   Dept1 != Dept2.
```

Interpretation of the Logic Program

F. Calimeri, S. Cozza, G. Ianni and N. Leone
Functions, Lists and Set in DLV System
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The *target language* of the mapping described in the previous Section is that of the novel DLV^* inferential engine.

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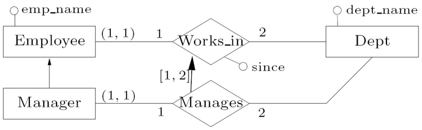
DLV* is an extension of the well-know DLV inferential engine[a] for deductive databases and disjunctive logic programming which supports functions, lists and sets.

[a]DLV and its extensions, and related literature are available from *http://www.dlvsystem.com/*.

Finally...



Relationship predicates reification are reified

```
-->dl my-eer-project.dlv

DLV [build BEN/Feb  8 2008   gcc 3.4.2 (mingw-s
{
 manages(man,dept),
 employee(emp),
 employee(man),
 manager(man),
 dept(dept),
 emp_name(emp,emp_name_of(emp)),
 emp_name(man,emp_name_of(man)),
 dept_name(dept,dept_name_of(dept)),
 works_in(emp,dept),
 works_in(man,dept),
 since(emp,dept,works_in_since(emp,dept)),
 since(man,dept,works_in_since(man,dept)),
 participates(emp,works_in,1),
 participates(man,works_in,1),
 participates(man,manages,1),
 participates(dept,works_in,2),
 participates(dept,manages,2)
}
```

Results

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Automated generation of illustrative instances for EER schema:
It assists Database design exp. w.r.t. the non-expert.

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Modified XML representation of EER projects.
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First-time application of DLV*

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Integration into ERW

1. Input: EER project in ERL encoding
2. Output:
   2.1 DLV* representation, an illustrative instance;
   2.2 SQL commands for DB creation, ready-made PHP pages and forms needed for populating the database and for maintenance.

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