

Assignment Project Exam Help

Entity Relationship Modelling

<https://eduassistpro.github.io>

Imperial College London

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Designing a Relational Database Schema

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How do you design a relational database schema for a particular UoD?

1 Need s

schema

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2 Need to map the ER/UML schema into a relational schema

3 Need to ensure that the relational schema is a good design

■ Normalisation

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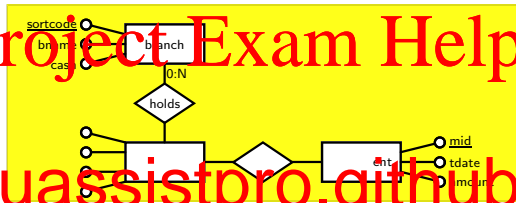
Semantic Modelling: ER Schemas

```
CREATE TABLE branch
(
  sortcode INTEGER NOT NULL,
  brname VARCHAR(40) NOT NULL,
  cash DECIMAL(10,2) NOT NULL,
  CONSTRAINT branch_pk PRIMARY KEY (sortcode)
)
```

```
CREATE TABLE a
(
  no INTEGER NOT NULL,
  type CHAR(8),
  cname VARCHAR(40),
  rate DECIMAL(10,2),
  sortcode INTEGER,
  CONSTRAINT account_fk FOREIGN KEY (sortcode) REFERENCES branch
)
```

```
CREATE INDEX account_type ON account (type)
```

```
CREATE TABLE movement
(
  mid INTEGER NOT NULL,
  no INTEGER NOT NULL,
  amount DECIMAL(10,2) NOT NULL,
  tdate DATETIME NOT NULL,
  CONSTRAINT movement_pk PRIMARY KEY (mid),
  CONSTRAINT movement_fk FOREIGN KEY (no) REFERENCES account
)
```



Core \mathcal{ER} : Entities and Relationships

Entities

E An entity E represents a set of objects which conceptually are the same type of thing

- **nouns** \rightarrow entity set
- proper

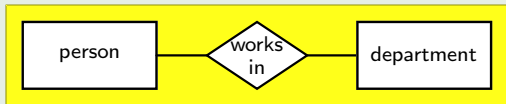
Relations

R A relation of conceptual association between entities E_1, E_2 type

- **verbs** \rightarrow relationship
- $R \subseteq \{(e_1, e_2) \mid e_1 \in E_1 \wedge e_2 \in E_2\}$

Identifying entities and relationships

In News Ltd, each person works in exactly one department; there are no restrictions on the number of persons a department may employ.



Core $\mathcal{ER}^{\mathcal{KM}\mathcal{O}}$: Attributes of EntitiesAttributes $\mathcal{ER}^{\mathcal{M}}$ $\mathcal{ER}^{\mathcal{O}}$ and $\mathcal{ER}^{\mathcal{K}}$

- A mandatory attribute $E.A$ is a function that maps from entity set E to value set V .

$$E.A \subseteq \{ \langle e, v \rangle \mid e \in E, v \in V \}$$

$$\text{2 unique: } \langle e, v_1 \rangle \in E.A \wedge \langle e, v_2 \rangle \in E.A \rightarrow v_1 = v_2$$

$$\text{3 mandatory: } E = \{ e \mid \langle e, v \rangle \in E.A \}$$

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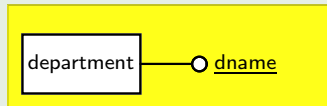
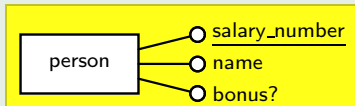
○ an ○

■ certai

$$E = \{ \langle v_1, \dots, v_n \rangle \mid \langle e, v \rangle \in E.A_1 \wedge \dots \wedge \langle e, v_n \rangle \in E.A_n \}$$

Identifying attributes

We record the name of each person working in the department; a person is identified by their salary number. Optionally they might have a bonus figure. Departments are identified by their name.



\mathcal{ER}^L : Look-Here Cardinality Constraints \mathcal{ER}^L

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- An upper bound cardinality constraint U states that E_1 may appear at most U times in R .
- Additionally with \mathcal{ER}^L : a lower bound cardinality constraint L states that each instance of E_1 must appear at least L times in R .

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Adding look-here cardinality constraints in \mathcal{ER}^L

Each person works in exactly one department; there are no restrictions on the number of persons a department may employ.



Quiz 1: Extent of Relationships

person = {'Peter', 'Jane', 'Mary'}

dept = {'CS', 'Maths'}



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Which is no

A

works_in = { ('Peter', 'Maths'), ('Peter', 'CS'), ('Mary', 'Maths'), ('Jane', 'Maths')}

B

works_in = { ('Peter', 'Maths'), ('Mary', 'Maths'), ('Jane', 'Maths')}

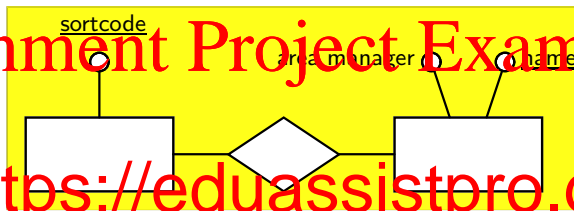
C

works_in = { ('Peter', 'CS'), ('Mary', 'Maths'), ('Jane', 'Maths')}

D

works_in = { ('Peter', 'CS'), ('Jane', 'Maths')}

Quiz 2: Cardinality Constraints on Relationships



*Branches based in towns are all assigned to an area manager for
managers are only assigned to towns that have branches*

What should be the cardinality constraints on

A

$x = 1:1, y = 0:N$

B

$x = 0:1, y = 0:N$

C

$x = 0:N, y = 1:N$

D

$x = 0:1, y = 1:N$

ER^C: Look-Across Cardinality Constraints

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- This course uses **look-here** cardinality constraints: state the number of occurrences of the entity next to the constraint



- Other variants of ER modelling use **look-across** cardinality constraints



- For binary relationships, ER^C and ER^L are equally expressive.

\mathcal{ER}^S : Subset/isa hierarchies

\mathcal{ER}^S

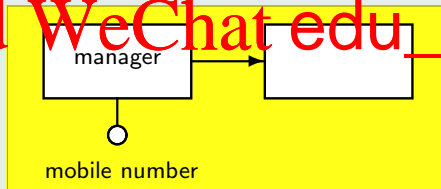
If it is found that the instances of one entity E_s are a subset of another entity E , we may add a **subset** constraint.

$E_s \subseteq E$

■ speci

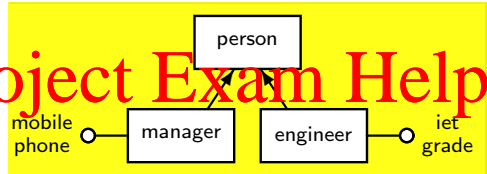
Identify

Some employees are ranked as managers, and receive a mobile number



Quiz 3: Extent of subset and superset entities

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Which is so

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A

```

person = {'Peter', 'Jane', 'Mary'}
engineer = {'Jane', 'Mary'}
  
```

B

```

person = {'Peter', 'Jane', 'Mary'}
engineer = {'Jane', 'Mary'}
  
```

C

```

person = {'Peter', 'Jane', 'Mary'}
engineer = {'John'}
  
```

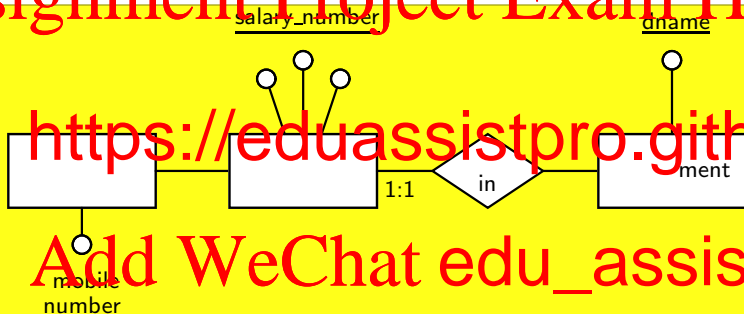
D

```

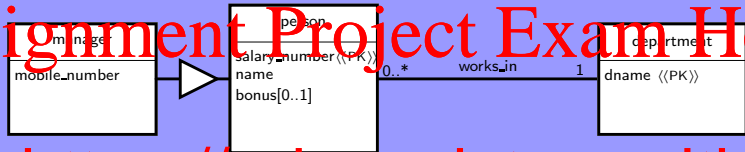
person = {'Peter', 'Jane', 'Mary', 'John'}
engineer = {'Peter', 'John'}
  
```

Combining Fragments

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Using UML Class Diagrams as ER Models



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How to Use UML Class Diagrams as an ER Schema

Use UML stereotypes to denote at least primary key information

Various approaches exist

ER Modelling Constructs *CKLMOS*

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Construct	Description
-----------	-------------

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O

Optional attribute

S

Isa hierarchy between

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A particular ER Modelling language normally chooses between

Worksheet: ER Modelling

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Draw an ER diagram to describe the following domain.

The payroll system for BIG Inc records the salaries, status, joining date, name

Each employee has a unique salary, status, joining date, name, and a record number.

For employees sent abroad by BIG Inc, we record the address, country and telephone number of the foreign tax office that will handle their tax. It is assumed that each country has one central tax office that all employees sent abroad have their tax affairs dealt with by that Revenue.

Worksheet: ER Modelling

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Draw an ER *ER* schema to describe the following domain.

The payroll system for BIG Inc records the *salaries*, *status*, *joining date*, *name* *yees*.

Each *e* *count*
numb *a record*
 the *a*

For *employees sent abroad* by BIG Inc, we record the *address*, *country* and *telephone number* of the *foreign tax office* th

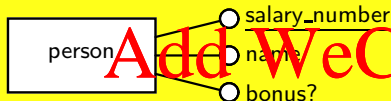
is assumed that each country has one central tax office that
 with. All other employees have their tax affairs dealt with by t
 Revenue.

Mapping \mathcal{ER}^{KLMOS} to a relational model: entities and attributes

Taking a **table per type (TPT)** approach, there is a simple mapping of entities and attributes to tables and columns:

- 1 Each entity E maps to a table R_E
- 2 Each attribute A maps to a column C_A of R_E
- 3 If A is an optional attribute, then C_A is nullable, otherwise C_A is not nullable
- 4 If \vec{K}

Tables gen



perso _____)
 department(dname)

Mapping \mathcal{ER}^{KLMOS} to a relational model: relationships

Taking a **table per type (TPT)** approach, for each relationship R between E_1, E_2 , entities E_1, E_2 map to R_1, R_2 as before, and

1 If R is a many-many relationship then it maps to

1 a table $R_{R_1-R_2}(K_1, K_2)$

2 a foreign key $R_{R_1-R_2}(K_1) \xrightarrow{fk} R_1(K_1)$

3 a f

2 If R is

1 a c

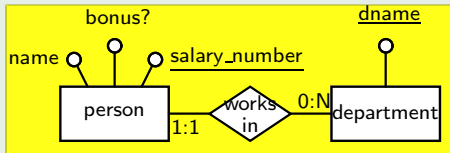
2 a foreign key $R_1(K_2) \xrightarrow{fk} R_2(K_2)$

3 if the participation of E_1 in R is optional, the

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Tables generated from relationships



person(salary_number, name, bonus?, dname)
 department(dname)
 person(dname) \xrightarrow{fk} department(dname)

Mapping \mathcal{ER}^{KLMOS} to a relational model: relationships

Taking a **table per type (TPT)** approach, for each relationship R between E_1, E_2 , entities E_1, E_2 map to R_1, R_2 as before, and

- 1 If R is a many-many relationship then it maps to

- 1 a table $R_{-}R_1_{-}R_2(E_1, E_2)$

- 2 a foreign key $R_{-}R_1_{-}R_2(K_1) \xrightarrow{fk} R_1(K_1)$

- 3 a f

- 2 If R i

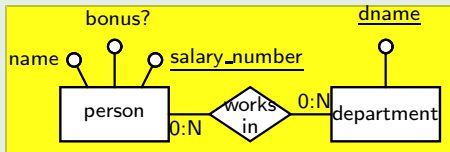
- 1 a c

- 2 a f

- 3 if the participation of E_1 in R is optional, the

 R_1

Tables generated from relationships



pe
department(dname)

works_in(salary_number, dname)

works_in(salary_number)

\xrightarrow{fk} person(salary_number)

works_in(dname) \xrightarrow{fk} department(dname)

Mapping \mathcal{ER}^{KLMOS} to a relational model: subsets

Taking a **table per type (TPT)** approach, for each subset E_s of E , entities E_s, E map to tables R_s, R as before and:

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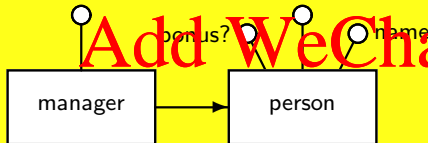
1 a key \vec{K} in R_s (where \vec{K} is the key of R)

2 a foreign $R \xrightarrow{\vec{K}}^{fk} R \xrightarrow{\vec{K}}$

Tables get

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mobile number salary_number



p m us?)
m phone)
-
person(salary_number)

Worksheet: Mapping \mathcal{ER}^{KLMOS} to a relational model

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Take your

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\mathcal{ER}^D : Disjointness and Generalisation Hierarchies

- In \mathcal{ER}^D : the disjointness of entities $E_1 \dots E_n$ may be specified, enforcing that $\forall x, y. x \neq y \rightarrow E_x \cap E_y = \emptyset$
- The notion of **generalisation hierarchies** combines the use of disjointness and subset.
- **disjoint specialisation of nouns** \rightarrow generalisation

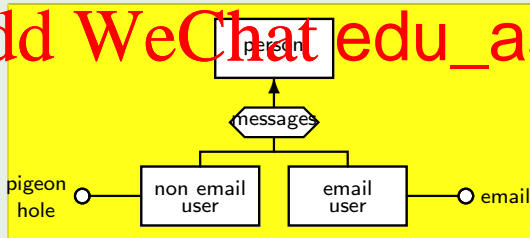
Identifyi

*Employee
email users a*

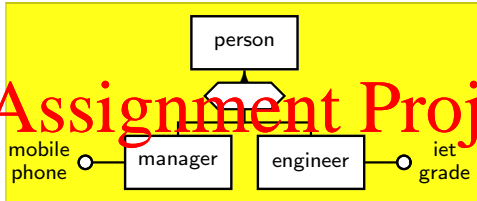
the later must have a pigeon hole number recorded.

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Quiz 4: Extent of generalisation entities



Which is correct?

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A

```

person={ 'Peter', 'Jane', 'Mary', 'John' }
engineer={ 'Peter', 'John' }
manager={ 'Jane', 'Mary' }

```

B

```

person={ 'Peter', 'Jane', 'Mary', 'John' }
engineer={ 'Peter', 'John' }
manager={ 'Jane', 'Mary' }

```

C

```

person={ 'Peter', 'Jane', 'Mary', 'John' }
engineer={ 'John' }
manager={ 'Jane', 'Mary' }

```

D

```

person={ 'Peter', 'Jane', 'Mary', 'John' }
engineer={ 'Peter', 'John', 'Mary' }
manager={ 'Jane', 'Mary' }

```

\mathcal{ER}^W : Weak entities

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- If we allow the participation of an entity in a relationship to be optional, we have a weak entity.

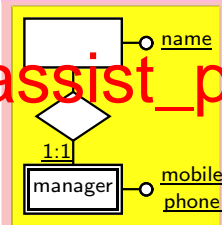
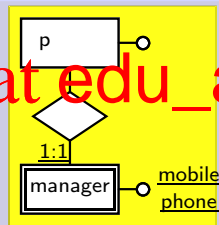
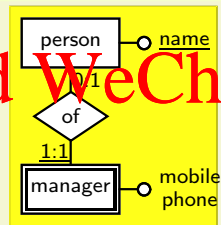
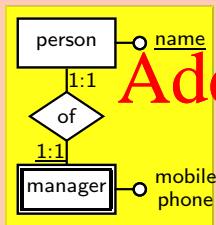
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Quiz 5: Subsets and weak entities



Which of th

A

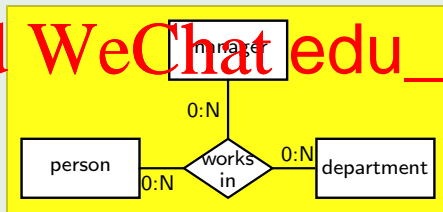


\mathcal{ER}^H : Allowing an n -ary relationship

- In graph theory, an edge connecting more than two nodes is called a **hyper-edge**.
- In \mathcal{ER}^H : Allow n -ary relationships between entities, rather than just binary
- An n -ary relationship is equivalent to a weak entity with n binary relationships

Identifyi

A person *na* works in, the person will be assigned a manager *e person*



Ternary Relationships: Inability to Express Constraints in $\mathcal{ER}^{\mathcal{LH}}$

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*each branch provides only one type of service in a
is only provided one branch in any postcode area*

service

Ternary Relationships: Inability to Express Constraints in $\mathcal{ER}^{\mathcal{CH}}$

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an atm machine from a leasing company may be assigned to a particular site, but banks do not have exclusive use of a

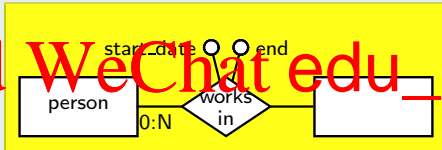
\mathcal{ER}^A : Allowing attributes on relationships

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Identifyi

We record the
leaves, record
department



Quiz 6: Appropriate use of attributes on relationships

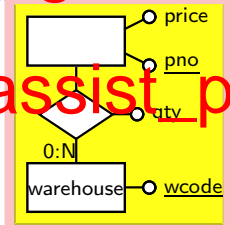
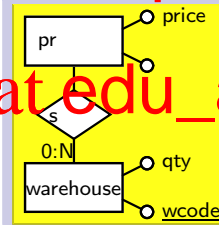
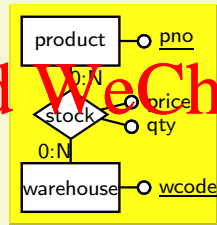
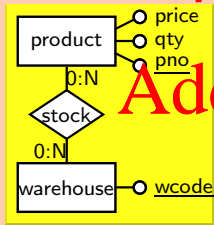
In the stock control system, we identify products by the pno, and keep our stock in a number of warehouses identified by wcode. We record single price of each product and the quantity qty of product we keep in each warehouse.

Which of th

A

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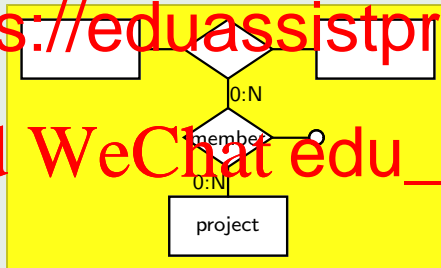
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\mathcal{ER}^N : Allowing nested relationships

Identifying a nested relationship

When a person works in a department, they may work on any number of projects with a certain role. People may take different roles on the project for each department that they wor

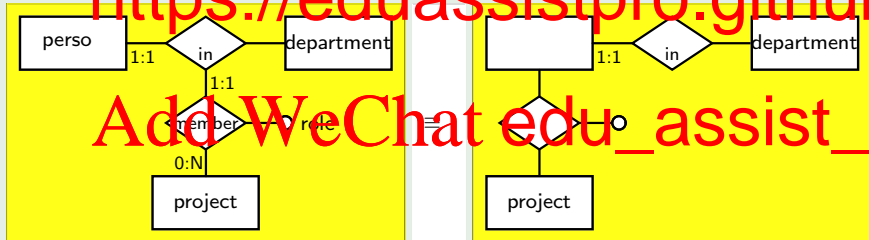


Nested relationship equivalences

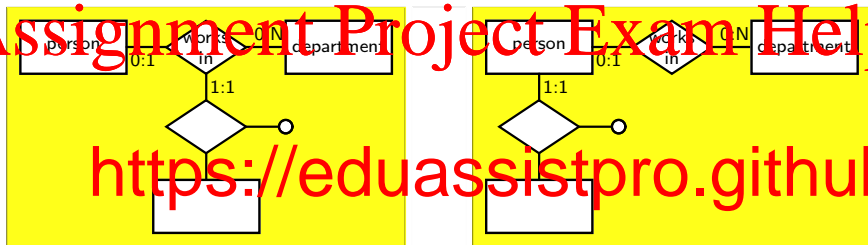
Need for using nested relationships

If a relationship to which a nested edge connects is mandatory and unique with entity E , then the nested relationship can instead connect to E

Equivalence



Quiz 7: Nested relationship equivalences



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Are the two ER schemata equivalent?

True

False

\mathcal{ER}^\vee : Multi-valued Attributes

Multi-valued Attributes

-  A mandatory attribute $E.A$ is a function that maps from entity set E to value set V .



- $E.A \subseteq \{\langle e, v \rangle \mid e \in E \wedge v \in V\}$



- unique: $\langle e, v_1 \rangle \in E.A \wedge \langle e, v_2 \rangle \in E.A \rightarrow v_1 = v_2$

-

adjective

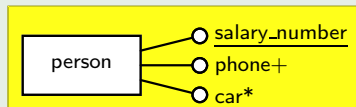
-  an optional attribute

-  a multi-valued attribute removes property (2) 

-  an attribute can be both optional and multi-valued 

Identifying multi-valued attributes

*Each person must have at least one home phone number record
number of cars registered as having access to the car park.*



EER Modelling Constructs $ADHKLMNOSVW$

EER

Define **Extended ER (EER)** modelling language as one that supports $LCMNOS$ plus at least one of $ADHKLVW$

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\mathcal{H} hyper-edges (n -ary relationships) allowed

\mathcal{L} Look-here cardinality cons

\mathcal{K} Key attributes

\mathcal{M} Mandatory attributes

\mathcal{N} Nested relationships

\mathcal{O} Optional attributes

\mathcal{S} Isa hierarchy between entities

\mathcal{V} Multi-valued attributes

\mathcal{W} Weak entities can be identified

Worksheet: Constructing an $\mathcal{ER}^{ADHKLMOSW}$ Schema

The customer and supplier database of Big Inc will hold all accounts of the company, divided into customer accounts and supplier accounts. All accounts have an account number, and one account number assigned from the company's staff. Big Inc identifies staff by a sid, and records the staff member's name and room. The account managers have a limit on the number of accounts they can manage.

Only ce

*For cus
accou*

For sup

at what price.

Big Inc products are identified by the company standard description. For some we record the colour. Some products have components, each component identified by a combination number, and again each has a description. Some products do n

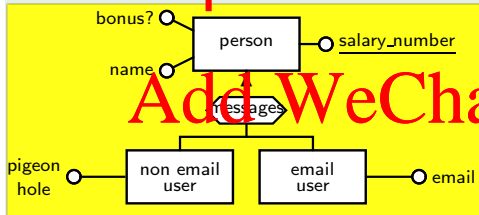
Big Inc has purchased a copy of the Post Office address file, and associates every account to an address from this file. The address data includes street number, street name, town, county and post code, and uses a combination of street number and post code as a key.

Mapping \mathcal{ER}^D to a relational model

Taking a **table per type (TPT)** approach, if E is a generalisation of E_1, \dots, E_n , then entities E_1, \dots, E_n, E map to tables R_1, \dots, R_n, R as before and:

- 1 treat each $E_x \in E_1, \dots, E_n$ as a subset of E
- 2 no imp

Tables get



non bonus?)
 non eon_hole)
 ema
 email_user(salary_number) \xrightarrow{fk} person(salary_number)

Mapping \mathcal{ER}^W to a relational model

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■ If E_W is a weak entity that maps to a relation R_W , the foreign key R_K due to the participation in a relationship is also used in the key of R_K

Tables gen



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person(salary_number, name, bonus?)
 swipe_card(salary_number, issue, date)
 swipe_card(salary_number) \xrightarrow{fk} person(salary_number)

Mapping \mathcal{ER}^W to a relational model

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■ If E_W is a weak entity that maps to a relation R_W , the foreign key R_K due to the participation in a relationship is also used in the key of R_K

Tables gen



person(salary_number, name, bonus?)
 swipe_card(salary_number, issue, date)
 swipe_card(salary_number) \xrightarrow{fk} person(salary_number)

Mapping \mathcal{ER}^H to a relational model

Rules for binary relationship R between E_1, E_2 generalise to rules for R between E_1, \dots, E_n

Tables generated from n -ary entities



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person(salary_number)
manager(salary_number)

manager(salary_number) \xRightarrow{fk} person(salary_number)

department(dname)

works_in(person_salary_number, manager_salary_number, dname)

works_in(person_salary_number) \xRightarrow{fk} person(salary_number)

works_in(manager_salary_number) \xRightarrow{fk} manager(salary_number)

works_in(dname) \xRightarrow{fk} department(dname)

Mapping \mathcal{ER}^A to a relational model

Attributes on Relationships

Attributes of a relationship go on the same table as that which implements the relationship.

Tables gen



person(salary_number)
 department(dname)
 works_in(salary_number, dname, start_date, end_date?)
 works_in(salary_number) $\xrightarrow{f^k}$ person(salary_number)
 works_in(dname) $\xrightarrow{f^k}$ department(dname)

Mapping \mathcal{ER}^A to a relational model

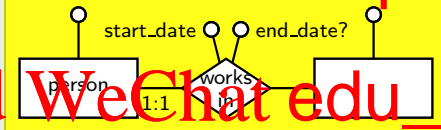
Attributes on Relationships

Attributes of a relationship go on the same table as that which implements the relationship

Tables generated

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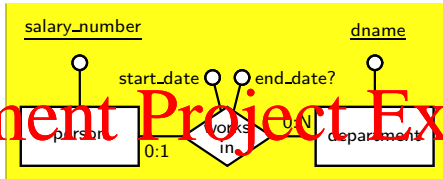
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person(salary_number, dname, start_date, end_date?)

department(dname)

person(dname) $\xrightarrow{f^k}$ department(dname)

Quiz 8: Handling of \mathcal{ER}^A 0:1 cardinality

Which is th

<https://eduassistpro.github.io>

A

```

person(salary_number)
department(dname)
works_in(salary_number, dname, start_date, end_date?)
works_in(salary_number)  $\xRightarrow{fk}$  person(salary_number)
works_in(dname)  $\xRightarrow{fk}$  department(dname)

```

```

perso
depar
works
works
works
works_in(dname)  $\Rightarrow$  department(dname)

```

C

```

person(salary_number, dname, start_date, end_date?)
department(dname)
person(dname)  $\xRightarrow{fk}$  department(dname)

```

D

```

person(salary_number, dname)
department(dname, salary_number, start_date, end_date?)
department(salary_number)  $\xRightarrow{fk}$ 
  person(salary_number)

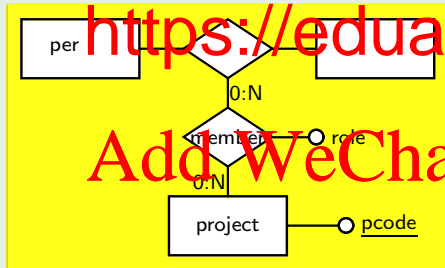
```

Mapping \mathcal{ER}^N to a relational model

Nested Relationships

If relationship R connects to relationship S , (1) map S as normal, (2) when mapping R , treat S as if it were an entity, and apply the normal rules for mapping R .

Mapping



pr
w
w

works_in(dname) department(dname)

member(pcode, salary_number, dname, role)

member(salary_number, dname) $\xRightarrow{f^k}$ works_in(salary_number, dname)

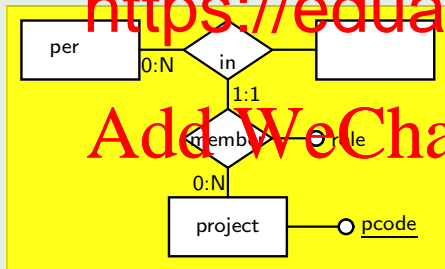
member(pcode) $\xRightarrow{f^k}$ project(pcode)

Mapping \mathcal{ER}^N to a relational model

Nested Relationships

If relationship R connects to relationship S (1) map S as normal, (2) when mapping R , treat S as if it were an entity, and apply the normal rules for mapping R .

Mapping



department(dname)

pr

w

w

w

de,role)

works_in(dname) \xRightarrow{fk} department(dname)

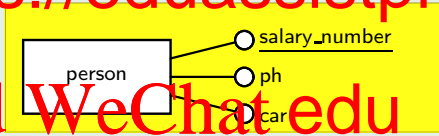
works_in(pcode) \xRightarrow{fk} project(pcode)

Mapping \mathcal{ER}^v to a relational model

Multi-valued Attributes

Each multi-valued attribute $E.A_v$ is stored in its own table RA_v , together with the key attributes of the table R used to represent the entity R .
 All attributes of RA_v form the key of RA_v , and there is a foreign key from RA_v to R .
 No efficient method of representing + constraint

Tables for



$\text{person}(\underline{\text{salary_number}})$
 $\text{person_phone}(\underline{\text{salary_number}}, \text{phone})$
 $\text{person_phone}(\text{salary_number}) \xRightarrow{fk} \text{person}(\text{salary_number})$
 $\text{person_car}(\underline{\text{salary_number}}, \text{car})$
 $\text{person_car}(\text{salary_number}) \xRightarrow{fk} \text{person}(\text{salary_number})$

Worksheet: Mapping $\mathcal{ER}^{ADHKLMOSWN}$ to a relational model

Assignment Project Exam Help

*Take your
schema.*

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