Logical design

Logical design

Logical design is a process of transforming a conceptual schema to the data model corresponding to a DBMS tool

- represents a **mapping** from an ER model to a Relational Model
- some CASE tools create schema graphically and automatically generate DDL from ER-models.

Algorithm for ER-to-relational mapping transforms:

- Entity types (strong and weak)
- Attributes
- Binary relationships
- n-ary relationships and other constraints

ER model to a Relational Model

- an entity set corresponds to a relation schema
- an entity corresponds to a tuple
- a relationship can be expressed using foreign keys

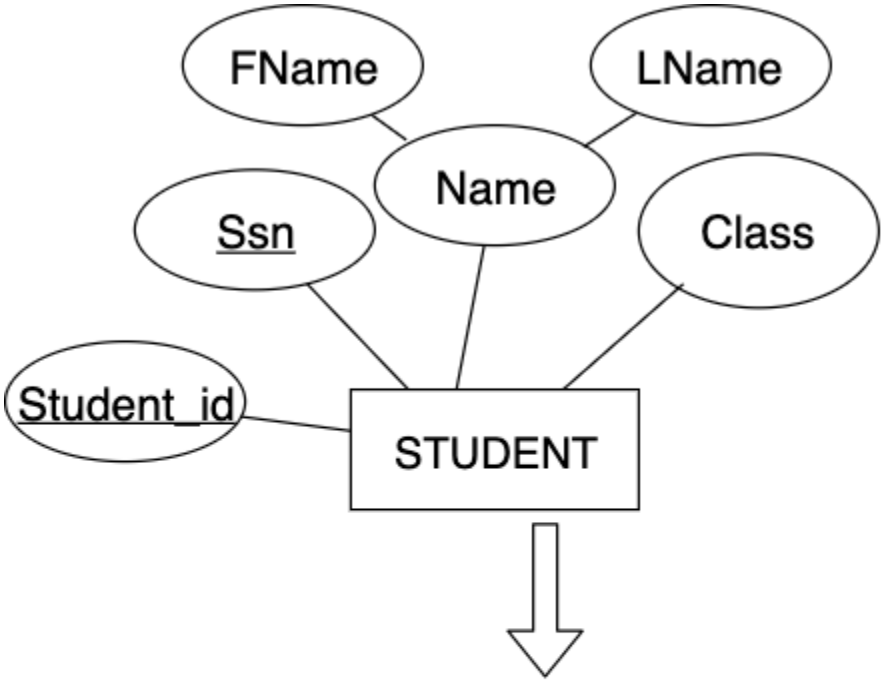
The following slides present a mapping algorithm in 8 steps.

1. Mapping of Entity types

The algorithm creates for each strong entity type E a relation R

- relation R includes all simple attributes of E
- simple component attributes of a composite attribute are mapped to attributes of R
- *one key* of E is chosen to be the primary key of R
- knowledge about other keys is useful to specify secondary unique keys for indexes

Mapping of Entity types - example



STUDENT(Student_id, Ssn, FName,LName, Class)

STUDENT

Student_id	Ssn	FName	LName	Class
1	123-45-6789	John	Brown	1
2	050-42-3729	Christine	Smith	2

2. Mapping of weak entity types

For each weak entity type W with an owner type E algorithm creates a relation R with

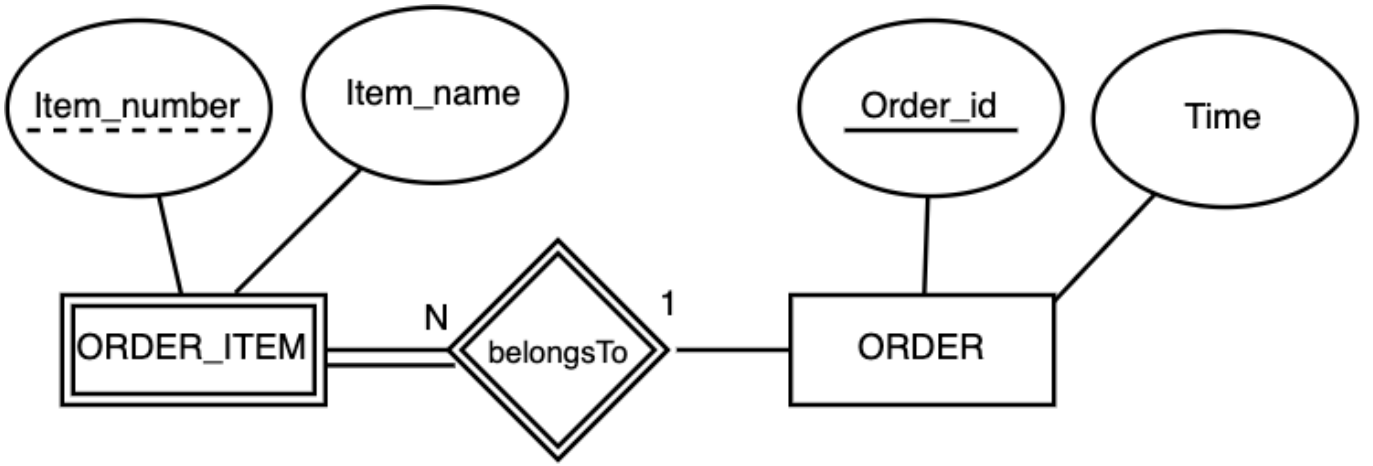
- simple attributes (and simple parts of composite attributes) of the weak entity type W as attributes of R
- a foreign key in R that points to the primary key of the relation corresponding to E (we can call this relation S). This foreign key implements the identifying relation
- primary key of R comprised of the foreign key to the primary key of the relation corresponding E and partial key of W

The owner of the weak entity (E) should be mapped before the weak entity (W) in order to have its primary key already determined.

propagate (CASCADE) is common as a referential triggered action on the foreign key of R

- ON UPDATE CASCADE ON DELETE CASCADE

Mapping of the weak entity - example



ORDER_ITEM(Order_id, Item_number, Item_name)

ORDER(Order_id, Time)

foreign key (Order_id) references ORDER(Order_id)

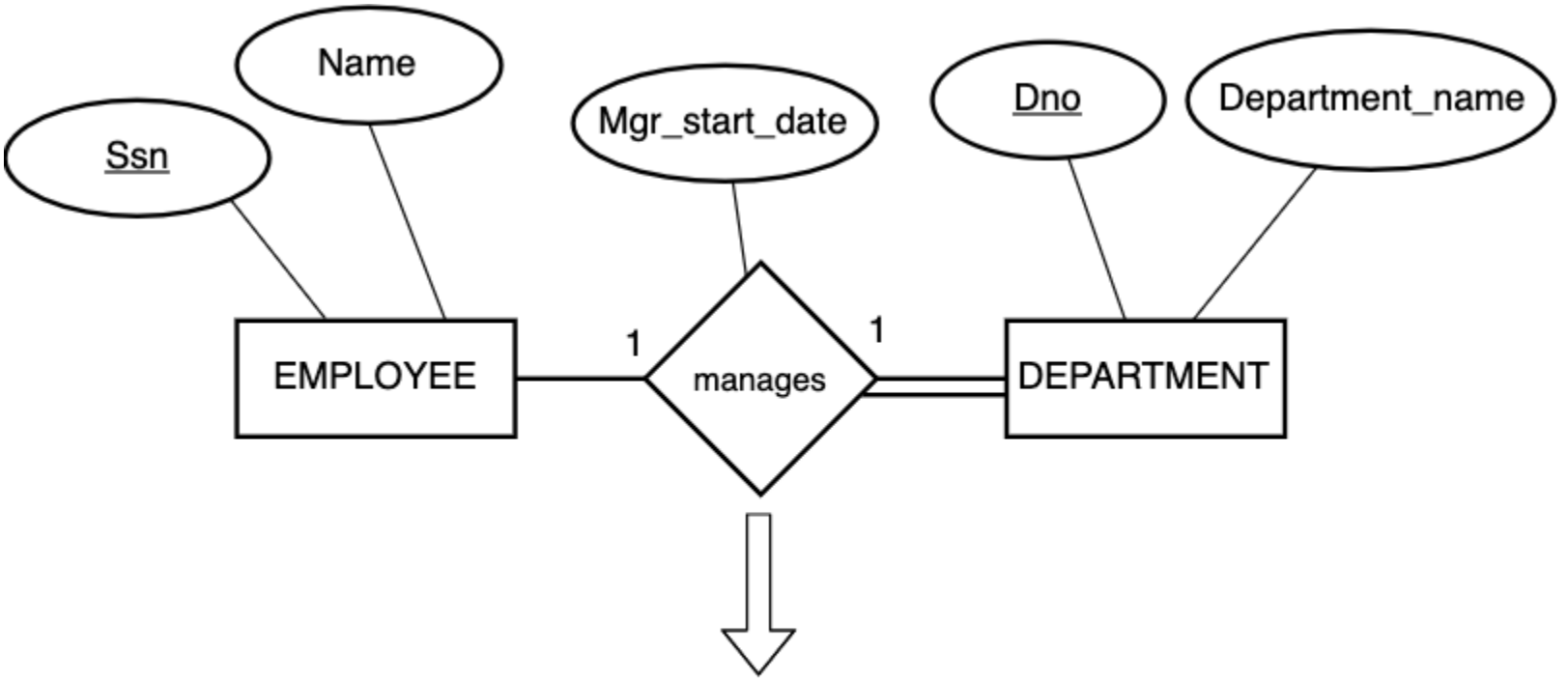
primary key (Order_id, Item_number)

3. Mapping of 1:1 Binary Relationship Type

Three possible approaches (the first approach is used whenever it's possible):

1. **foreign key** approach
   - a relation to one of the participating entities in the relationship gets a foreign key to the primary key of relation corresponding to the other entity
   - foreign key placed on the side with total participation
   - uniqueness of the foreign key must be ensured
2. merged relation approach
   - merging the two entity types and the relationship into a single relation
   - applicable only in the case when both participations are total
3. relationship relation approach
   - a new *relationship relation* (lookup table) - created with primary keys of the corresponding entities as its foreign keys.
   - only one of foreign keys is a primary key of the lookup table

Mapping of 1:1 Binary Relationship Type - example



EMPLOYEE(Ssn, Name)

DEPARTMENT(Dno, Department_name, **Mgr_ssn,**
Mgr_start_date)

unique foreign key (Mgr_ssn) references EMPLOYEE(Ssn)

4. Mapping of Binary 1:N Relationship Type

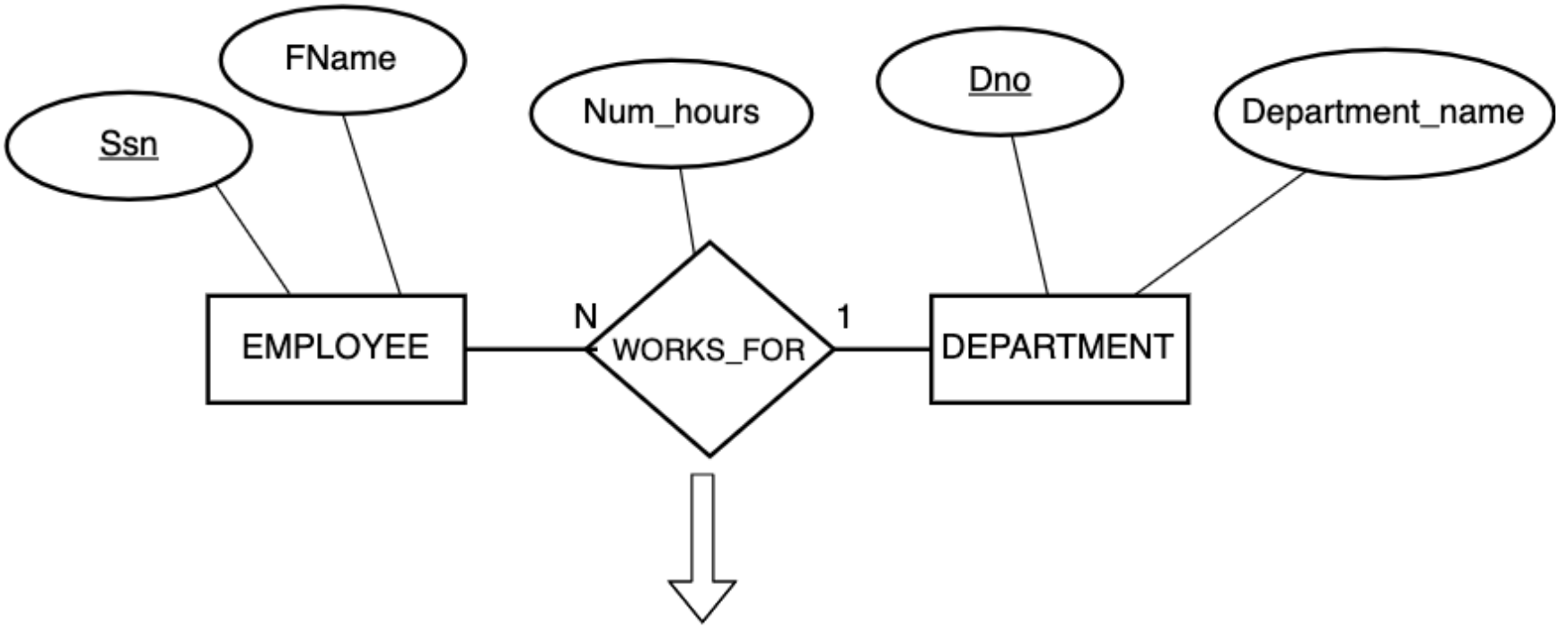
Relation which corresponds to the entity type on the N side of the relationship is changed:

- primary key of the second relation is included as a foreign key
- all simple attributes of the 1:N Relationship are included in this relation

Alternative option (used rarely)

- creating a new relationship relation (lookup table) as in the case of 1:1 relationships.
- used when only few tuples participate in the relationship to avoid excessive NULLs

Mapping of Binary 1:N Relationship Type - example



EMPLOYEE(Ssn, FName, Dno, Num_hours)

DEPARTMENT(Dno, Department_name)

foreign key (DNo) references DEPARTMENT(DNo)

5. Mapping of Binary M:N Relationship Type

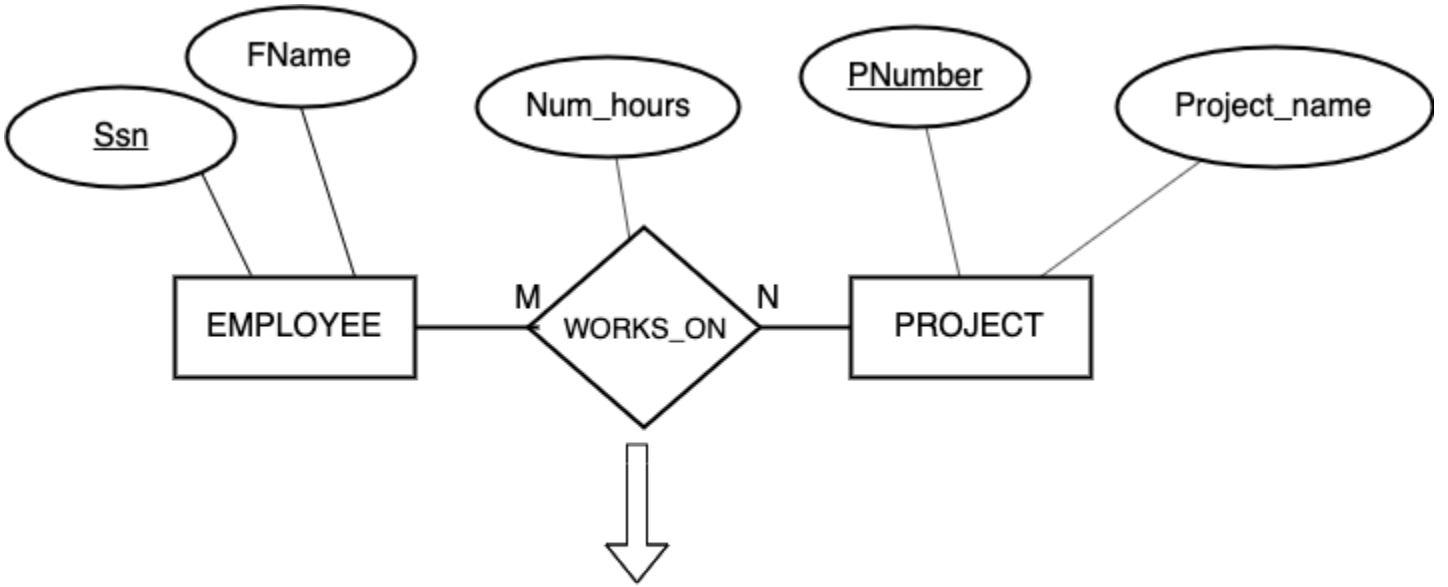
A new relationship relation which corresponds to the relationship type is created and within that relation:

- included as a foreign key the primary keys of the relations that represent the participating entity types.
- *combination* of foreign keys created a primary key of the relationship relation
- all simple attributes of the M:N Relationship type are included in this relation

Propagation (CASCADE) for the referential triggered action on the foreign keys is common in the relationship relation

- ON UPDATE CASCADE ON DELETE CASCADE

Mapping of Binary M:N Relationship Type - example



WORKS_ON(Essn, PNo, Num_hours)

EMPLOYEE(Ssn, FName)

PROJECT(PNumber, Project_name)

– foreign key (PNo) references PROJECT(PNumber)

– foreign key (Essn) references EMPLOYEE(Ssn)

– primary key (Essn, PNo)

6. Mapping of Multivalued Attributes

A new relation is created for each multivalued attribute

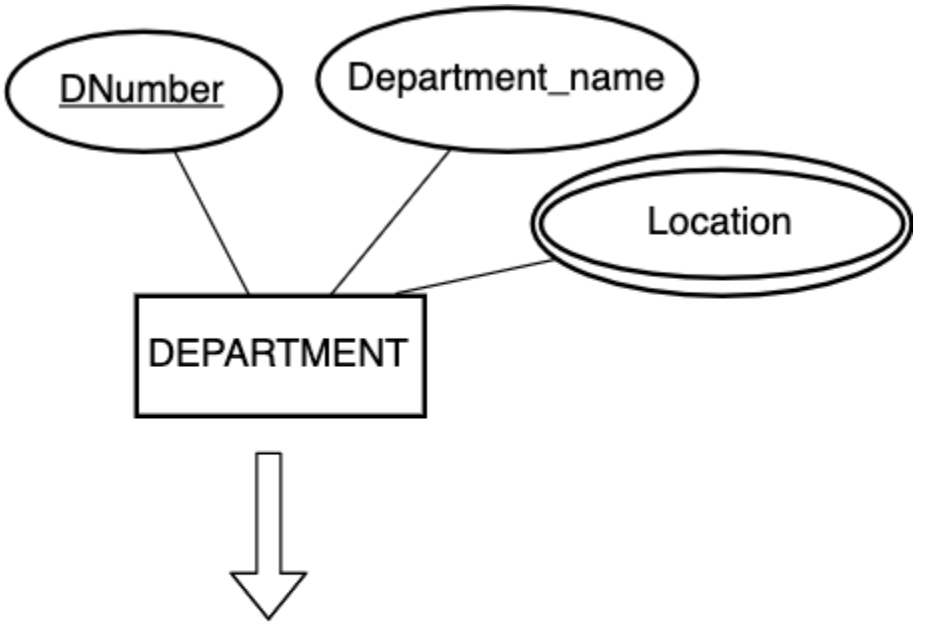
- included as foreign key the primary key of the relation which corresponds to the basic entity type of the multivalued attribute
- primary key is comprised of the foreign key to the basic entity and the attribute which corresponds to multivalued attribute
- included simple components if the multivalued attribute is composite

Propagate (CASCADE) for the referential triggered action on the foreign keys is common in the relation

- ON UPDATE CASCADE ON DELETE CASCADE

When the multivalued attribute is composite only some of the component attribute should be part of the primary key (multivalued attributes correspond to weak entity types)

Mapping of Multivalued Attributes - example



DEPT_LOCATION (DNo, Location)

DEPARTMENT(DNumber, Department_name)

foreign key (DNo) references DEPARTMENT(DNumber)

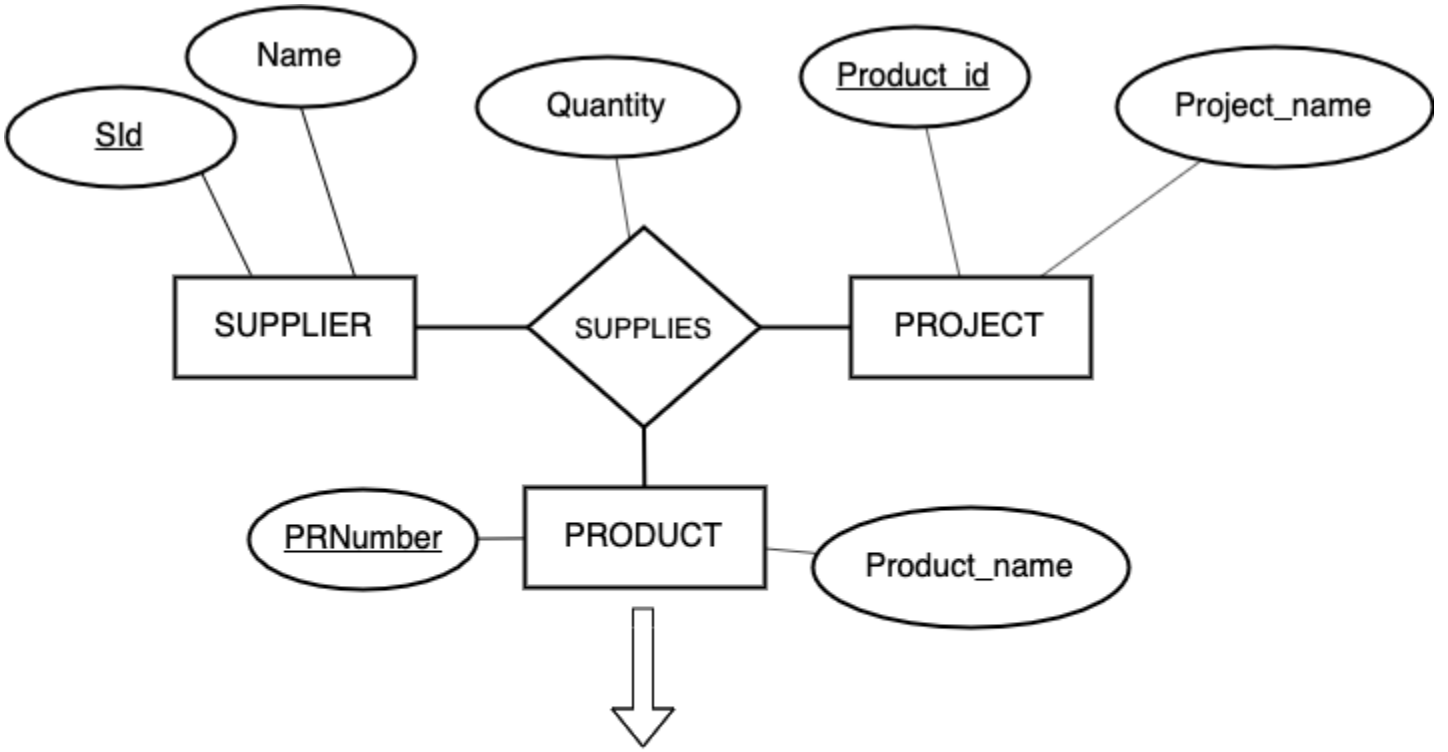
primary key (DNo, Location)

7. Mapping of n-ary Relationship Types

Situation is similar to M:N Relationship types. A new relation is created with

- primary keys of the relations representing participating entity types are included as foreign key attributes
- included simple attributes and simple components of composite attributes of the relationship type
- primary key is *usually* a *combination* of all the foreign keys
  - exception - if one of entity types participates with the cardinality constraint 1 than corresponding foreign key is excluded form the primary key

Mapping of n-ary Relationship Types - example



SUPPLIES(SId, PNo, PRNo, Quantity)

SUPPLIER(SId, Name)

PROJECT(PNumber, Project_name)

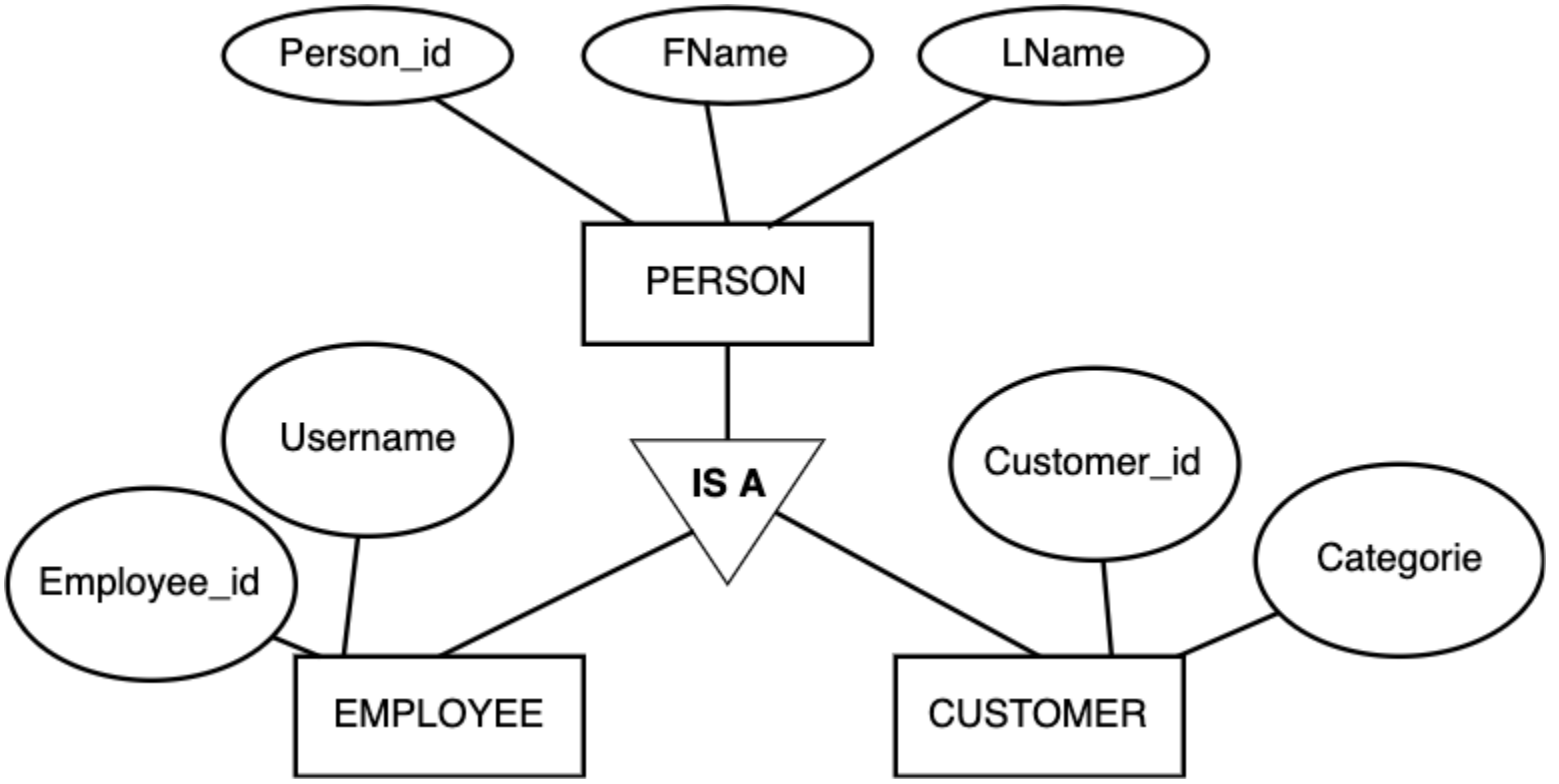
PRODUCT(PRNumber, Project_name)

8. Mapping Generalization/Specialization

Three appraches:

1. Multiple relations - superclass and subclasses
   - primary key of subclasses is the same as primary key of the superclass
2. Multiple relations - subclass only
   - only in those cases when each attribute of the superclass belongs to some subclass
   - recommended when subclasses are disjoint
3. Single relation with one or more discriminating attributes
   - **type** or **discriminating** attribute whose value indicates which subset the tuple belongs to
   - only when subclasses are disjoint
   - potential for generating many null values

Generalization example



Generalization - superclass and subclasses

PERSON

Person_id	Name
1	John Brown
2	Christine Smith
3	Leslie Connor
7	Larissa Doe
5	Leslie Doe

EMPLOYEE

Person_id	Employee_id	Username
1	7	jbrown
2	12	csmith
3	18	lconnor

CUSTOMER

Person_id	Customer_id	Categorie
7	101	A
2	170	B
5	171	A

There exist relations for all entities

- Person_id is the primary key in all relations.
- Data retrievals require more join operations.

Generalization - only subclasses

EMPLOYEE

Person_id	Employee_id	Name	Username
1	7	John Brown	jbrown
2	12	Christine Smith	csmith
3	18	Leslie Connor	lconnor

CUSTOMER

Person_id	Customer_id	Name	Categorie
7	101	Larissa Doe	A
2	170	Christine Smith	B
5	171	Leslie Doe	A

Relation corresponding to the person entity type doesn't exist.
Attribute Person_id is the primary key for both relations.

Generalization - single relation

PERSON

Person_id	Employee_id	Name	Username	Categorie	Customer_id	TYPE
1	7	John Brown	jbrown	NULL	NULL	E
3	18	Leslie Connor	lconnor	NULL	NULL	E
5	NULL	Leslie Doe	NULL	A	171	C
7	NULL	Larissa Doe	NULL	A	101	C

Only single relation corresponding to all entity types

- relation contains many null values and is not easy for maintenance
- one attribute is the type attribute
  - in the example the value E represents an employee and value C represents a customer

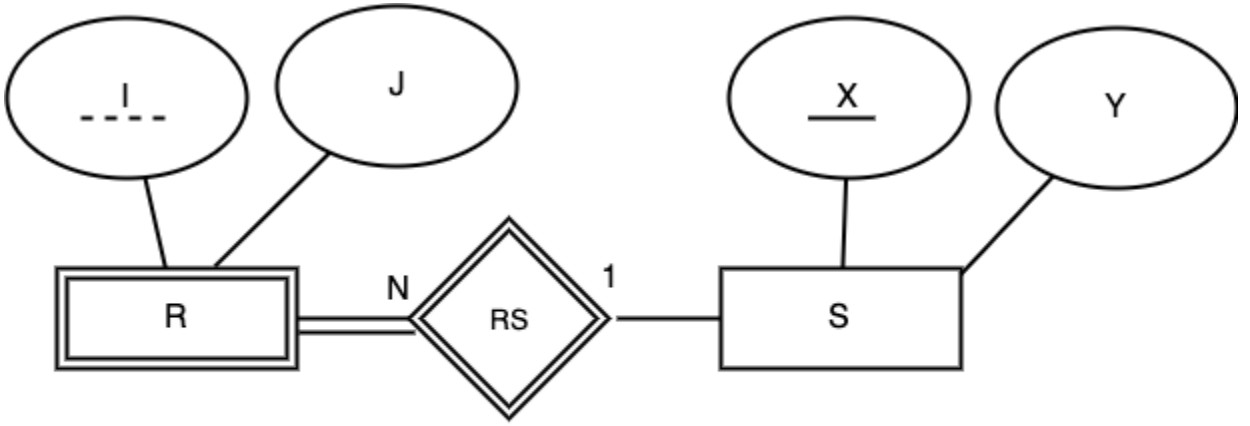
Summary

Mapping of elements

- Entity type → Entity relation
- 1:1, 1:N relationship type → One foreign key (or relationship relation)
- M:N relationship type → Relationship relation and two foreign keys
- n-ary relationship type → Relationship relation and n foreign keys
- Multivalued attribute (and weak entity) → Relation and foreign key
- Simple attribute → Attribute
- Key attribute → Primary (or secondary) key
- Generalization → Multiple relations (or combination of all attributes in a single relation)

Review questions

What is wrong with the following logical database mapping?



R(I, J)

S(X, Y)