International University, VNU-HCMC

School of Computer Science and Engineering

Lecture 3:
ER – Relational Translation

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Acknowledgement

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- The following slides have been created by adapting materials from the [GUW] book provided by the authors, Prof. Jeffrey D. Ullman and others.
- Other slides are referenced from Northeastern University and Duke University.

Purpose of the Lecture

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- To explain how to translate Entity–Relationship (ER) models into Relational Schemas.
- To provide a step-by-step method for mapping entities, attributes, and relationships.
- To ensure students can design relational databases that accurately represent real-world requirements.

Warm-up Question

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- Why do we need to translate an ER diagram into a relational model?

Outlines

- Introduction
- Mapping Rules Overview
- Detailed Mapping Cases
- Examples

ER model: review

Design ERD

- Notation
- Entity/ Weak entity
- Attributes
- Relationship
  - ○ Attributes on relationships
  - ○ Multiplicity
  - ○ Binary versus n-ary relationships
  - ○ ISA relationships

Example

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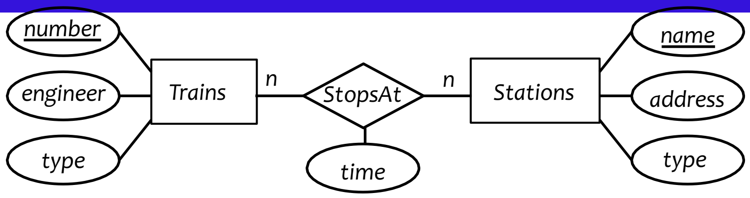

You designed an ER digram

Translate it to a Relational Database

Train (number, engineer, type)
Station (name, address, type)
TrainStop (train_number, station_name, time)

Introduction

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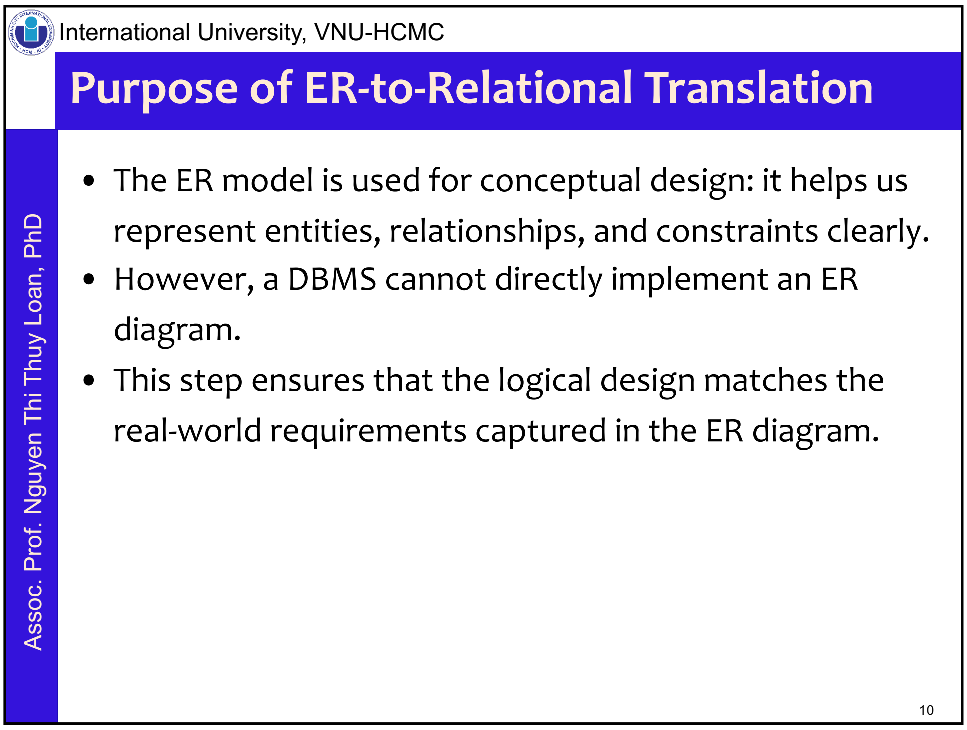
- Purpose of ER-to-Relational Translation
- Role in Database Design Process



Purpose of ER-to-Relational Translation

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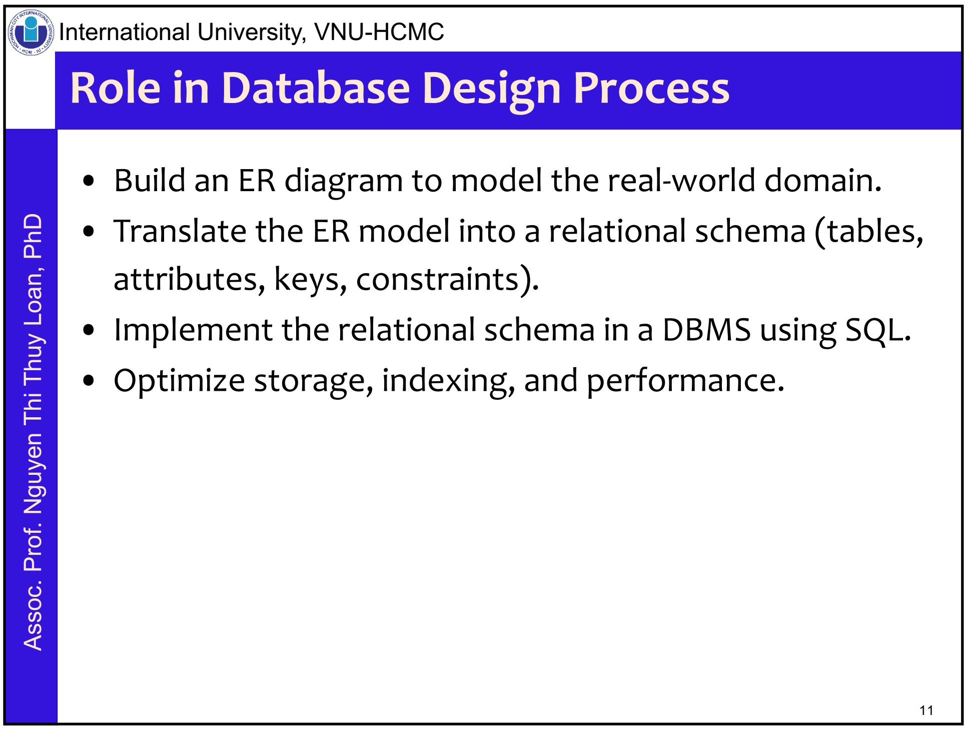
- The ER model is used for conceptual design: it helps us represent entities, relationships, and constraints clearly.
- However, a DBMS cannot directly implement an ER diagram.
- This step ensures that the logical design matches the real-world requirements captured in the ER diagram.



Role in Database Design Process

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- Build an ER diagram to model the real-world domain.
- Translate the ER model into a relational schema (tables, attributes, keys, constraints).
- Implement the relational schema in a DBMS using SQL.
- Optimize storage, indexing, and performance.

Mapping Rules Overview

Step 1: Regular Entity Types

Create a relation (Table)

- For each strong entity type, make a table.
- Include all simple attributes (including simple attributes of composite relations).

Choose a primary key

- Pick one key attribute as the primary key.
- If the key is composite, use all its simple attributes together.

Keep other keys unique

- Any other key attributes become secondary unique keys.
- These are useful for indexing and faster queries.

Step 2: Weak Entity Types

Create a Relation (Table)

- For each weak entity, make a table.
- Include all its simple attributes.

Add Foreign Key

- Insert the primary key of the owner entity as a foreign key in this table.

Define Primary Key

- The primary key of the weak entity table is:
  - The owner's primary key (from the foreign key), plus
  - The partial key of the weak entity (if it exists).

Step 3: Mapping Binary 1-to-1

Choose One Relation as "S"

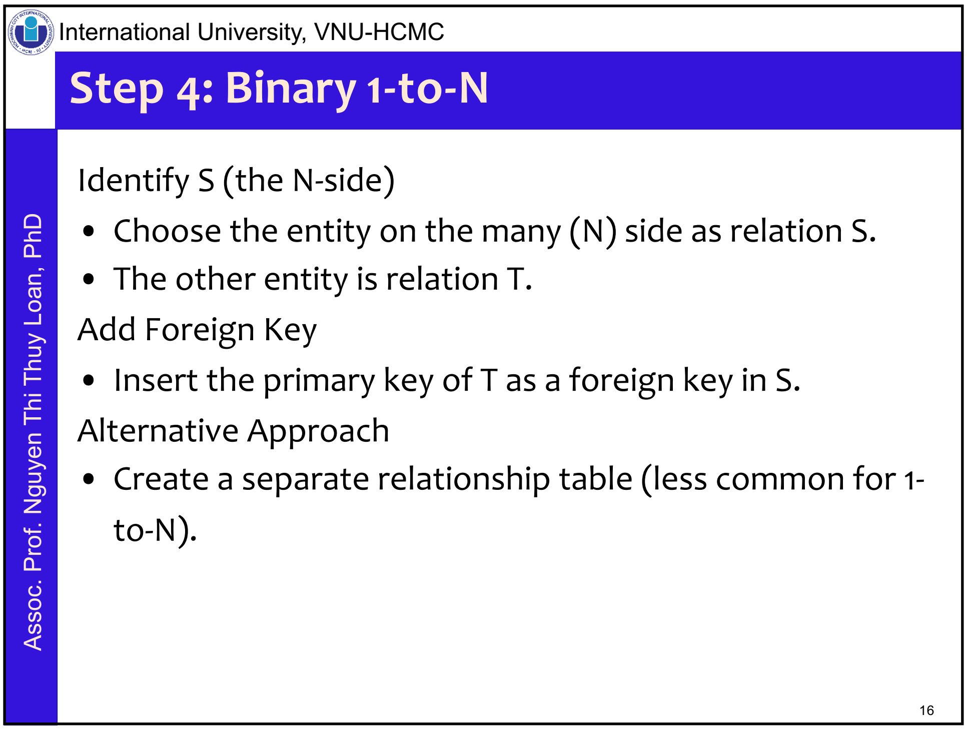
- The other relation is "T".
- Prefer S if it has total participation (reduces NULL values).

Add Relationship Attributes

- Put all the simple attributes of the relationship into S.

Add Foreign Key

- Insert the primary key of T as a foreign key in S.



Step 4: Binary 1-to-N

Identify S (the N-side)

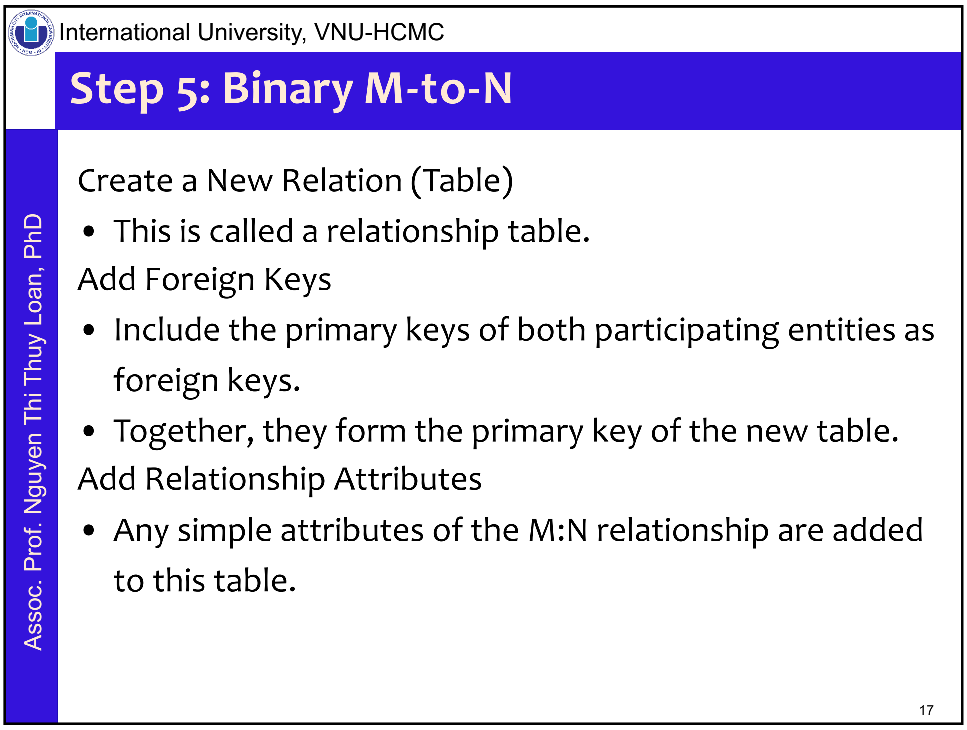
- Choose the entity on the many (N) side as relation S.
- The other entity is relation T.

Add Foreign Key

- Insert the primary key of T as a foreign key in S.

Alternative Approach

- Create a separate relationship table (less common for 1-to-N).



Step 5: Binary M-to-N

Create a New Relation (Table)

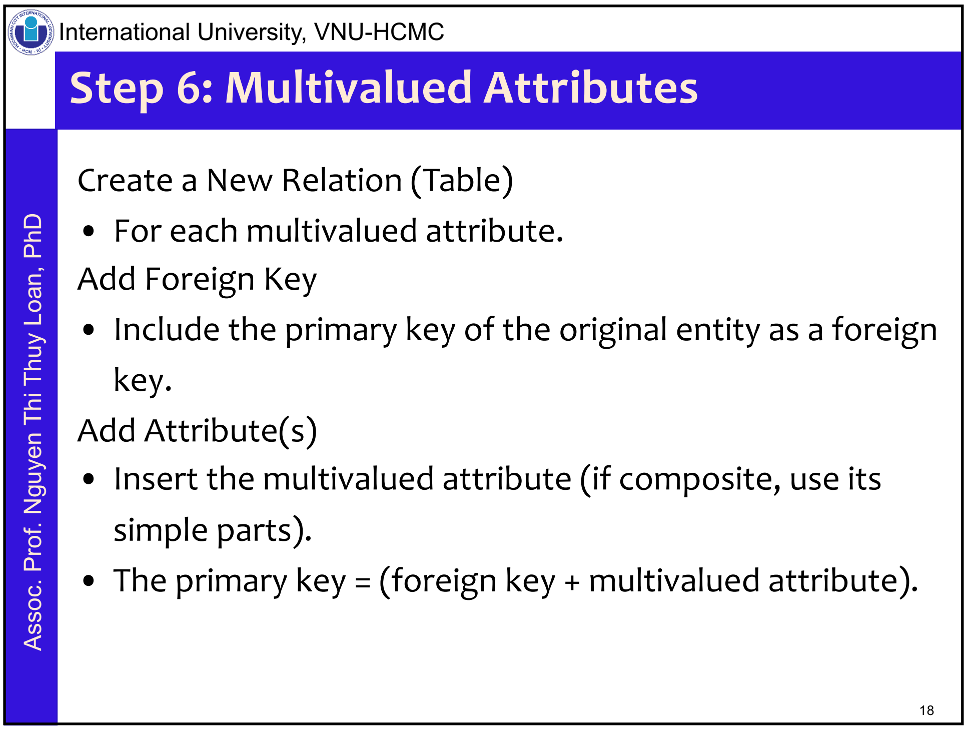
- This is called a relationship table.

Add Foreign Keys

- Include the primary keys of both participating entities as foreign keys.
- Together, they form the primary key of the new table.

Add Relationship Attributes

- Any simple attributes of the M:N relationship are added to this table.



Step 6: Multivalued Attributes

Create a New Relation (Table)

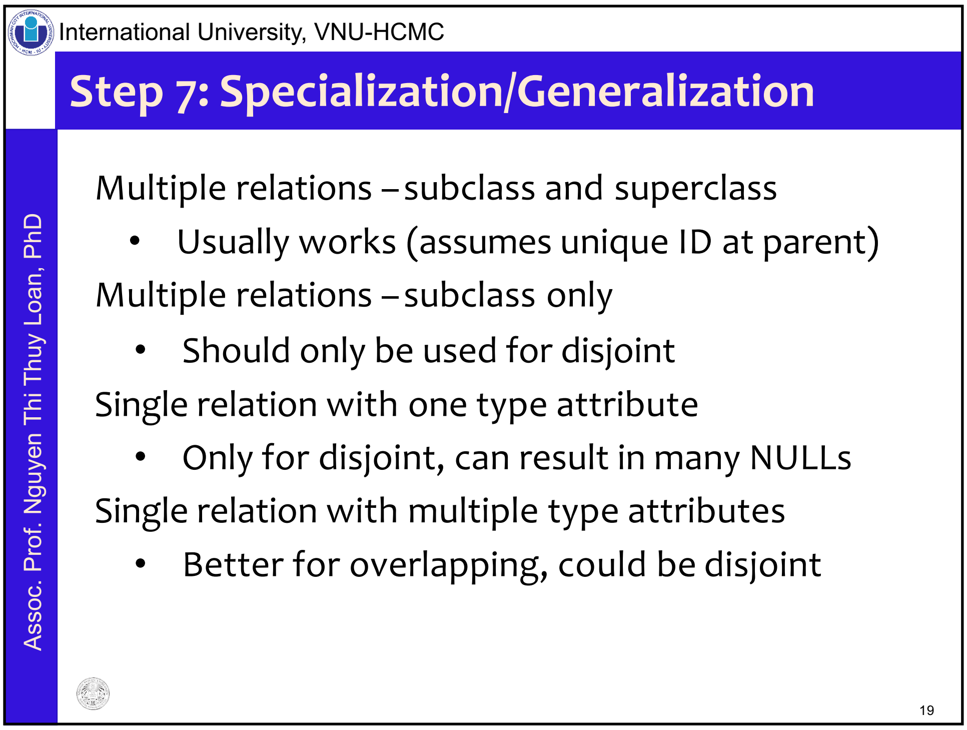
- For each multivalued attribute.

Add Foreign Key

- Include the primary key of the original entity as a foreign key.

Add Attribute(s)

- Insert the multivalued attribute (if composite, use its simple parts).
- The primary key = (foreign key + multivalued attribute).



Step 7: Specialization/Generalization

Multiple relations – subclass and superclass

- Usually works (assumes unique ID at parent)

Multiple relations – subclass only

- Should only be used for disjoint

Single relation with one type attribute

- Only for disjoint, can result in many NULLs

Single relation with multiple type attributes

- Better for overlapping, could be disjoint

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Detailed Mapping Cases

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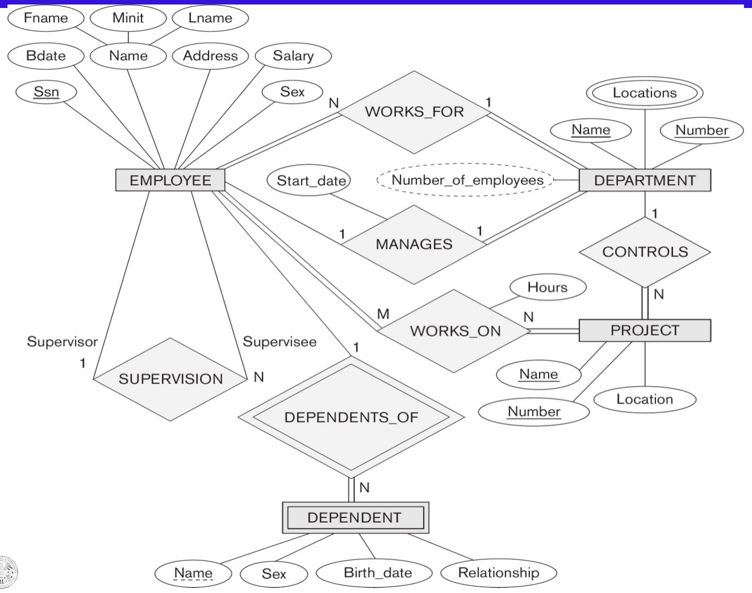
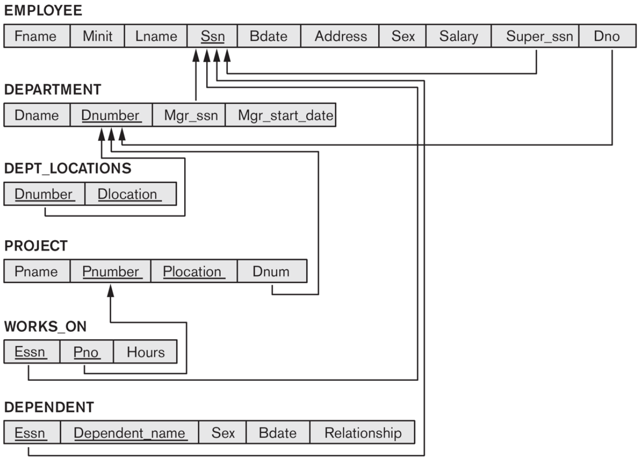
Detailed Mapping Cases



Resulting Relational Schema



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Step 1: Regular Entity Types

Create a relation (Table)

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Choose a primary key

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Keep other keys unique

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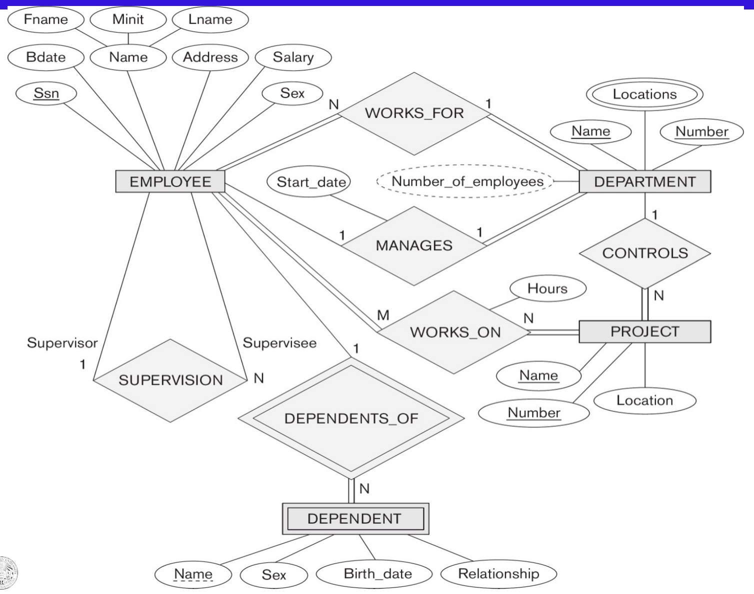
Detailed Mapping Cases



Step 1 Result

EMPLOYEE

Fname	Minit	Lmane	<u>Ssn</u>	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	<u>Dnumber</u>

PROJECT

Pname	<u>Pnumber</u>	Plocation

Step 2: Weak Entity Types

Create a Relation (Table)

- For each weak entity, make a table.
- Include all its simple attributes.

Add Foreign Key

- Insert the primary key of the owner entity as a foreign key in this table.

Define Primary Key

- The primary key of the weak entity table is:
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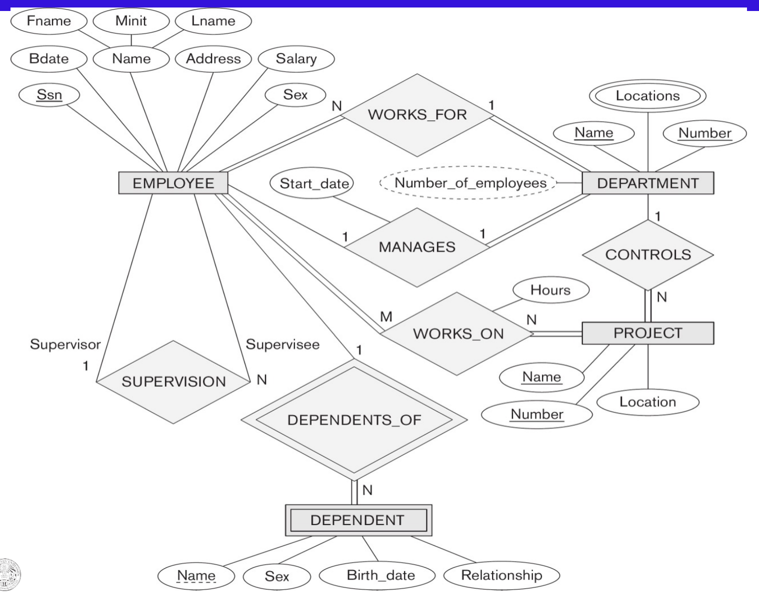
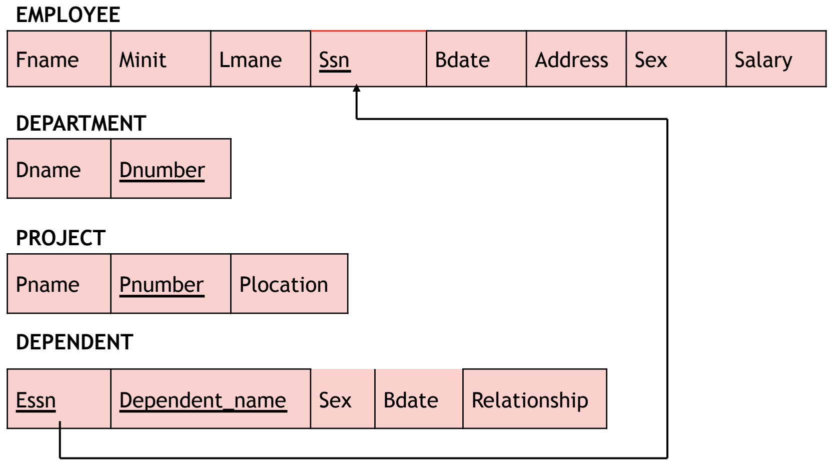
Detailed Mapping Cases



Step 2 Result



EMPLOYEE

Fname	Minit	Lmane	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber

PROJECT

Pname	Pnumber	Plocation

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Step 3: Mapping Binary 1-to-1

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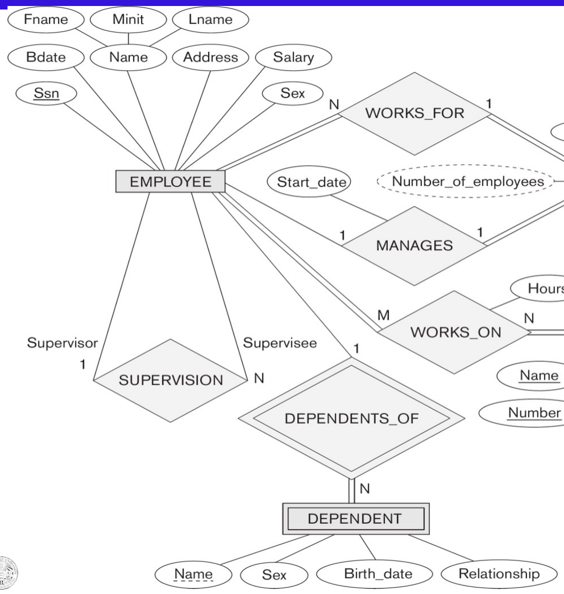


Step 2 Result

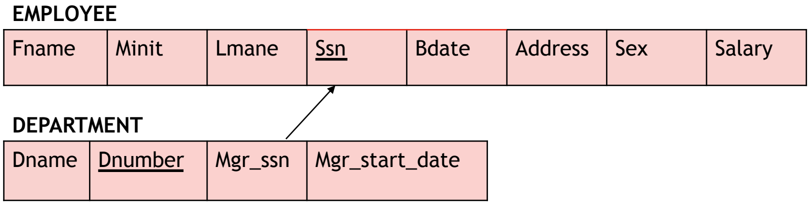
EMPLOYEE

Fname	Minit	Lname	<u>Ssn</u>	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	<u>Dnumber</u>

Step 3 Result



EMPLOYEE

Fname	Minit	Lmane	Ssn	Bdate	Address	Sex	Salary

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

Step 4: Binary 1-to-N

Identify S (the N-side)

- Choose the entity on the many (N) side as relation S.
- The other entity is relation T.

Add Foreign Key

- Insert the primary key of T as a foreign key in S.

Alternative Approach

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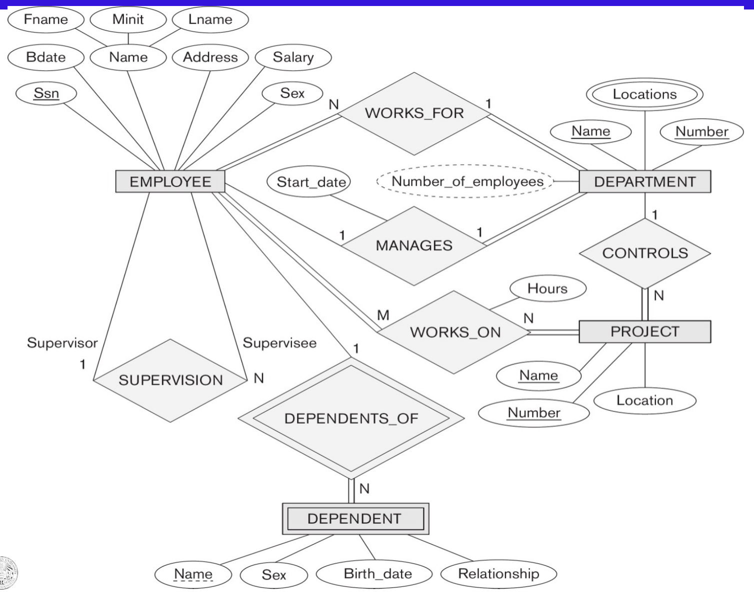
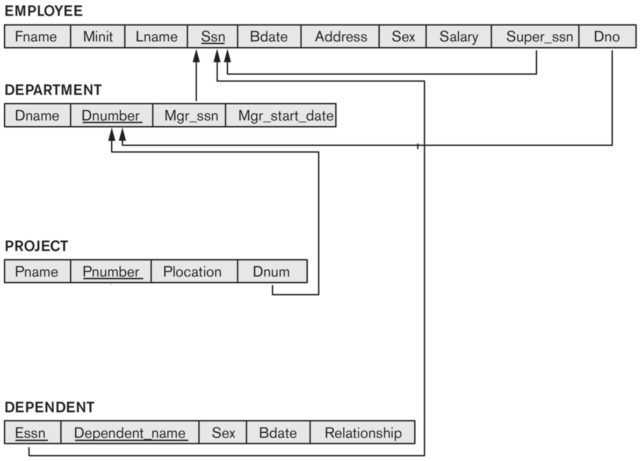
Detailed Mapping Cases



Step 4 Result



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

PROJECT

Pname	Pnumber	Plocation	Dnum

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Step 5: Binary M-to-N

Create a New Relation (Table)

- This is called a relationship table.

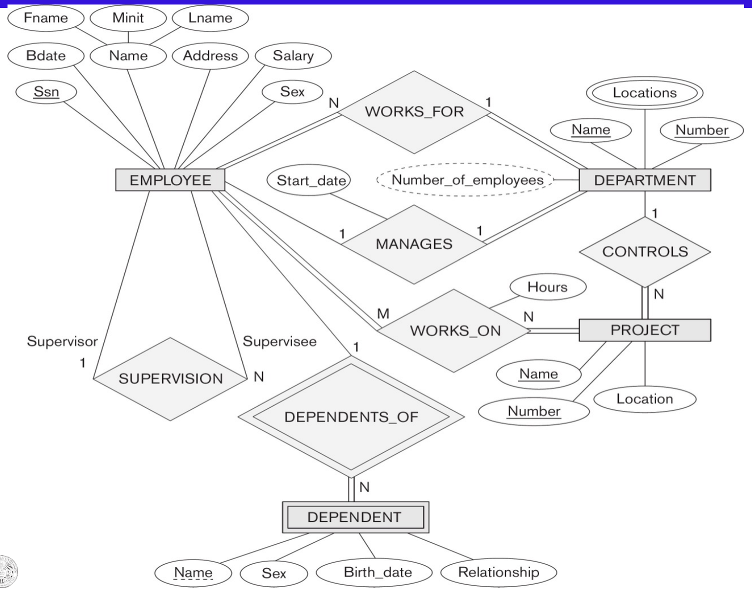
Add Foreign Keys

- Include the primary keys of both participating entities as foreign keys.
- Together, they form the primary key of the new table.

Add Relationship Attributes

- Any simple attributes of the M:N relationship are added to this table.

Detailed Mapping Cases



Step 5 Result

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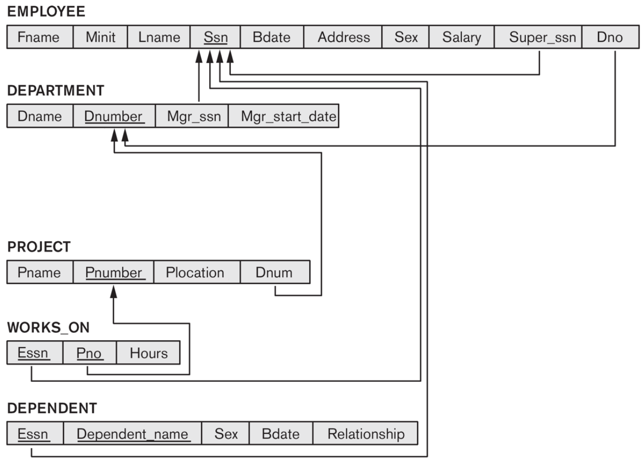

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Step 6: Multivalued Attributes

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Create a New Relation (Table)

- For each multivalued attribute.

Add Foreign Key

- Include the primary key of the original entity as a foreign key.

Add Attribute(s)

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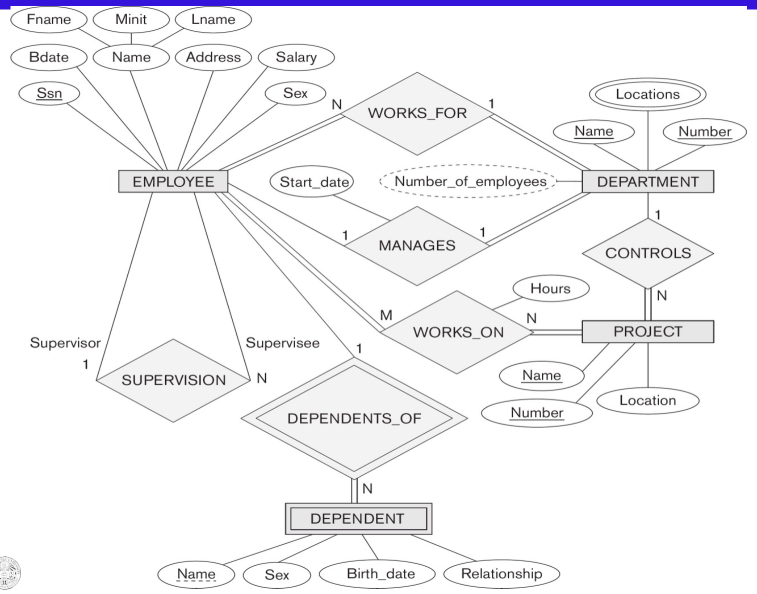
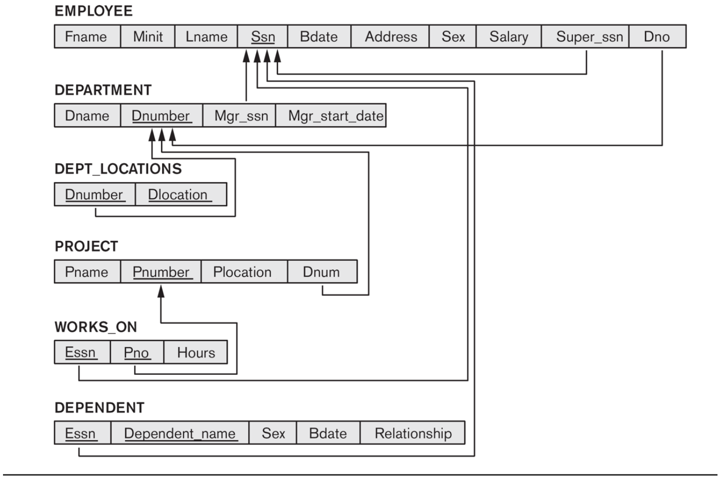
Detailed Mapping Cases



Step 6 Result



EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	Dno

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date

DEPT_LOCATIONS

Dnumber	Dlocation

PROJECT

Pname	Pnumber	Plocation	Dnum

WORKS_ON

Essn	Pno	Hours

DEPENDENT

Essn	Dependent_name	Sex	Bdate	Relationship

Step 7: Specialization/Generalization

Multiple relations – subclass and superclass

- Usually works (assumes unique ID at parent)

Multiple relations – subclass only

- Should only be used for disjoint

Single relation with one type attribute

- Only for disjoint, can result in many NULLs

Single relation with multiple type attributes

- Better for overlapping, could be disjoint

Specialization/Generalization (A)

Multiple relations – subclass and superclass

Usually works (assumes unique ID at parent)

(a) EMPLOYEE

Ssn	Fname	Minit	Lname	Birth_date	Address	Job_type

SECRETARY

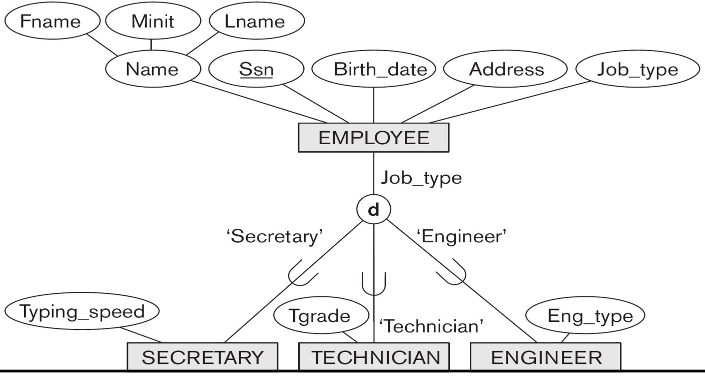
Ssn	Typing_speed

TECHNICIAN

Ssn	Tgrade

ENGINEER

Ssn	Eng_type



Specialization/Generalization (B)

Multiple relations –subclass only

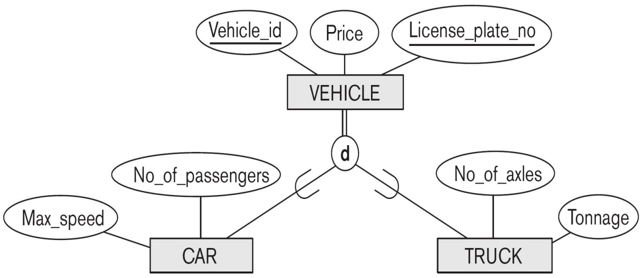
Should only be used for disjoint

CAR

Vehicle_id	License_plate_no	Price	Max_speed	No_of_passengers

TRUCK

Vehicle_id	License_plate_no	Price	No_of_axles	Tonnage



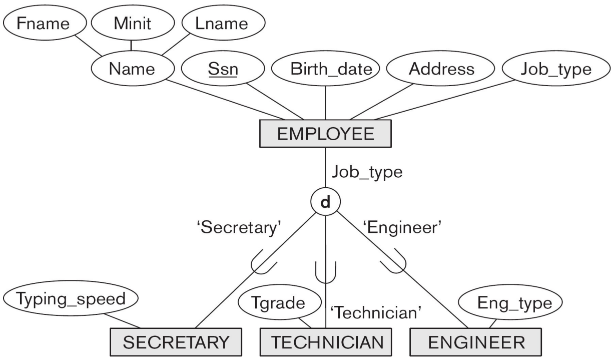
Specialization/Generalization (C)

Single relation with one type attribute

Only for disjoint, can result in many NULLs

EMPLOYEE

Ssn	Fname	Minit	Lname	Birth_date	Address	Job_type	Typing_speed	Tgrade	Eng_type



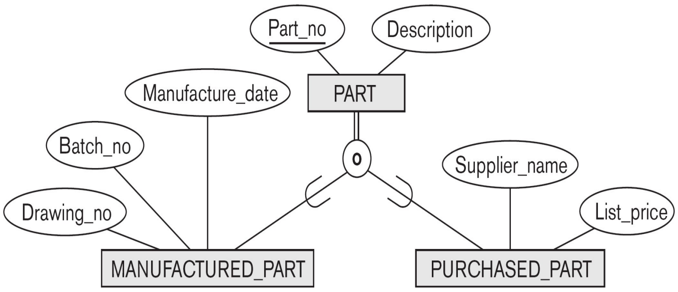
Specialization/Generalization (D)

Single relation with multiple type attributes

Better for overlapping, could be disjoint

PART

Part_no	Description	Mflag	Drawing_no	Manufacture_date	Batch_no	Pflag	Supplier_name	List_price



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Subclasses: Three Approaches

1. *Object-oriented*: One relation per subset of subclasses, with all relevant attributes.
2. *Use nulls*: One relation; entities have NULL in attributes that don’t belong to them.
3. *E/R style*: One relation for each subclass:
   - Key attribute(s).
   - Attributes of that subclass.

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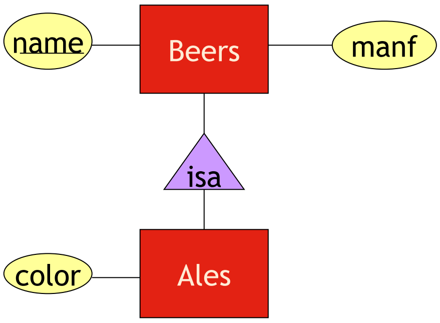
Example: Subclass → Relations



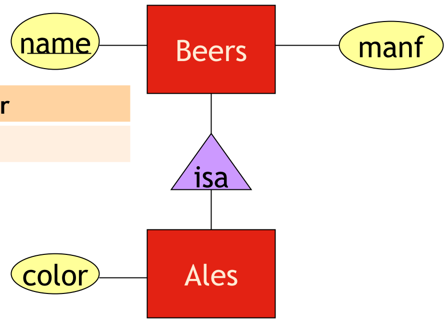
Object-Oriented

Name	Manf
Bud	Anheuser-Busch

Beers

Name	Manf	Color
Summerbrew	Pete's	Drak

Ales



Good for queries like "find the color of ales made by Pete's."

E/R Style

Name	Manf
Bud	Anheuser-Busch
Summerbrew	Pete’s

Beers

Name	Color
Summerbrew	Drak

Ales

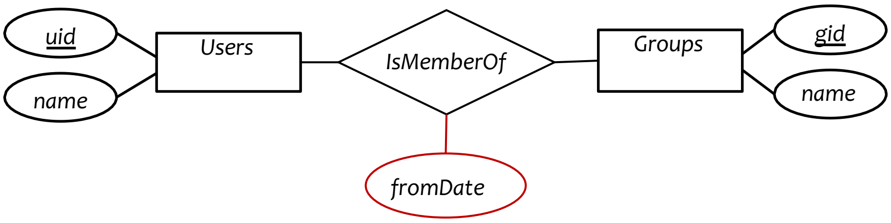
Good for queries like “find all beers (including ales) made by Pete’s.”

Using Nulls

Name	Manf	Color
Bud	Anheuser-Busch	Null
Summerbrew	Pete’s	Drak

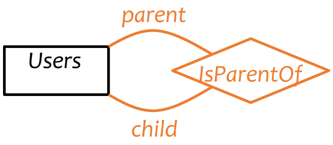
Saves space unless there are *lots* of attributes that are usually NULL.

Examples

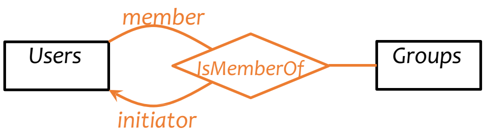


- Where do the dates go?
  - With *Users*?
    - But a user can join multiple groups on different dates
  - With *Groups*?
    - But different users can join the same group on different dates
  - With *IsMemberOf*!

More examples



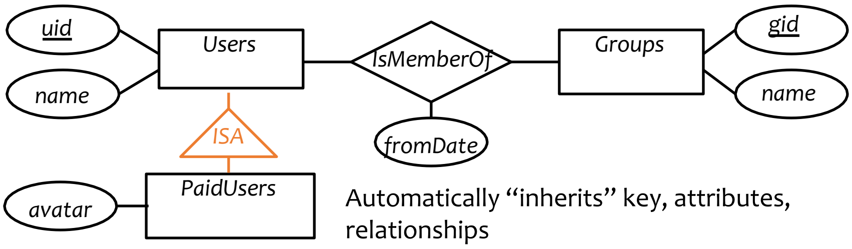
Parent (parent_uid, child_uid)



Member (uid, initiator_uid, gid)

ISA relationships

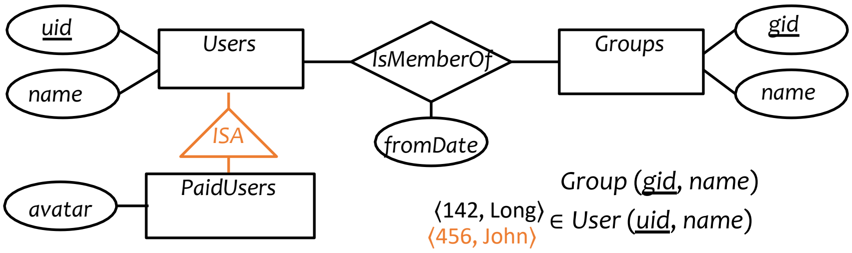
- Similar to the idea of subclasses in object-oriented programming: subclass = special case, fewer entities, and possibly more properties
  - Represented as a triangle (direction is important)
- Example: paid users are users, but they also get avatars (yay!)



Automatically "inherits" key, attributes, relationships

Translating subclasses & ISA: approach 1

- Entity-in-all-superclasses approach ("E/R style")
  - An entity is represented in the table for each subclass to which it belongs
  - A table includes only the attributes directly attached to the corresponding entity set, plus the inherited key



Group (<u>gid</u>, name)

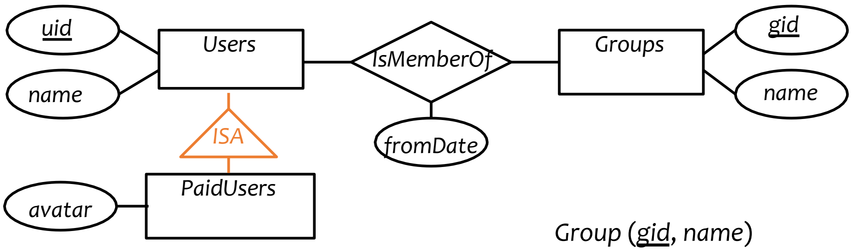
⟨142, Long⟩ ⟨456, John⟩ ∈ *User (<u>uid</u>, name)*

Member (<u>uid</u>, <u>gid</u>, from_date)

⟨456, ☺ ⟩ ∈ *PaidUser (<u>uid</u>, avatar)*

Translating subclasses & ISA: approach 2

- Entity-in-most-specific-class approach (“OO style”)
  - An entity is only represented in one table (the most specific entity set to which the entity belongs)
  - A table includes the attributes attached to the corresponding entity set, plus all inherited attributes



Group (gid, name)

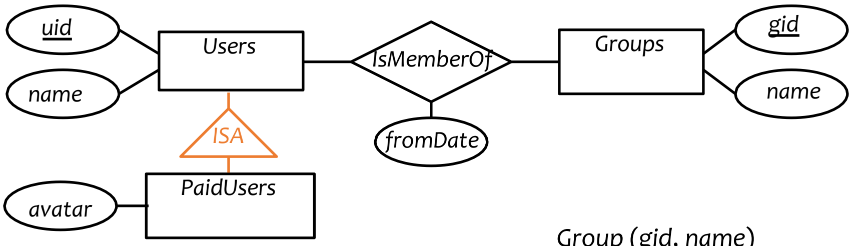
⟨142, Long⟩ ∈ User (uid, name)

Member (uid, gid, from_date)

⟨456, Ralph, ☺⟩ ∈ PaidUser (uid, name, avatar)

Translating subclasses & ISA: approach 3

- All-entities-in-one-table approach (“NULL style”)
  - One relation for the root entity set, with all attributes found in the network of subclasses (plus a “type” attribute when needed)
  - Use a special NULL value in columns that are not relevant for a particular entity

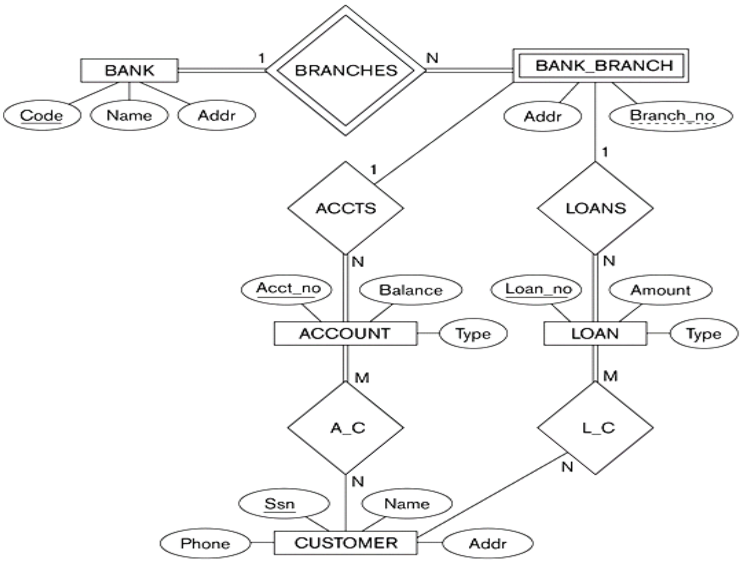


Group (gid, name)

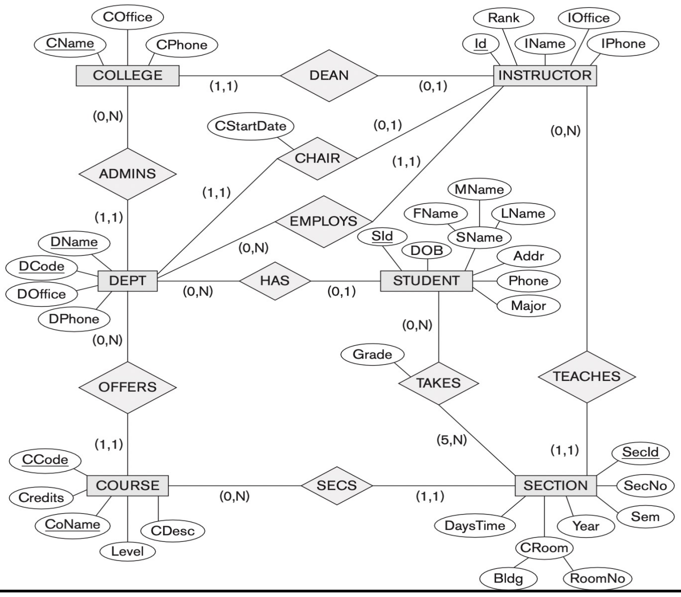
⟨142, Long , NULL⟩
⟨456, John, ☺ ⟩ ∈ User (uid, name, avatar)

Member (uid, gid, from_date)

Example ERD



Example ERD



Thank you for your attention!