Data Modeling Using the Entity-Relationship (ER) Model

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Chapter 2

Chapter Outline

- Database Design Steps
- ER Model Concepts
  - Entity Types and Key Attributes
  - Attribute types
  - Relationships and Relationship Types
  - Weak Entity Types
  - Constraints on Relationships
  - Structural Constraints
- Alternative notation
- Examples

Example COMPANY Database

Data requirment:

- Requirements of the Company
  - The company is organized into DEPARTMENTs. Each department has a name, number and an employee who ***manages*** the department. We keep track of the start date of the department manager.

    مش
    عدد لكن متغير
    مجموعة تدل على العدد

  - Each department ***controls*** a number of PROJECTs. Each project has a name, number and is located at a single location.

Example COMPANY Database (Cont.)

- We store each EMPLOYEE's ssn, address, salary, sex, and birthdate. Each employee *works for* one department but may *work on* several projects. We keep track of the number of hours per week that an employee currently works on each project. We also keep track of the *direct supervisor* of each employee.

- Each employee may *have* a number of DEPENDENTs. For each dependent, we keep track of their name, sex, birthdate, and relationship to employee.

Database Design Steps

- Understand and document the data requirement
- Designing the conceptual schema
  - ❑data types / entities
  - ❑Relationships
  - ❑constraints
- Implementing the database using a commercial DBMS.

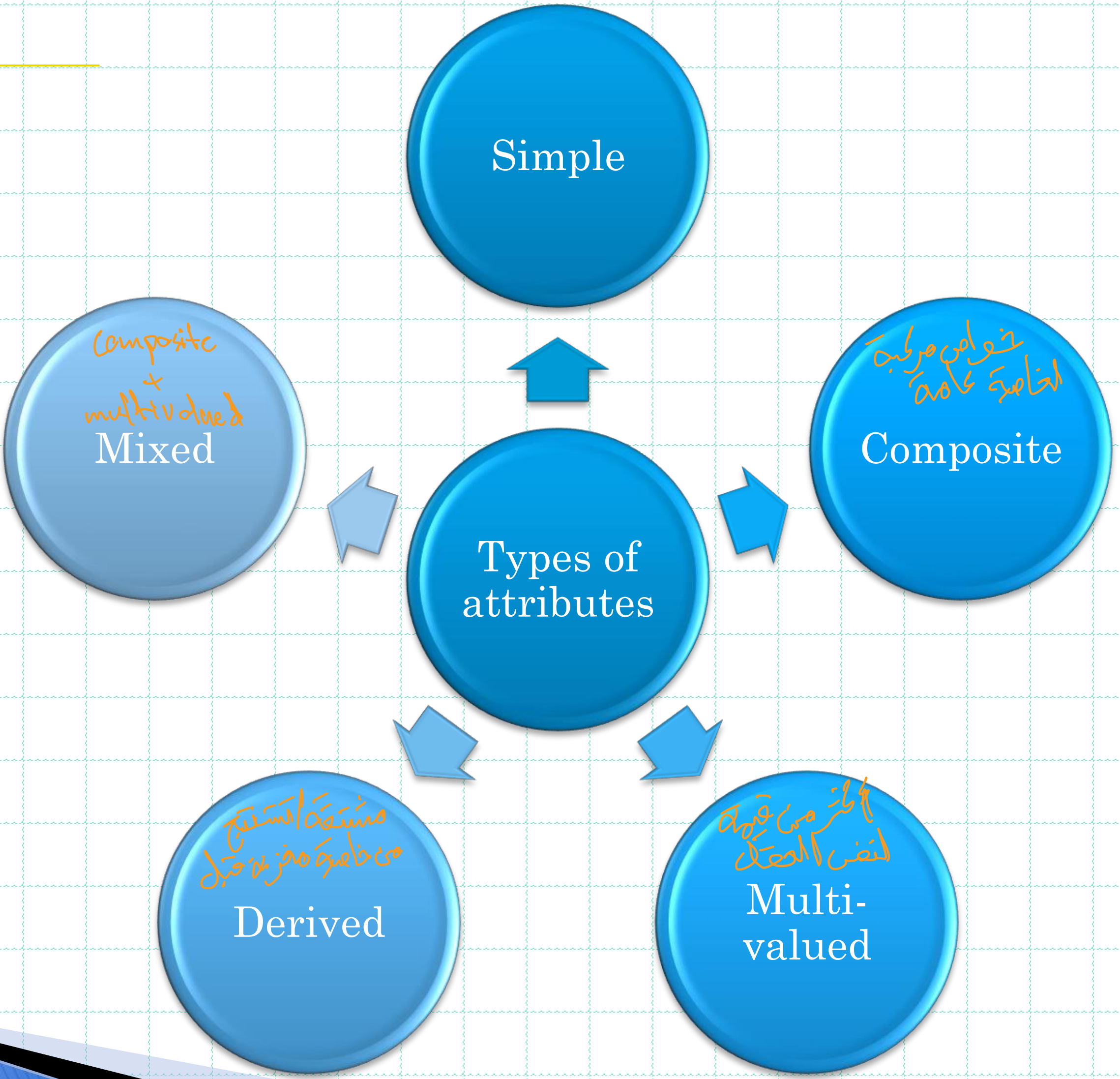
The Entity-Relationship (ER) model is a high-level conceptual data model.

It describes entities, relationships, and attributes (or elementary data).

ER Model Concepts

- Entities and Attributes
  - Entities are specific objects or things in the mini-world that are represented in the database. For example the EMPLOYEE Sami Ali, the Research DEPARTMENT, the ProductX PROJECT
  - Attributes are properties used to describe an entity. For example an EMPLOYEE entity may have a Name, SSN, Address, Sex, BirthDate
  - A specific entity will have a value for each of its attributes. For example a specific employee entity may have Name= Yassine shahri', SSN='123456789', Address =35, Olaya Street', Sex='M', BirthDate='09-JAN-75‘
  - Each attribute has a *value set* (or data type) associated with it – e.g. integer, string, subrange, enumerated type, …

Types of Attributes



Types of attributes

Simple

خواص مركبة
الخاصية عامة

Composite

أكثر من قيمة
لنفس الحقل

Multi-valued

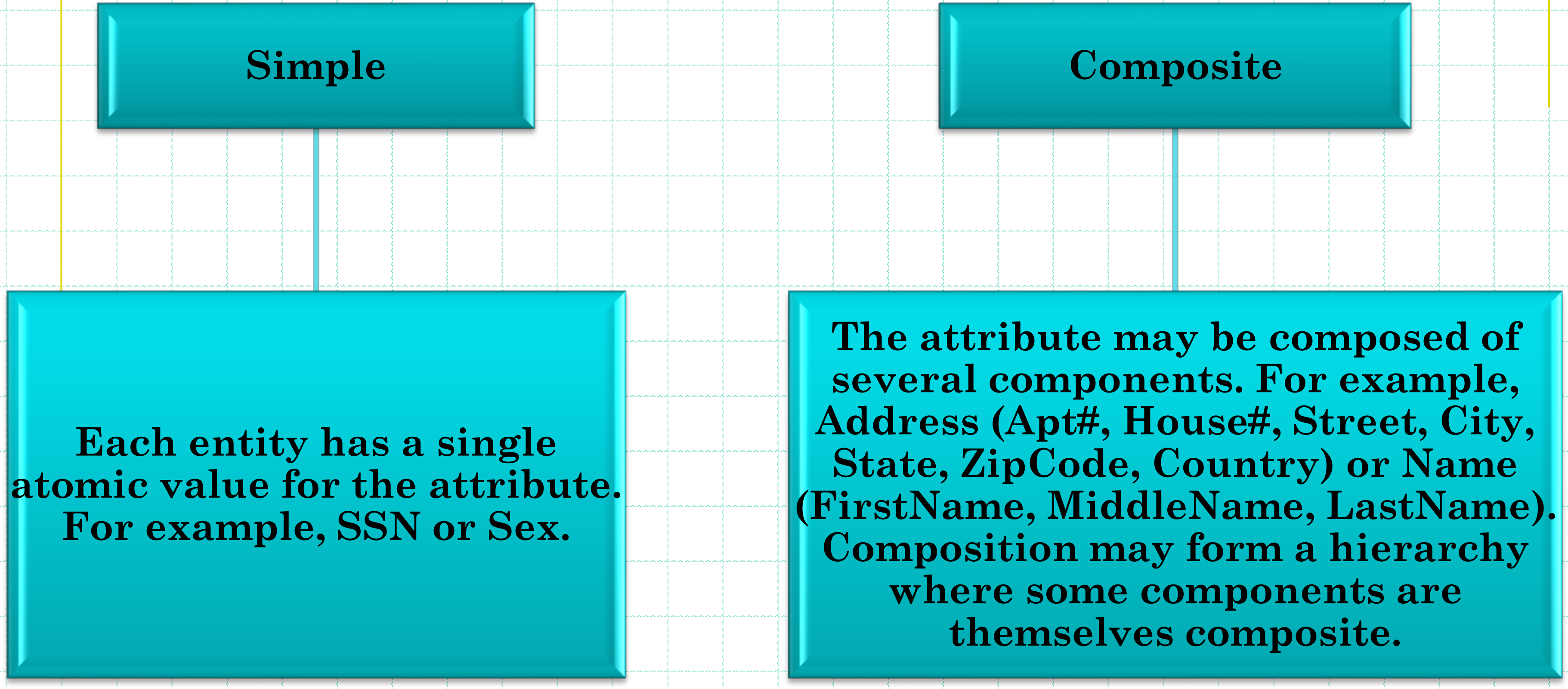
مشتقة/استنتج
من خاصية مخزنة قبل

Derived

composite
+
multivalued

Mixed

Types of Attributes



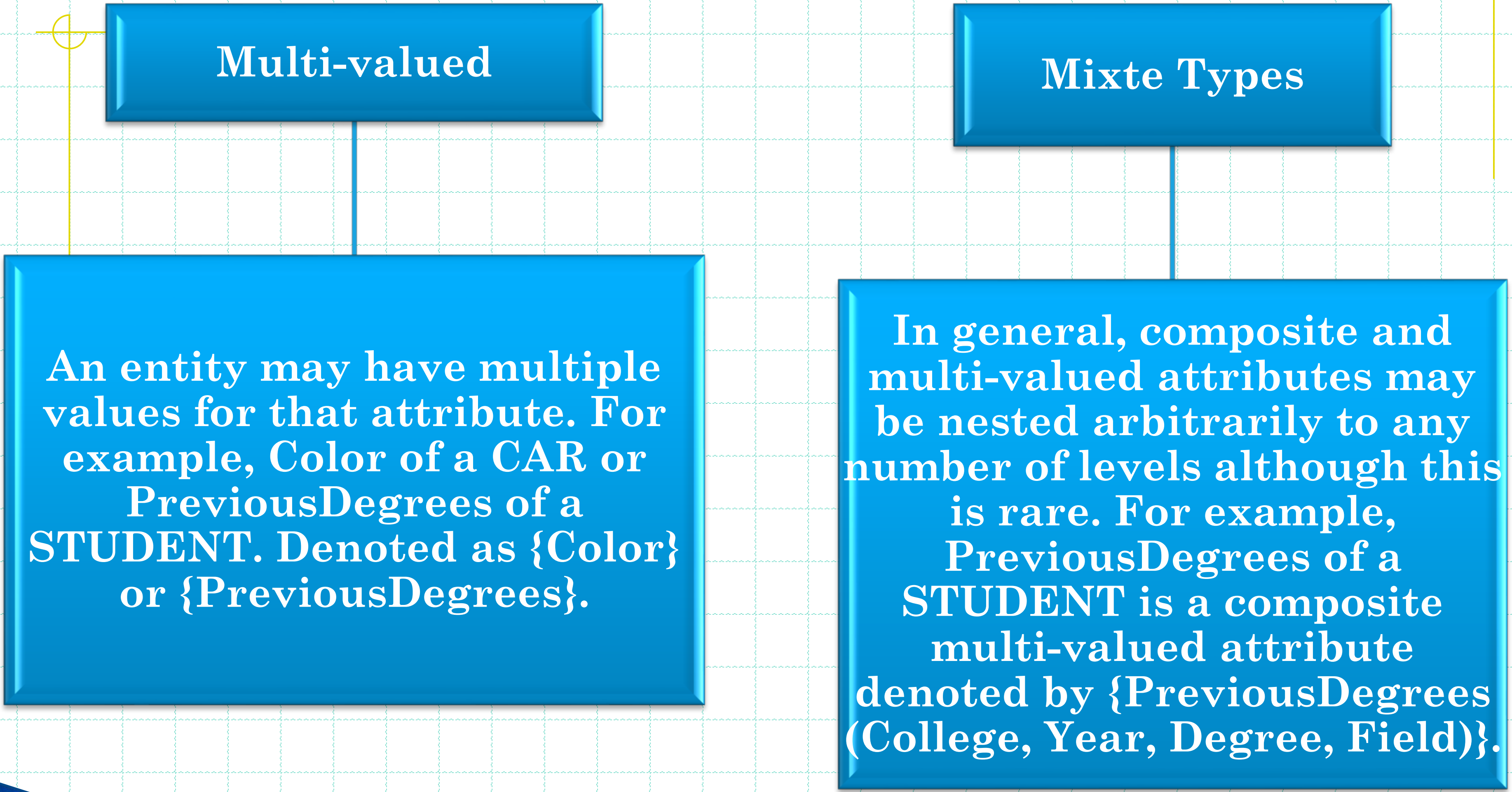
Simple

Each entity has a single atomic value for the attribute. For example, SSN or Sex.

Composite

The attribute may be composed of several components. For example, Address (Apt#, House#, Street, City, State, ZipCode, Country) or Name (FirstName, MiddleName, LastName). Composition may form a hierarchy where some components are themselves composite.

Types of Attributes (2)



Multi-valued

An entity may have multiple values for that attribute. For example, Color of a CAR or PreviousDegrees of a STUDENT. Denoted as {Color} or {PreviousDegrees}.

Mixte Types

In general, composite and multi-valued attributes may be nested arbitrarily to any number of levels although this is rare. For example, PreviousDegrees of a STUDENT is a composite multi-valued attribute denoted by {PreviousDegrees (College, Year, Degree, Field)}.

Entity Types and Key Attributes

- Entities with the same basic attributes are grouped or typed into an entity type. For example, the EMPLOYEE entity type or the PROJECT entity type.
- An attribute of an entity type for which each entity must have a unique value is called a key attribute of the entity type. For example, SSN of EMPLOYEE.
- A key attribute may be composite. For example, VehicleTagNumber is a key of the CAR entity type with components (Number, label).
- An entity type may have more than one key. For example, the CAR entity type may have two keys:
  - VehicleIdentificationNumber (VIN) and
  - VehicleTagNumber (Number, Lael), also known as license plate number.

Entity Set corresponding to the Entity Type Car

composed Key

CAR

Registration(RegistrationNumber, Label), VehicleID, Make, Model, Year, (Color)

schema

car1

((123, اب ج), TK629, Mercedes E280, 4-door, 1999, (red, black))

car2

((333, س ي ث), WP9872, Nissan 300ZX, 2-door, 2002, (blue))

car3

((720, ن م خ), TD729, Toyota camry, 4-door, 2003, (white, blue))

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Relationships and Relationship Types

- A relationship relates two or more distinct entities with a specific meaning. For example, EMPLOYEE Badr Ali works on the ProductX PROJECT or EMPLOYEE Yassine Shehri manages the Research DEPARTMENT.

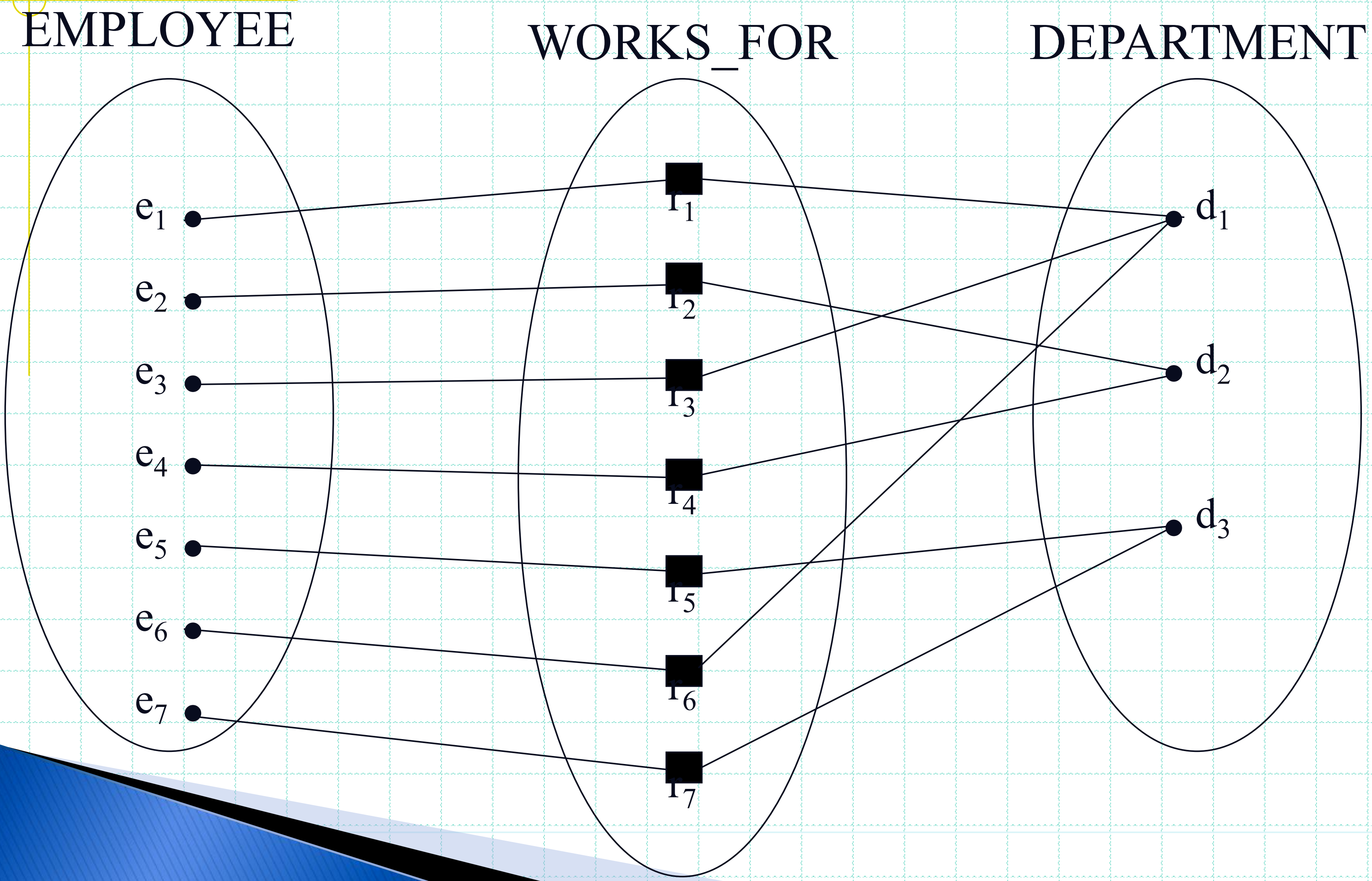
- Relationships of the same type are grouped or typed into a relationship type. For example, the WORKS_ON relationship type in which EMPLOYEEs and PROJECTs participate, or the MANAGES relationship type in which EMPLOYEEs and DEPARTMENTs participate.

Relationships and Relationship Types (2)

- The degree of a relationship type is the number of participating entity types. Both MANAGES and WORKS_ON are binary relationships.
- More than one relationship type can exist with the same participating entity types. For example, MANAGES and WORKS_FOR are distinct relationships between EMPLOYEE and DEPARTMENT, but with different meanings and different relationship instances

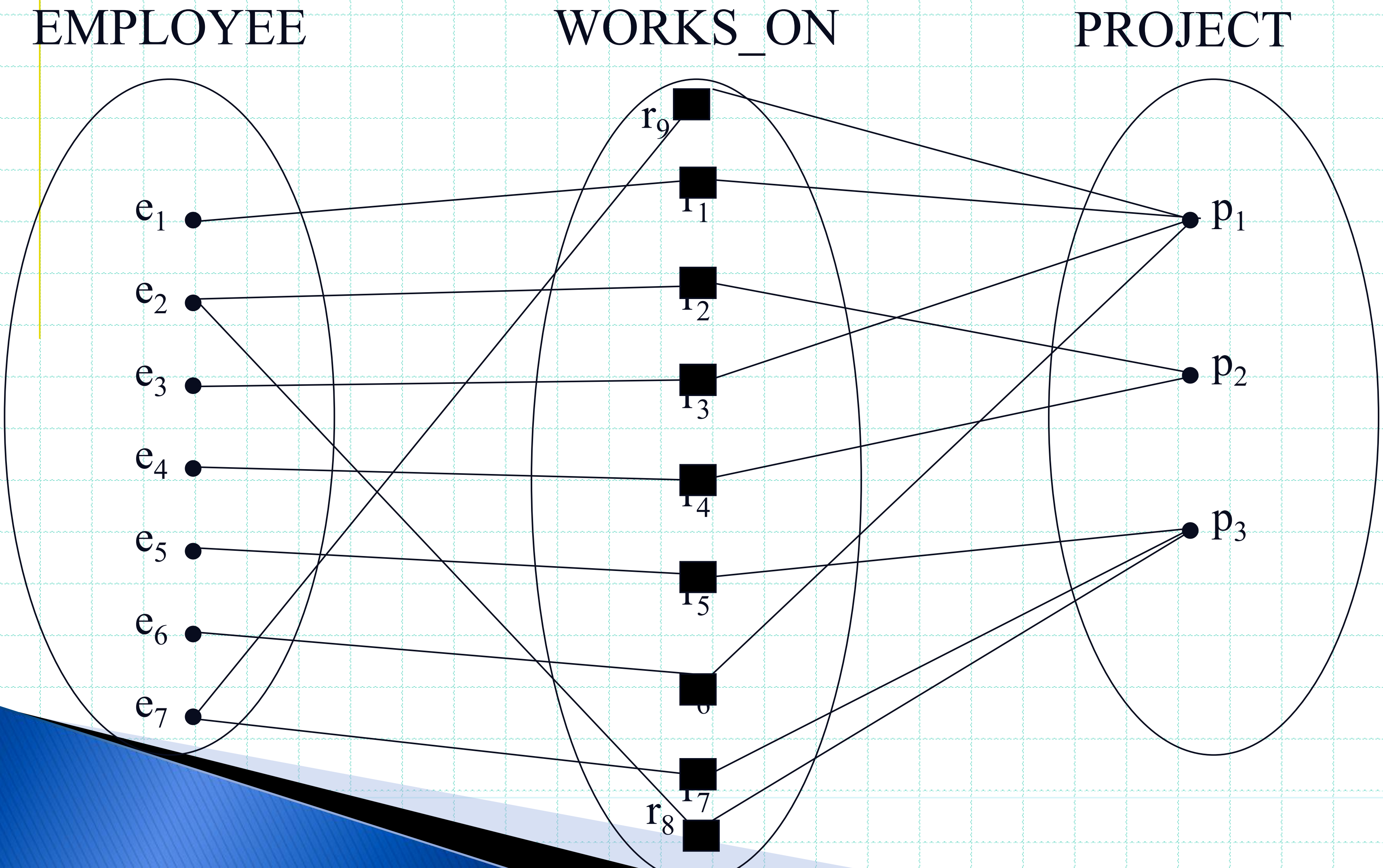
Relationship Example

WORKS_FOR relationship between EMPLOYEE and DEPARTMENT



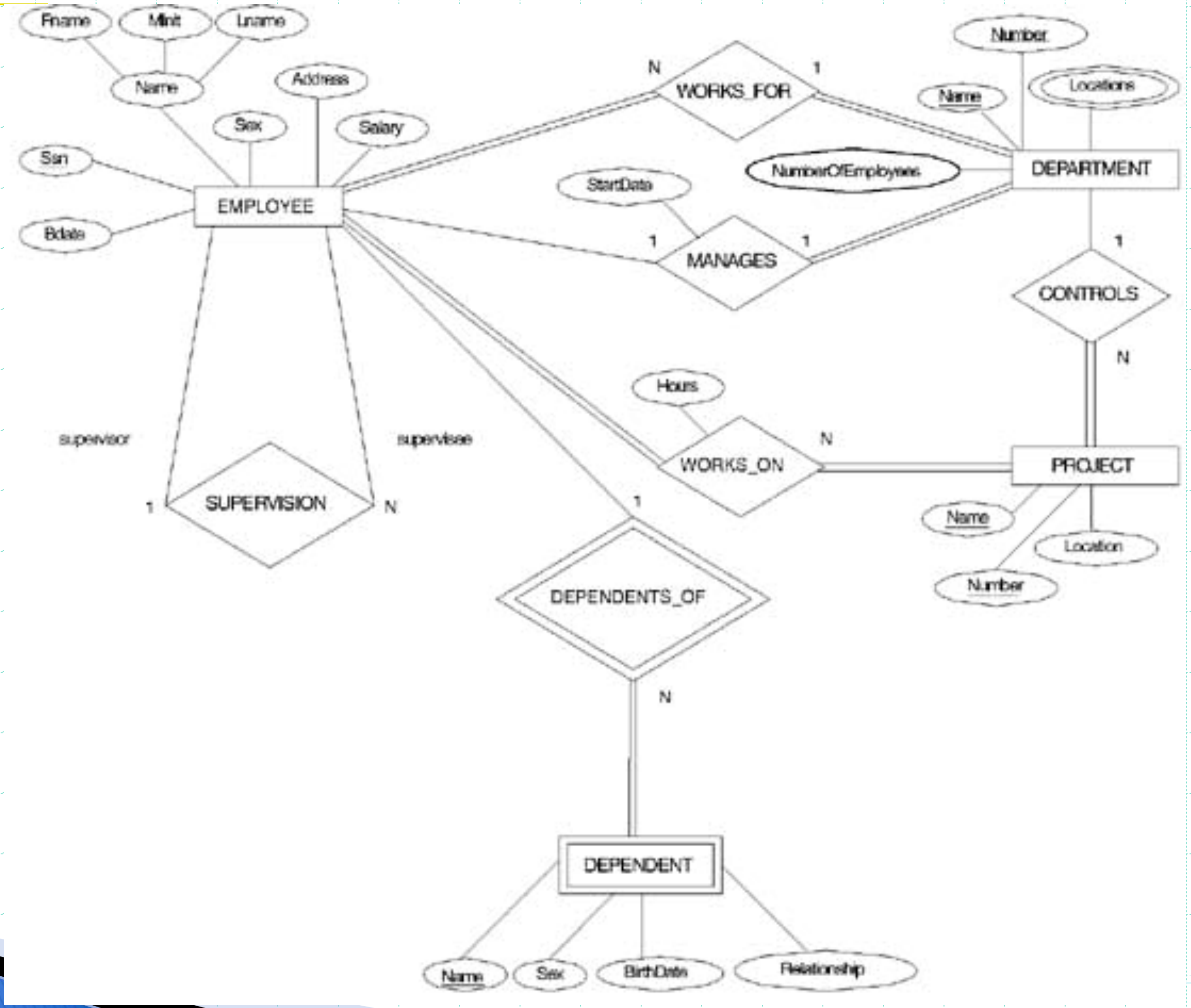
Relationship Example

Example relationship instances of the WORKS_ON relationship between EMPLOYEE and PROJECT



ER Diagram Example

Entity Types are:
EMPLOYEE, DEPARTMENT, PROJECT



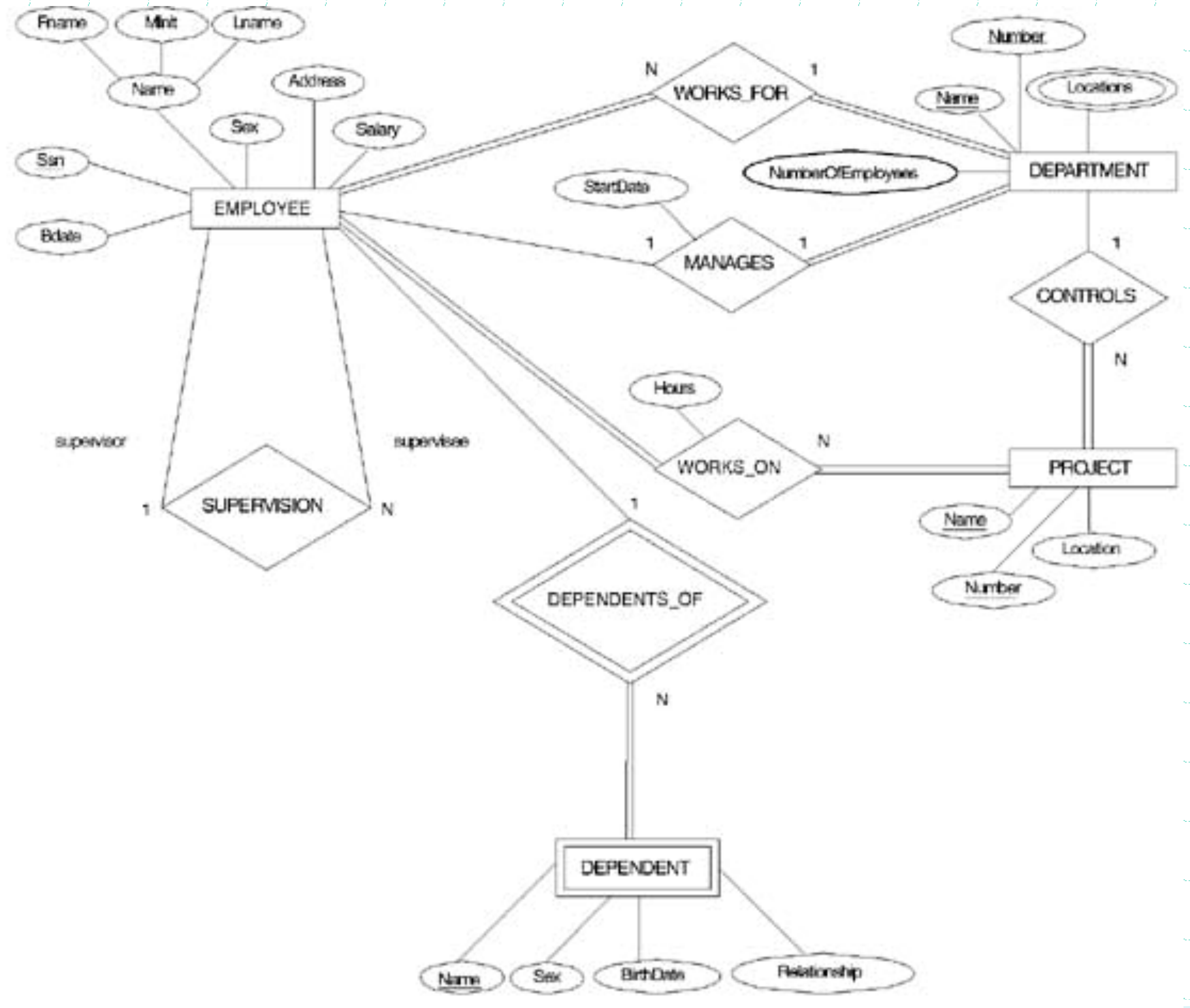
Weak Entity Types

- An entity that does not have a key attribute
- A weak entity must participate in an identifying relationship type with an owner or identifying entity type
- Entities are identified by the combination of:
  - A partial key of the weak entity type
  - The particular entity they are related to in the identifying entity type

Example:

Suppose that a DEPENDENT entity is identified by the dependent's first name and birhtdate, *and* the specific EMPLOYEE that the dependent is related to. DEPENDENT is a weak entity type with EMPLOYEE as its identifying entity type via the identifying relationship type DEPENDENT_OF

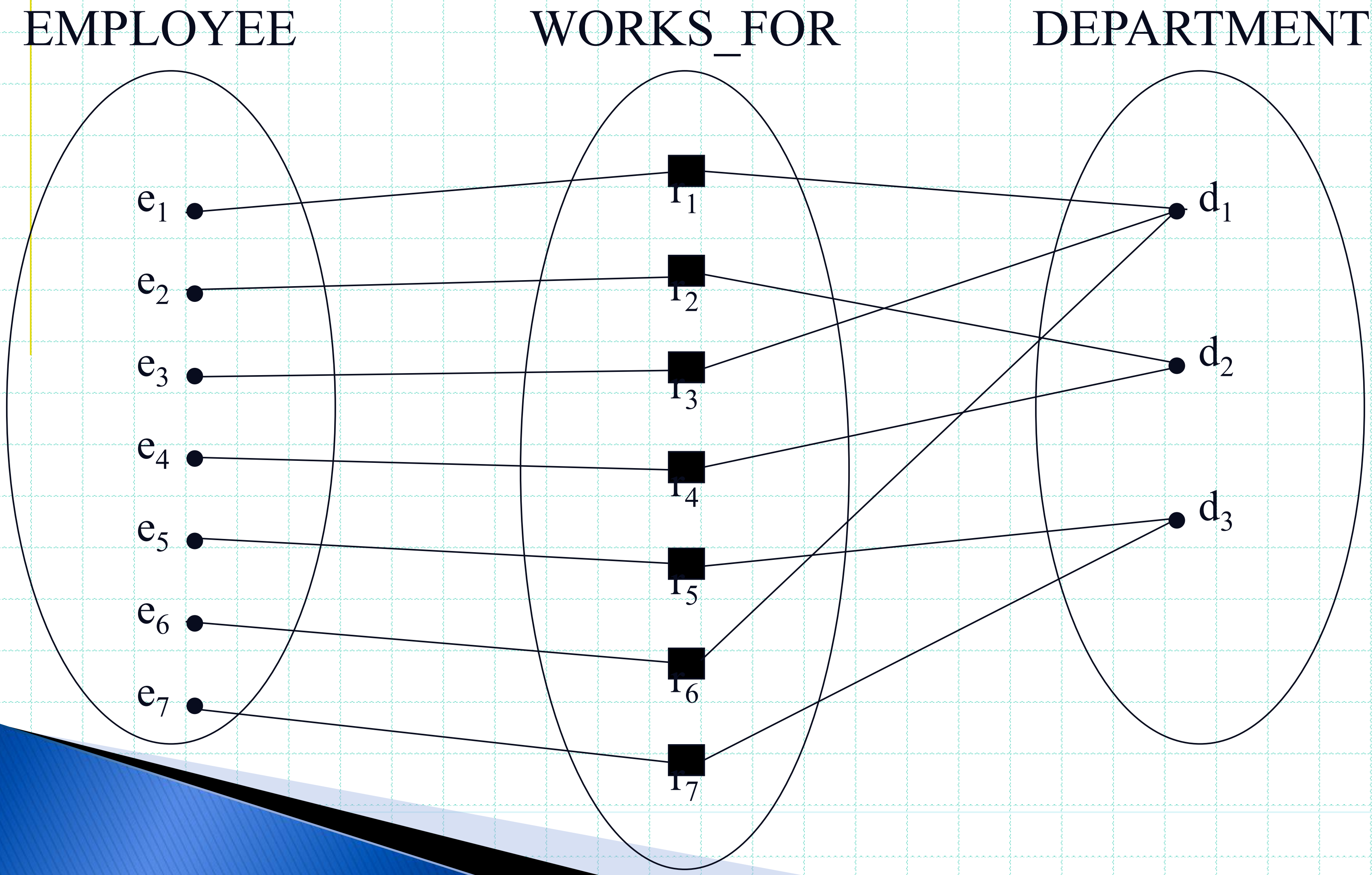
Weak Entity Type is: DEPENDENT
Identifying Relationship is: DEPENDENTS_OF



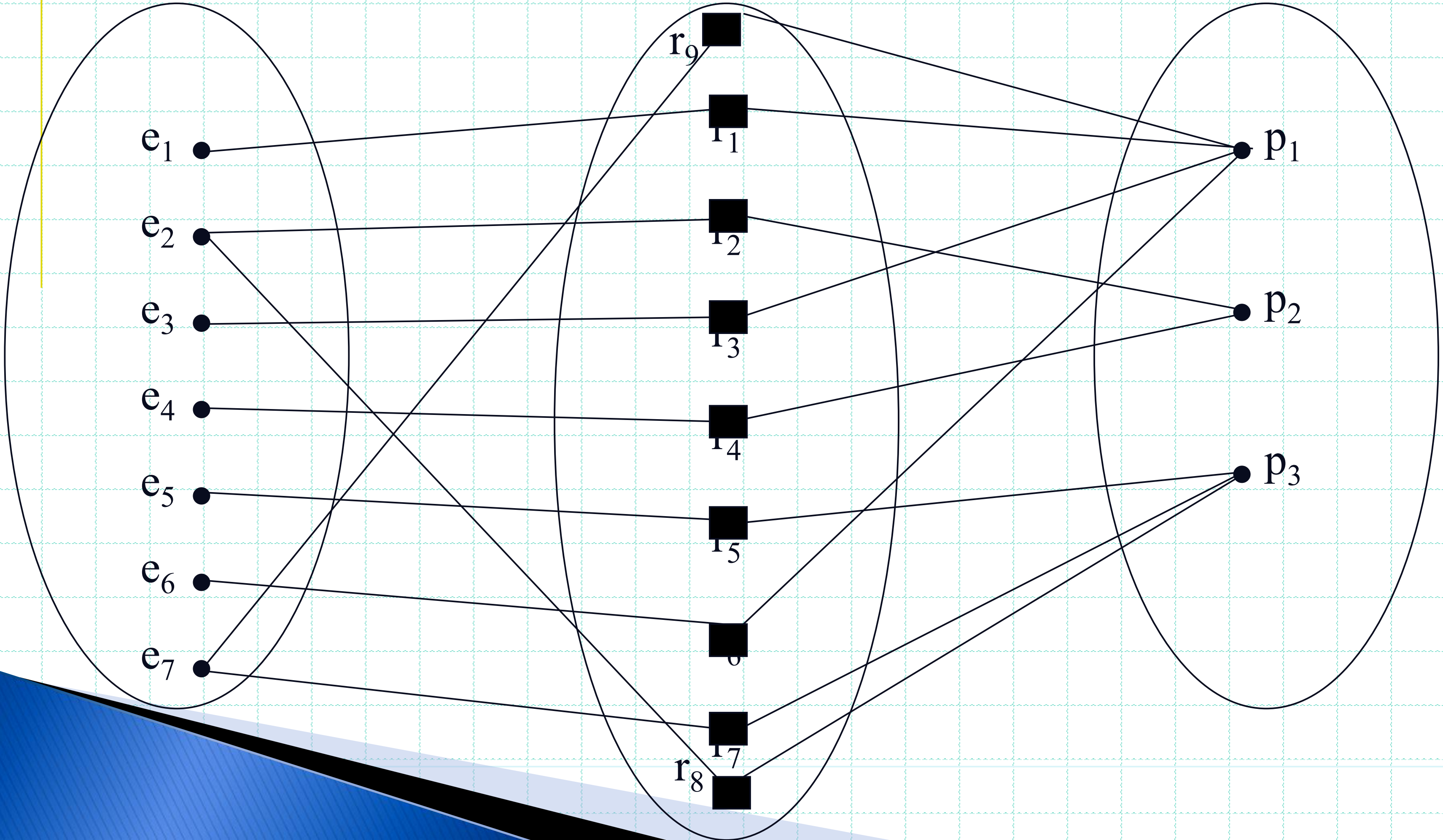
Constraints on Relationships

- Constraints on Relationship Types
  - Maximum Cardinality
    - One-to-one (1:1)
    - One-to-many (1:N) or Many-to-one (N:1)
    - Many-to-many
  - Minimum Cardinality (also called participation constraint or existence dependency constraints)
    - zero (optional participation, not existence-dependent)
    - one or more (mandatory, existence-dependent)

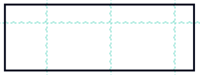
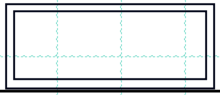
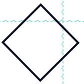
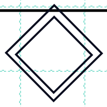
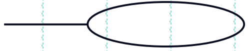
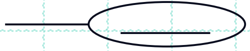
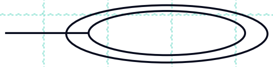
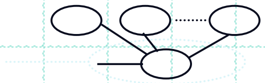
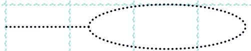
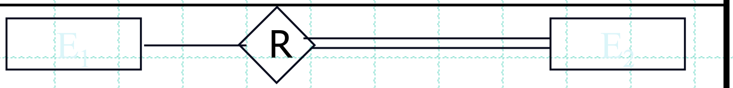
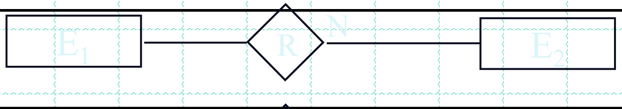
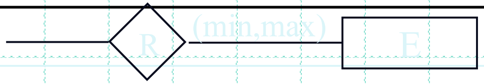
Many-to-one (N:1) Relationship



Many-to-many (M:N) Relationship



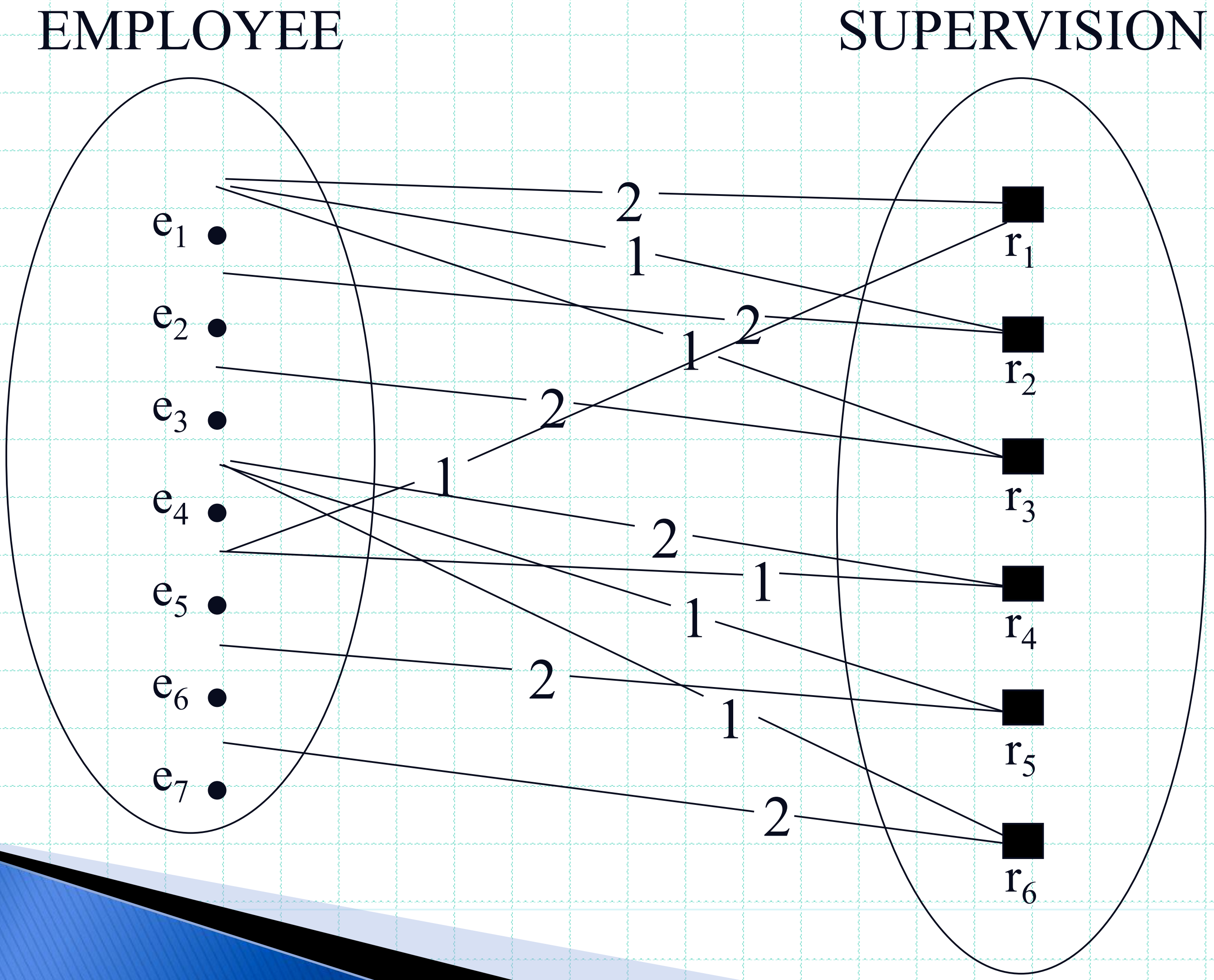
Summary of ER-Diagram Notation for ER Schemas

ENTITY TYPE	
WEAK ENTITY TYPE	
RELATIONSHIP TYPE	
IDENTIFYING RELATIONSHIP TYPE	
ATTRIBUTE	
KEY ATTRIBUTE	
MULTIVALUED ATTRIBUTE	
COMPOSITE ATTRIBUTE	
DERIVED ATTRIBUTE	
TOTAL PARTICIPATION OF E$_2$ IN R	
CARDINALITY RATIO 1:N FOR E$_1$:E$_2$ IN R	
STRUCTURAL CONSTRAINT (min, max) ON PARTICIPATION OF E IN R	

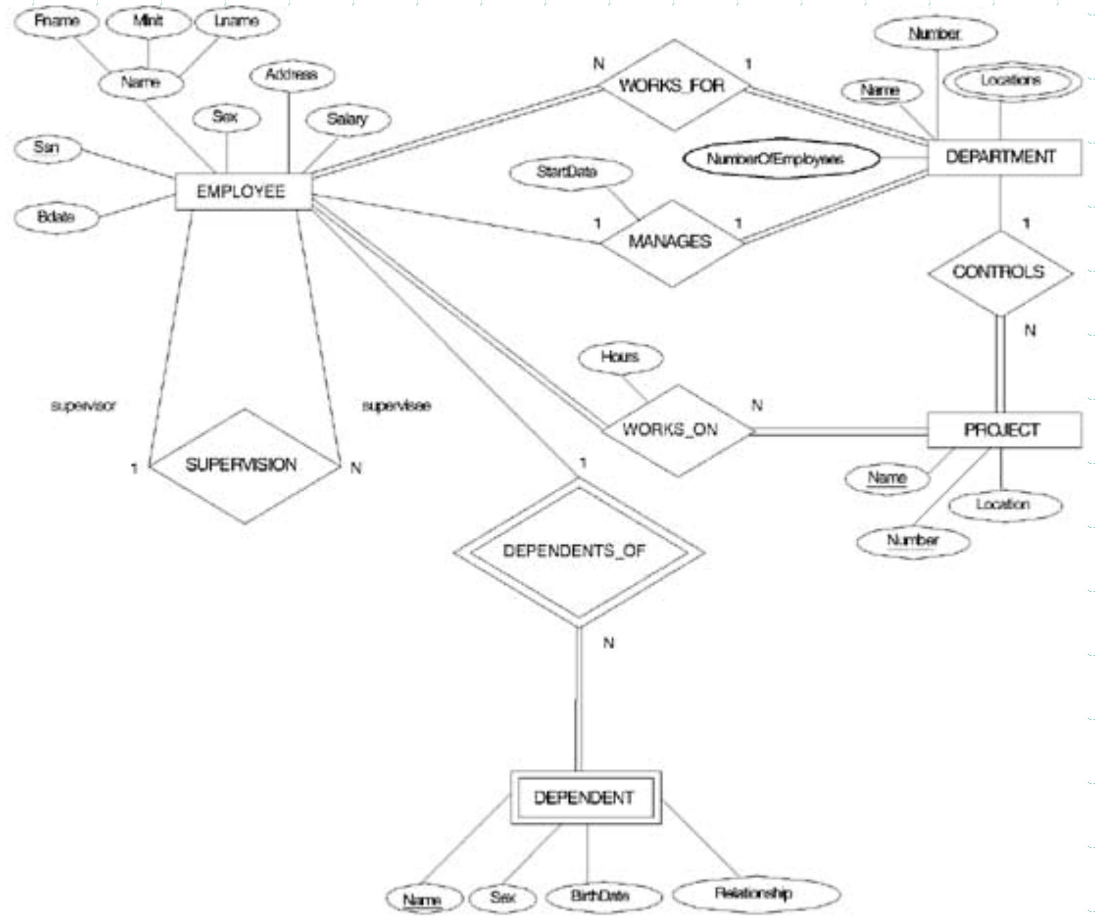
Relationships and Relationship Types (3)

- We can also have a **recursive** relationship type.
- Both participations are same entity type in different roles.
- For example, SUPERVISION relationships between EMPLOYEE (in role of supervisor or boss) and (another) EMPLOYEE (in role of subordinate or worker).
- In following figure, first role participation labeled with 1 and second role participation labeled with 2.
- In ER diagram, need to display role names to distinguish participations.

A Recursive Relationship: Supervision



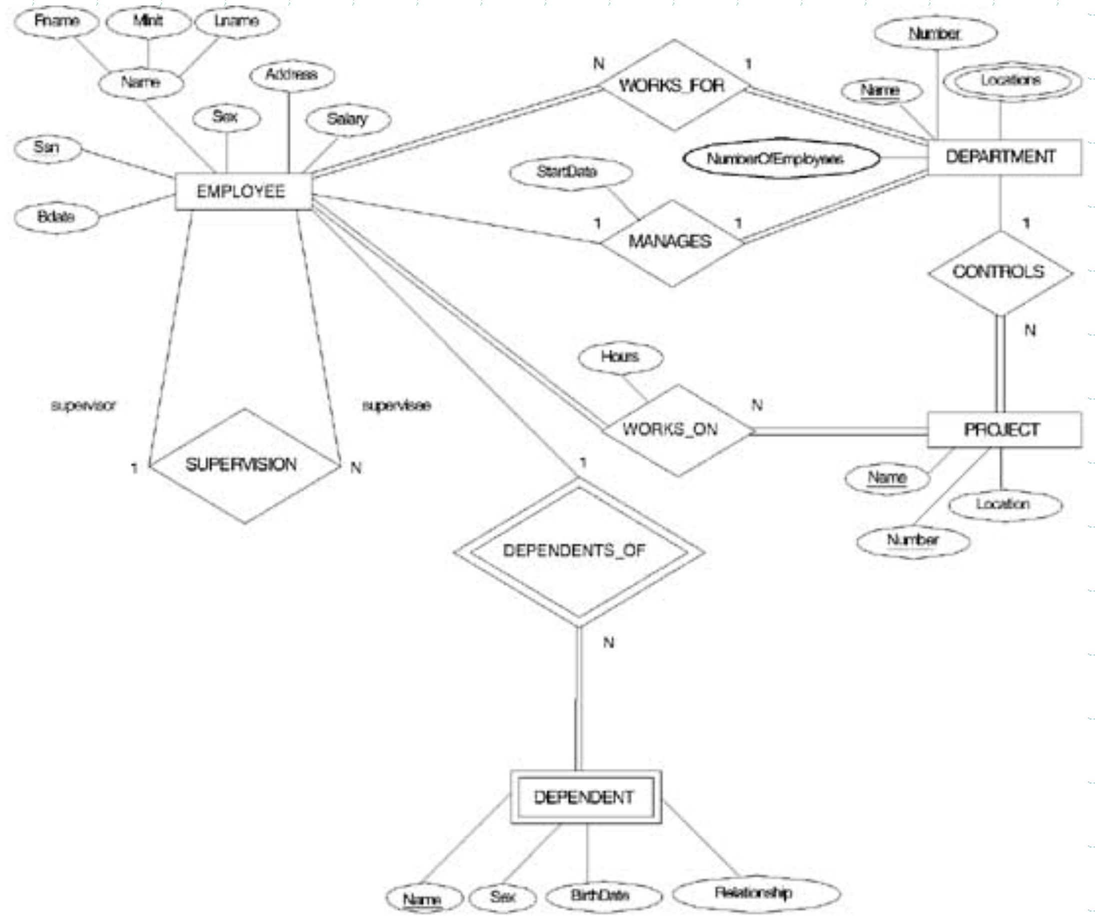
Recursive Relationship Type : SUPERVISION (participation role names are shown)



Attributes of Relationship types

- A relationship type can have attributes; for example, HoursPerWeek of WORKS_ON; its value for each relationship instance describes the number of hours per week that an EMPLOYEE works on a PROJECT.

Attribute of a Relationship Type is: Hours of WORKS_ON



Structural Constraints

one way to express semantics of relationships

Structural constraints on relationships:

- **Cardinality ratio** (of a binary relationship):

  1:1, 1:N, N:1, or M:N

  SHOWN BY PLACING APPROPRIATE NUMBER ON THE LINK.

- **Participation constraint** (on each participating entity type): total (called *existence dependency*) or partial.

  SHOWN BY DOUBLE LINING THE LINK

Alternative notation

- Alternative (min, max) notation for relationship structural constraints:
  - Specified on *each participation* of an entity type E in a relationship type R
  - Specifies that each entity e in E participates in *at least* min and *at most* max relationship instances in R
  - Default(no constraint): min=0, max=n
  - Must have min≤max, min≥0, max ≥1
  - Derived from the knowledge of mini-world constraints

Examples

A department has *exactly one* manager and an employee can manage *at most one* department.

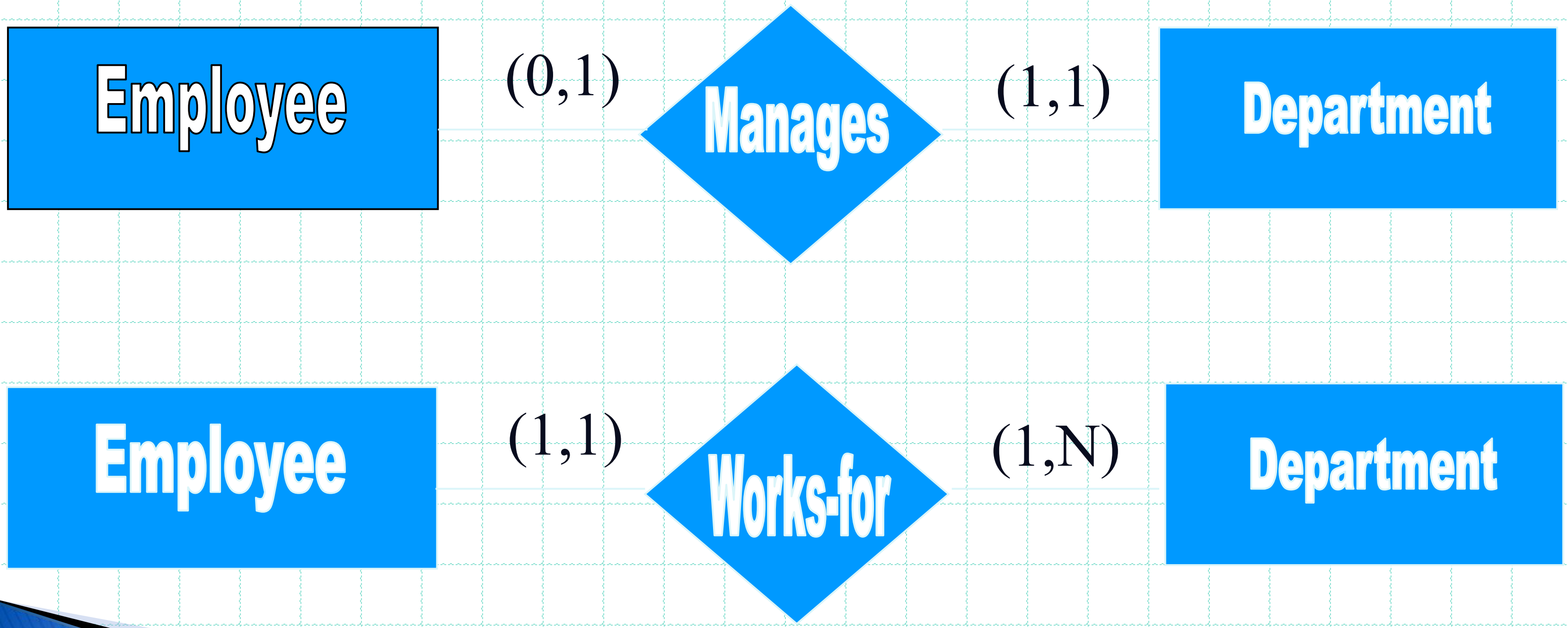
- Specify (0,1) for participation of EMPLOYEE in MANAGES
- Specify (1,1) for participation of DEPARTMENT in MANAGES

An employee can work for *exactly one* department but a department can have *any number of employees*.

- Specify (1,1) for participation of EMPLOYEE in WORKS_FOR
- Specify (0,n) for participation of DEPARTMENT in WORKS_FOR

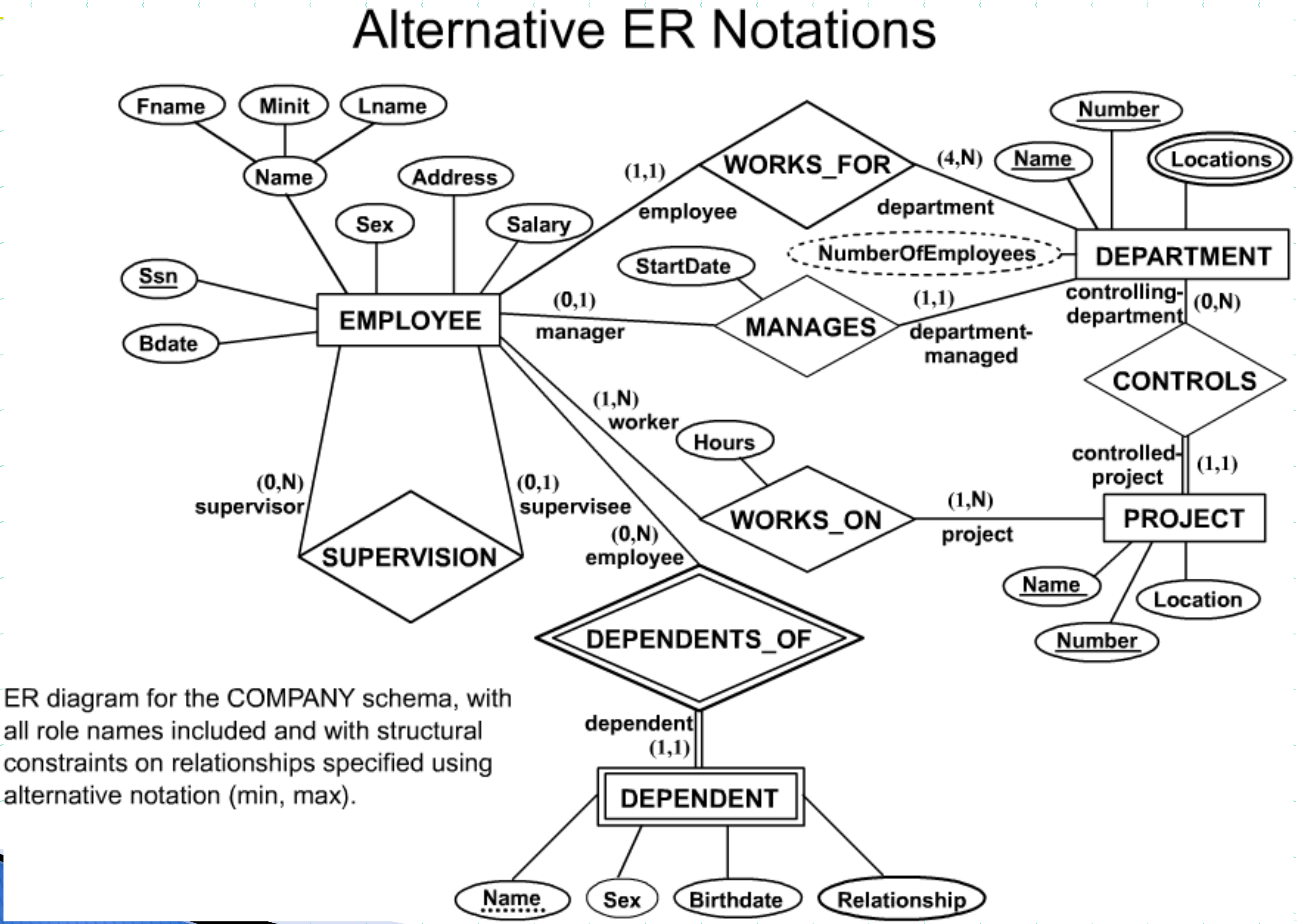
Examples

- The (min,max) notation relationship constraints



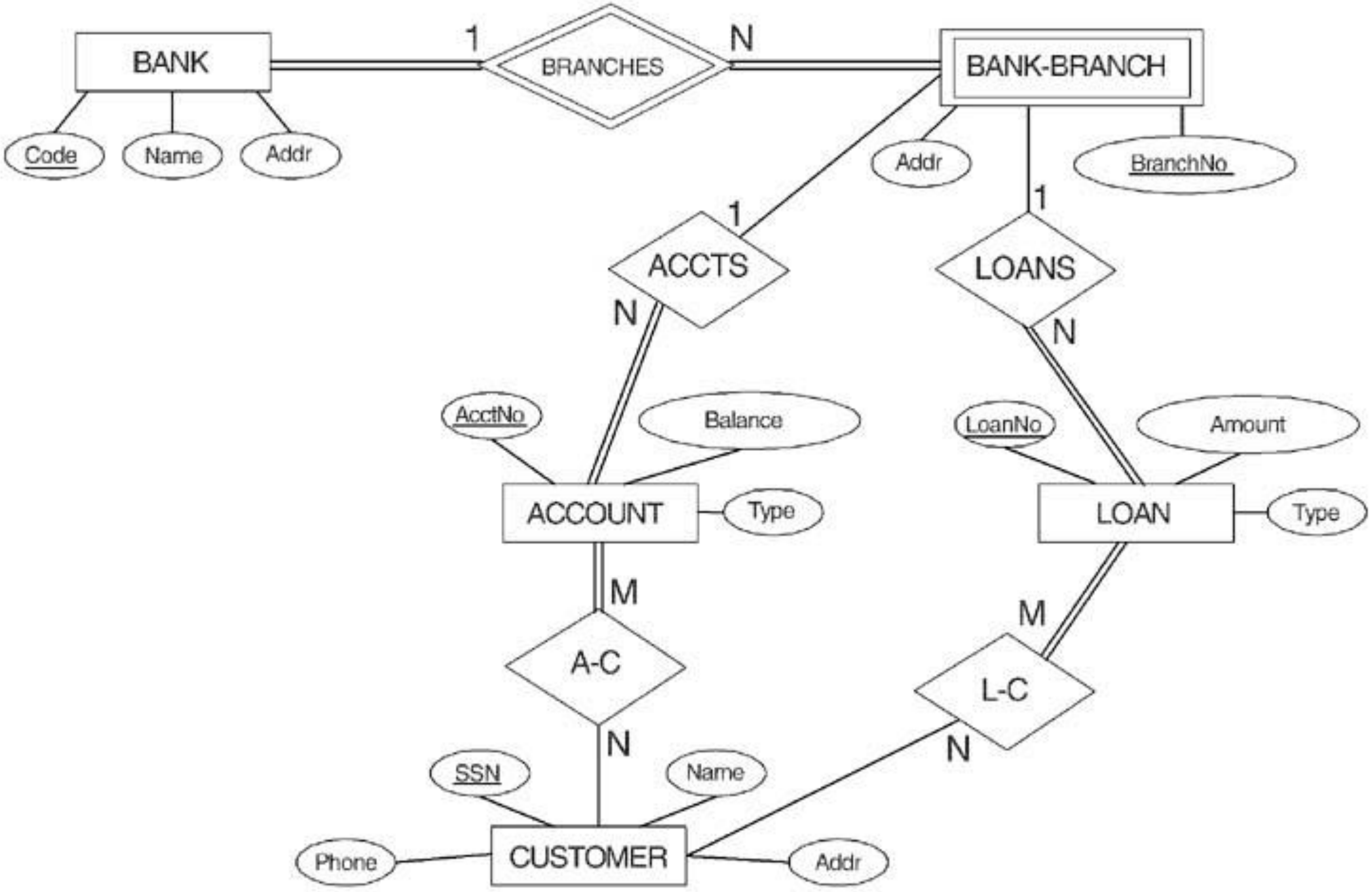
Company ER Schema Diagram

(min, max) notation



ER diagram for the COMPANY schema, with all role names included and with structural constraints on relationships specified using alternative notation (min, max).

ER Diagram For a Bank Database


BANK
Code
Name
Addr
1
BRANCHES
N
BANK-BRANCH
Addr
BranchNo
1
ACCTS
N
1
LOANS
N
AcctNo
Balance
ACCOUNT
Type
LoanNo
Amount
LOAN
Type
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A-C
N
M
L-C
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SSN
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Phone
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