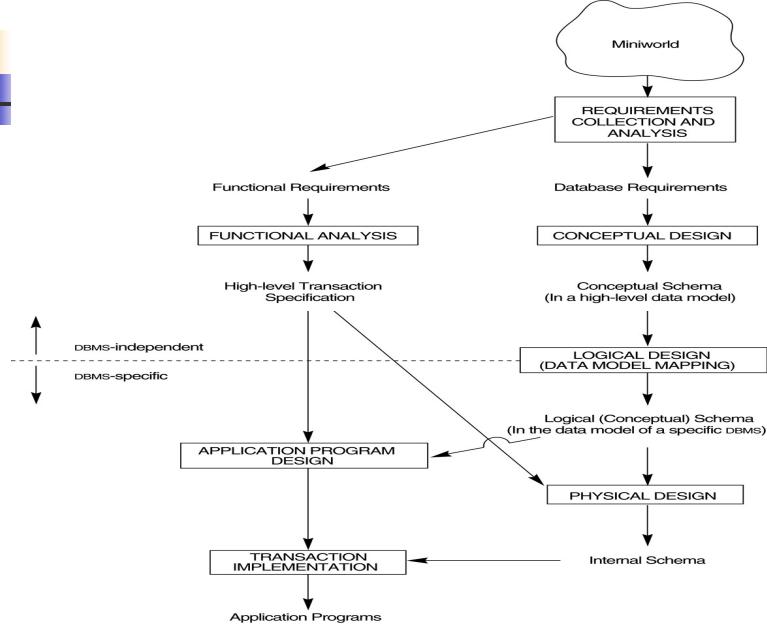


Data Modeling Using the Entity-Relationship (ER) Model

Outline

- Phases in Database Design
 - Example Database Application (COMPANY)
 - ER Model Concepts
 - Entities and Attributes
 - Entity Types, Value Sets, and Key Attributes
 - Relationships and Relationship Types
 - Weak Entity Types
 - Roles and Attributes in Relationship Types
 - ER Diagrams - Notation
 - ER Diagram for COMPANY Schema

Phases in Database Design



Example: COMPANY Database

- Requirements of the Company (oversimplified for illustrative purposes)
 - 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.
 - 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 social security number, 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.

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 John Smith, 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='John Smith', SSN='123456789', Address ='731, Fondren, Houston, TX', Sex='M', BirthDate='09-JAN-55'
- Each attribute has a *value set* (or data type) associated with it – e.g. integer, string, subrange, enumerated type, ...

Types of Attributes (1)

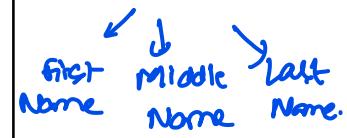
- Simple
 - Each entity has a single atomic value for the attribute. For example, SSN or Sex.
- Composite
 - The attribute may be composed of several components. For example, Address (Apt#, House#, Street, City, State, ZipCode, Country) or Name (FirstName, MiddleName, LastName). Composition may form a hierarchy where some components are themselves composite.
- 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}.

Composite Attr



Can be further divided.

~~Ex~~ Name of a person



Simple attribute



Cannot be further divided.

Ex: Age, Salary etc.

Multi-valued Attr



An entity can have multiple values at a time.

Eg: Languages known

Complex Attribute

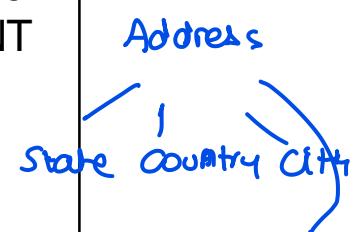


It has both composite attribute & multi-valued attribute.

→ Multi-valued are denoted by '{ }'

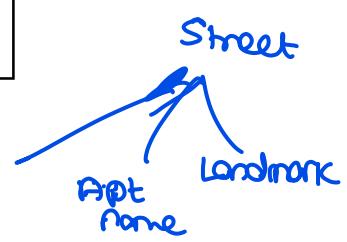
Types of Attributes (2)

- 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)}.



hierarchy

D.no



∴ One can be further divided again.

Entity Type

- Called also as Table.
- Entity-type is collection of entities having same attributes.

Attribute
is
Property of
entity.

A primary key may
be composite
Ex: Car Number
(AP 16 BK 3712)
number + state.

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, State).
- An entity type may have more than one key. For example, the CAR entity type may have two keys:
 - VehicleIdentificationNumber (popularly called VIN) and
 - VehicleTagNumber (Number, State), also known as license_plate number.

What are all the entities in the table. ENTITY SET corresponding to the ENTITY TYPE CAR

CAR
Registration(RegistrationNumber, State), VehicleID, Make, Model, Year, (Color)

car,
((ABC 123, TEXAS), TK629, Ford Mustang, convertible, 1999, (red, black))
car₂
((ABC 123, NEW YORK), WP9872, Nissan 300ZX, 2-door, 2002, (blue))
car₃
((VSY 720, TEXAS), TD729, Buick LeSabre, 4-door, 2003, (white, blue))
.
.
.

Entity/ Entry,

Row/ Tuple/

Record.

Attribute/
Column/
field.

:: Weak Entity Types
 ↓
 Have relation with another table
 ↓
 Owner
 This relationship b/w owner and weak entity → Identifying Relationship

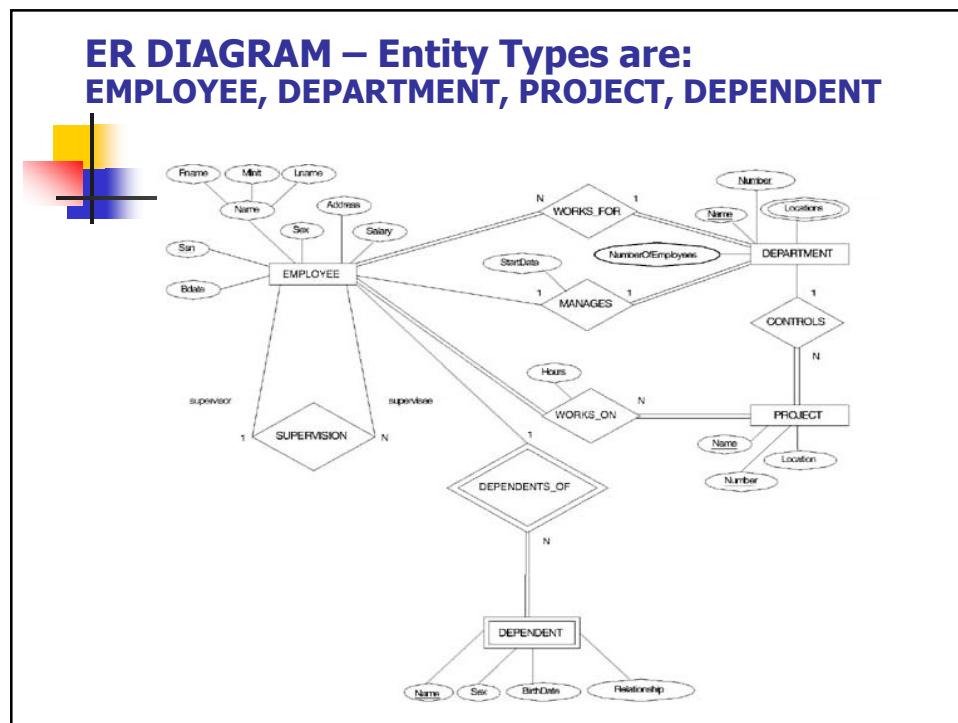
Double line from Entity to Relation
 ↓
 total participation of that entity.

Symbol	Meaning
	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

→ The entity that does not have key attribute of its own.

Age → Derived Attr.
DOB → Stored Attr.

Ex Age can be DOB.
→ Attribute that can be derived from other.



Relationship is
between 2 distinct
entities

Relationships and Relationship Types (1)

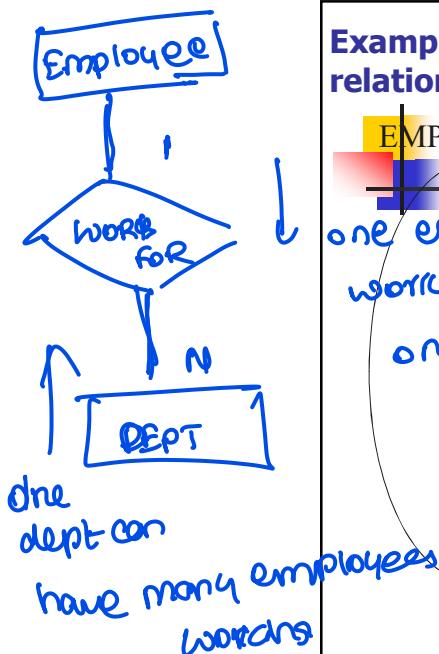
- A relationship relates two or more distinct entities with a specific meaning. For example, EMPLOYEE John Smith works on the ProductX PROJECT or EMPLOYEE Franklin Wong manages the Research DEPARTMENT.
- Relationships of the same type are grouped or typed into a relationship type. For example, the WORKS_ON relationship type in which EMPLOYEES and PROJECTS participate, or the MANAGES relationship type in which EMPLOYEES and DEPARTMENTS participate.
- The degree of a relationship type is the number of participating entity types. Both MANAGES and WORKS_ON are binary relationships.

∴ A relationship cannot have duplicate entities / topics.

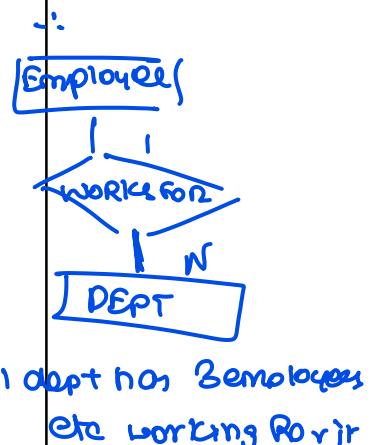
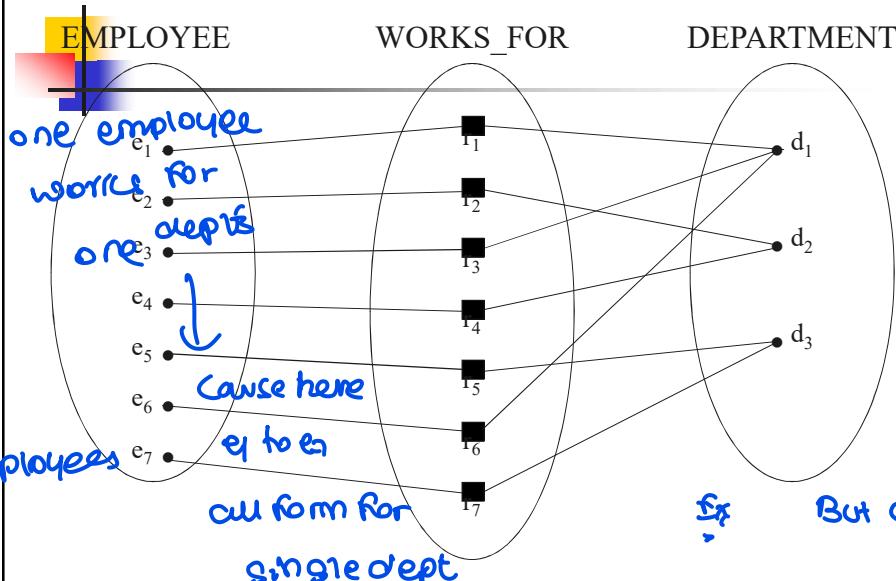
Relationship Type

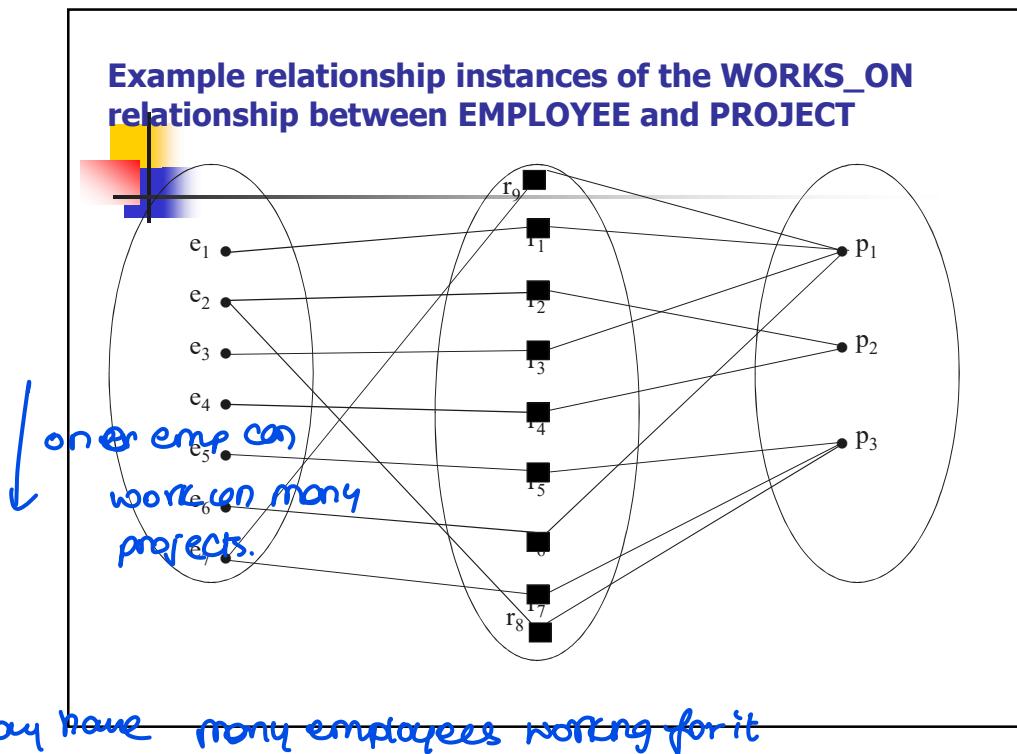


Group of typed
relationships.



Example relationship instances of the WORKS_FOR relationship between EMPLOYEE and DEPARTMENT

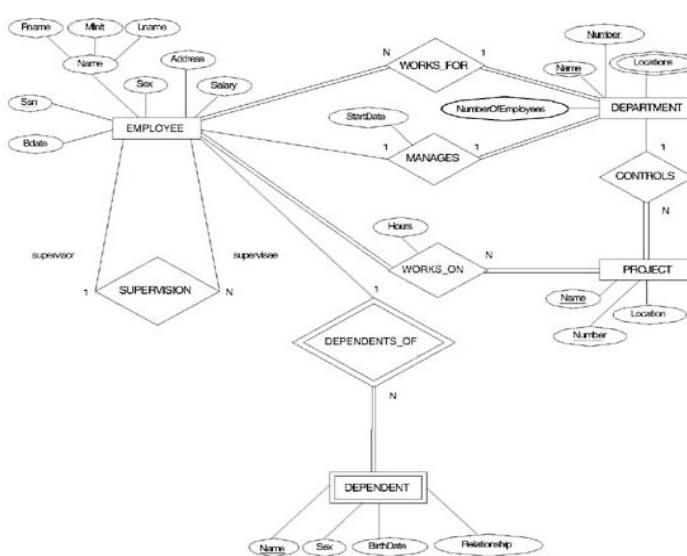




Relationships and Relationship Types (2)

- 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.

ER DIAGRAM – Relationship Types are: WORKS_FOR, MANAGES, WORKS_ON, CONTROLS, SUPERVISION, DEPENDENTS_OF



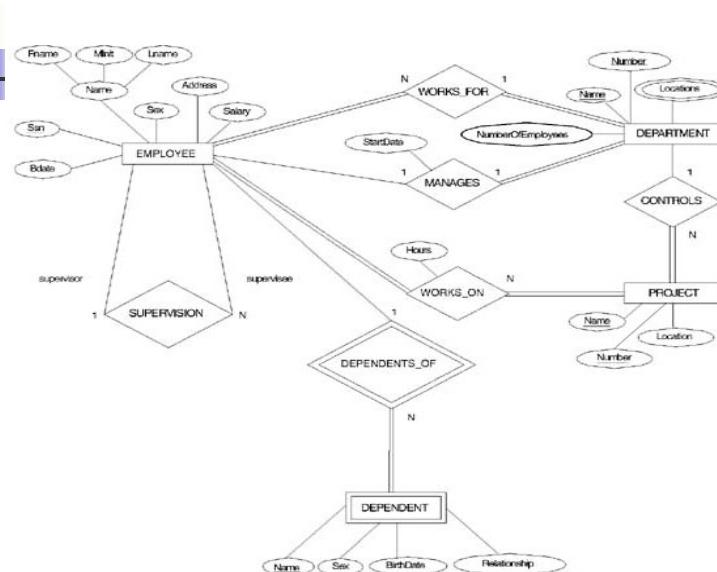
Weak Entity Types

- 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 birthrate, *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

Cardinality Ratio

Specifies the maximum number of relationship instances that an entity can participate in.

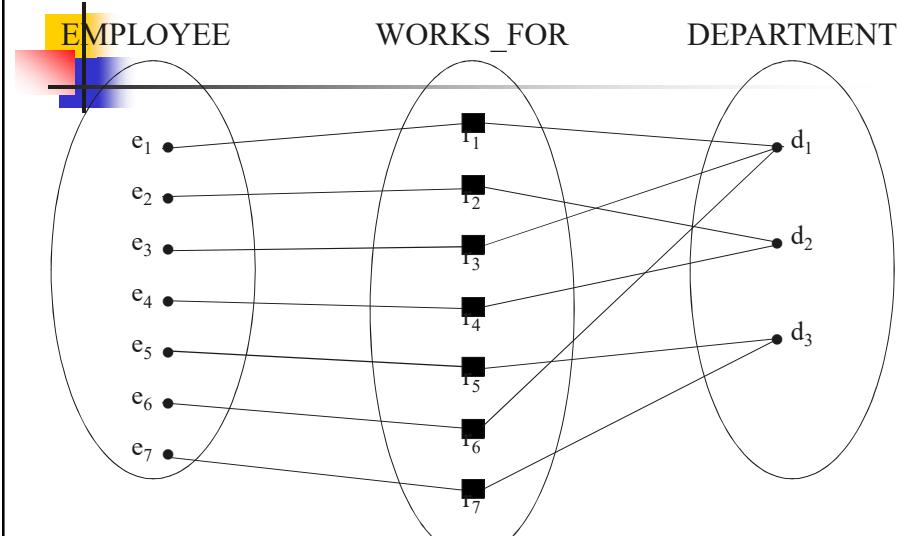
- One-to-one (1:1)
- One-to-many (1:N) or Many-to-one (N:1)
- Many-to-many

Participation

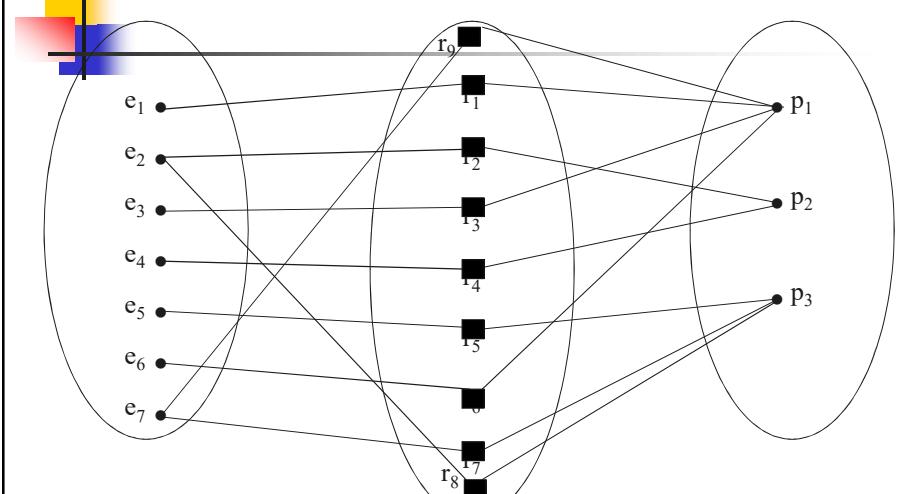
- Also called minimum cardinality constraint
- Specifies the minimum number of relationship instances that each entity can participate in.

max no. of relationship instances on entity can participate in.

Many-to-one (N:1) RELATIONSHIP

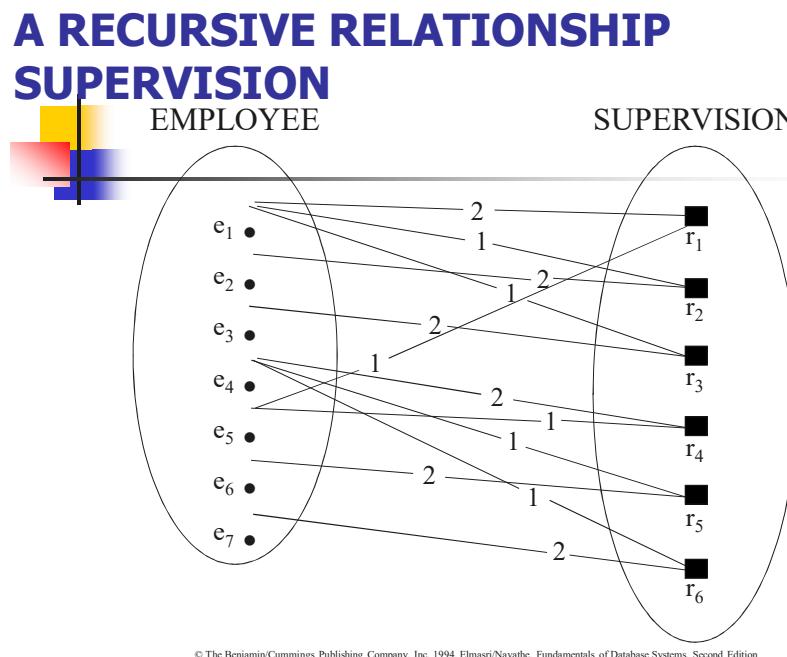


Many-to-many (M:N) RELATIONSHIP

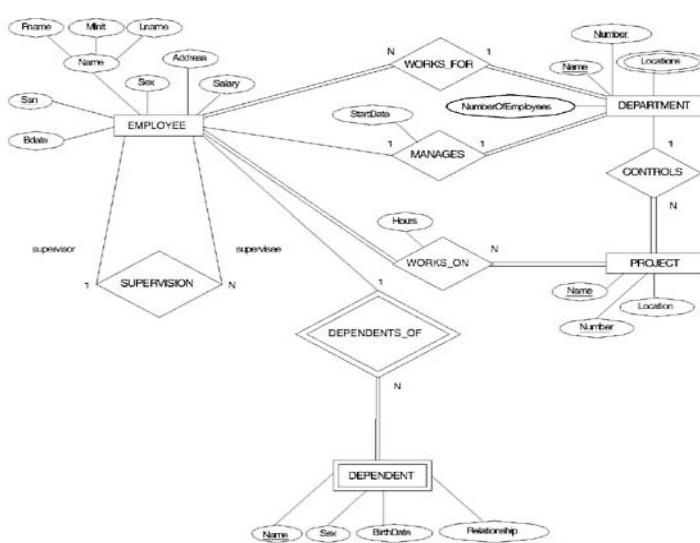


Relationships and Relationship Types (3)

- 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 the 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.



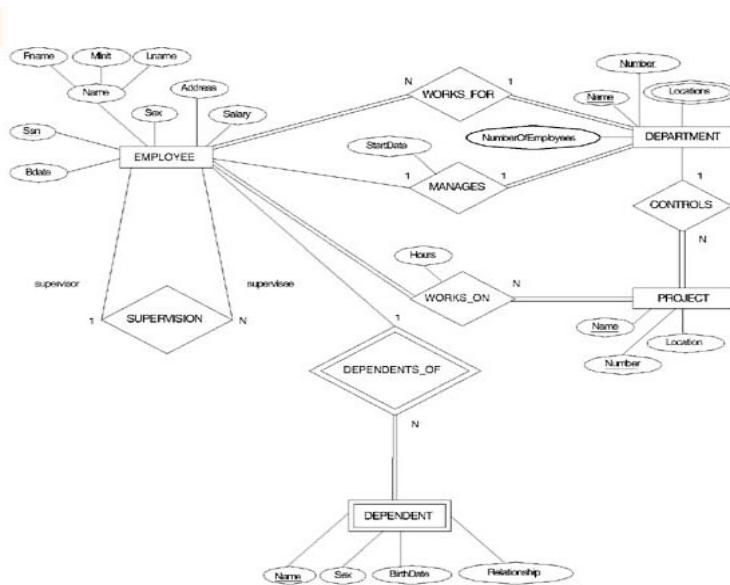
Recursive Relationship Type is: SUPERVISION (participation role names are shown)



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

NOTE: These are easy to specify for Binary Relationship Types.

Alternative (min, max) notation for relationship structural constraints:

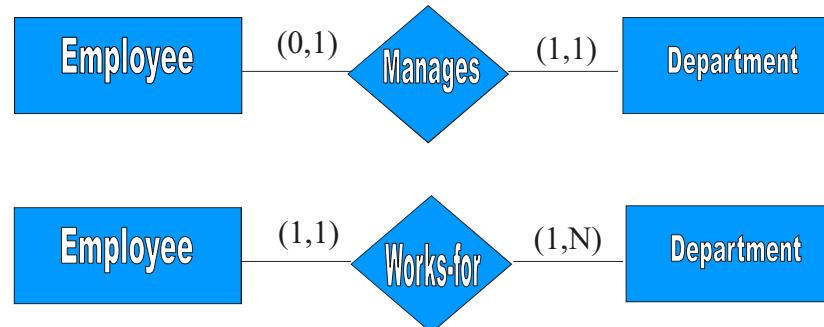
- Specified on *each participation* of an entity type E in a relationship type R
- Specifies that each entity e in E participates in *at least min* and *at most max* relationship instances in R
- Default (no constraint): min=0, max=n
- Must have $\text{min} \leq \text{max}$, $\text{min} \geq 0$, $\text{max} \geq 1$
- Derived from the knowledge of mini-world constraints

Alternative (min, max) notation for relationship structural constraints:

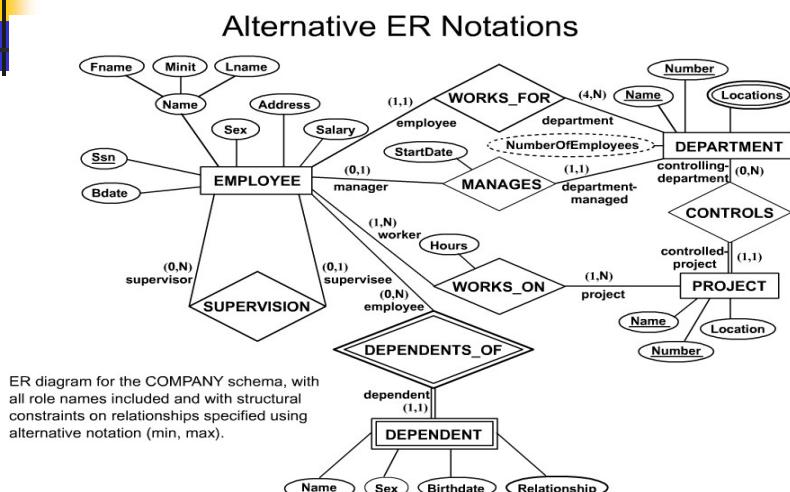
Examples:

- 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 (1,N) for participation of DEPARTMENT in WORKS_FOR

The (min,max) notation relationship constraints



COMPANY ER Schema Diagram using (min, max) notation





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