

# Entity Relationship Model (ER-Model)

CSI-406 Database Systems



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# Entity Relationship Model

- **Entity Relationship Model (ER Modeling)** is a *graphical approach* to database design (i.e. **conceptual design**).
- It is a high-level data **model** that defines *data elements* and their *relationship* for a specified software system.
- An **ER model** is used to represent **real-world objects (i.e. Entities)**.

# Entity Relationship Model cont...

## COMPANY Database

- Requirements of the Company (simplified 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.

# Entity Relationship Model cont...

## COMPANY Database

- 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.

# Entity Relationship Model cont...

## COMPANY Database

- 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.

# Entity Relationship Model cont...

## Entities and Attributes

- **Entities** are specific objects or things in the **mini-world** (Universe of Discourse) 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**.

# Entity Relationship Model cont...

## Entities and Attributes

- 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, ...

# Entity Relationship Model cont...

## Types of Attributes

- **Simple**: Each entity has a *single atomic value* for attribute. E.g., SSN or Sex.
- **Composite**: The attribute may be *composed of several components*. E.g., Address (Apt#, House#, Street, City, State, ZipCode, Country) or Name (FirstName, MiddleName, LastName).
- **Multi-valued**: An entity may have *multiple values for that attribute*. E.g., Contact of an EMPLOYEE or PreviousDegrees of a STUDENT.



# Entity Relationship Model cont...

## Types of Attributes

- 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 Relationship Model cont...

## 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* (*Primary Key*) of the entity type. For example, SSN of **EMPLOYEE**.

# Entity Relationship Model cont...

## Entity Types and Key Attributes

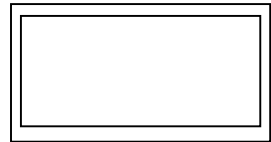
- A key attribute may be composite. For example, VehicleTagNumber is a key of the CAR entity type with components (Number, State).
- An entity type may have more than one key. For example, the CAR entity type may have two keys:
  - VehicleIdentificationNumber (popularly called VIN) and
  - VehicleTagNumber (Number, State), also known as license\_plate number.

# Entity Relationship Model cont...

## NOTATION FOR ER SCHEMAS



ENTITY TYPE



WEAK ENTITY TYPE



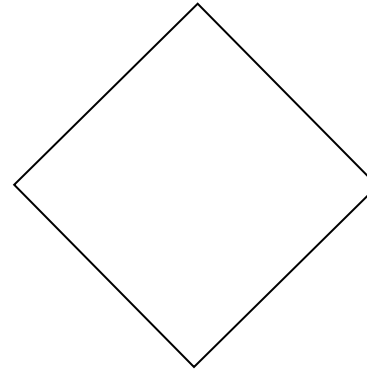
ATTRIBUTE



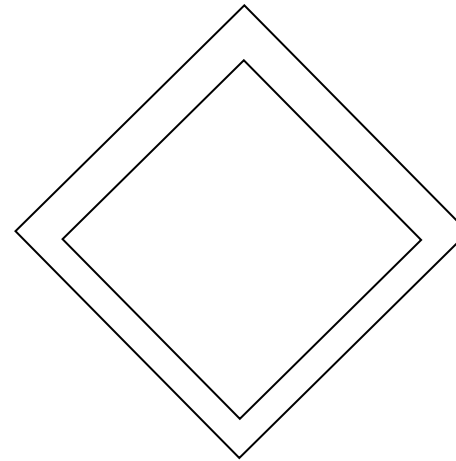
KEY ATTRIBUTE



MULTIVALUED ATTRIBUTE



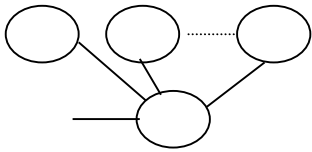
RELATIONSHIP TYPE



IDENTIFYING RELATIONSHIP TYPE

# Entity Relationship Model cont...

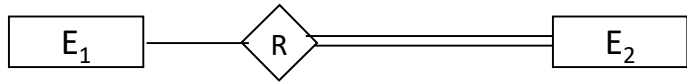
## NOTATION FOR ER SCHEMAS



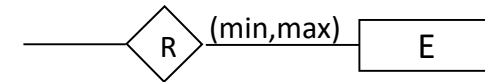
COMPOSITE ATTRIBUTE



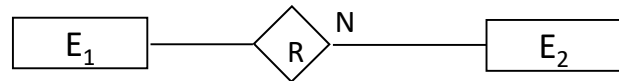
DERIVED  
ATTRIBUTE



TOTAL PARTICIPATION OF  $E_2$  IN R



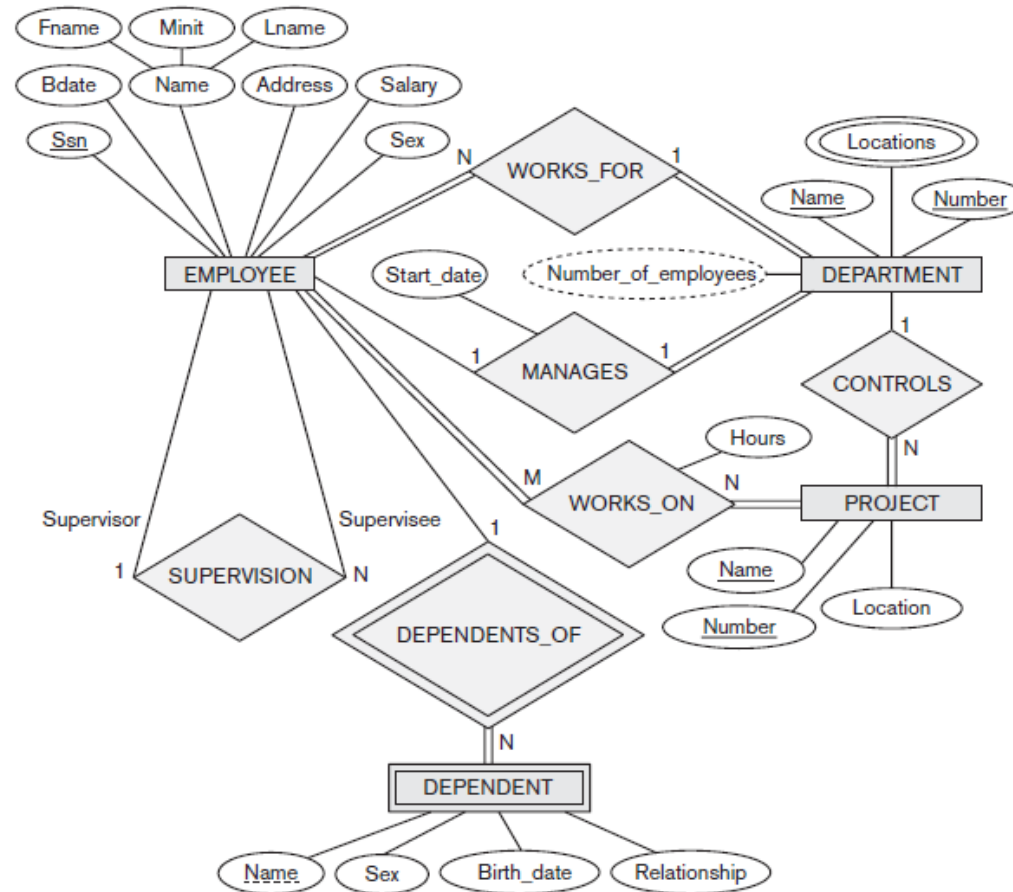
STRUCTURAL CONSTRAINT  
(min, max) ON PARTICIPATION  
OF E IN R



CARDINALITY RATIO 1:N FOR  $E_1:E_2$  IN R

# Entity Relationship Model cont...

## Types of Attributes



# Entity Relationship Model cont...

## Relationships & Relationship Types

- 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.

# Entity Relationship Model cont...

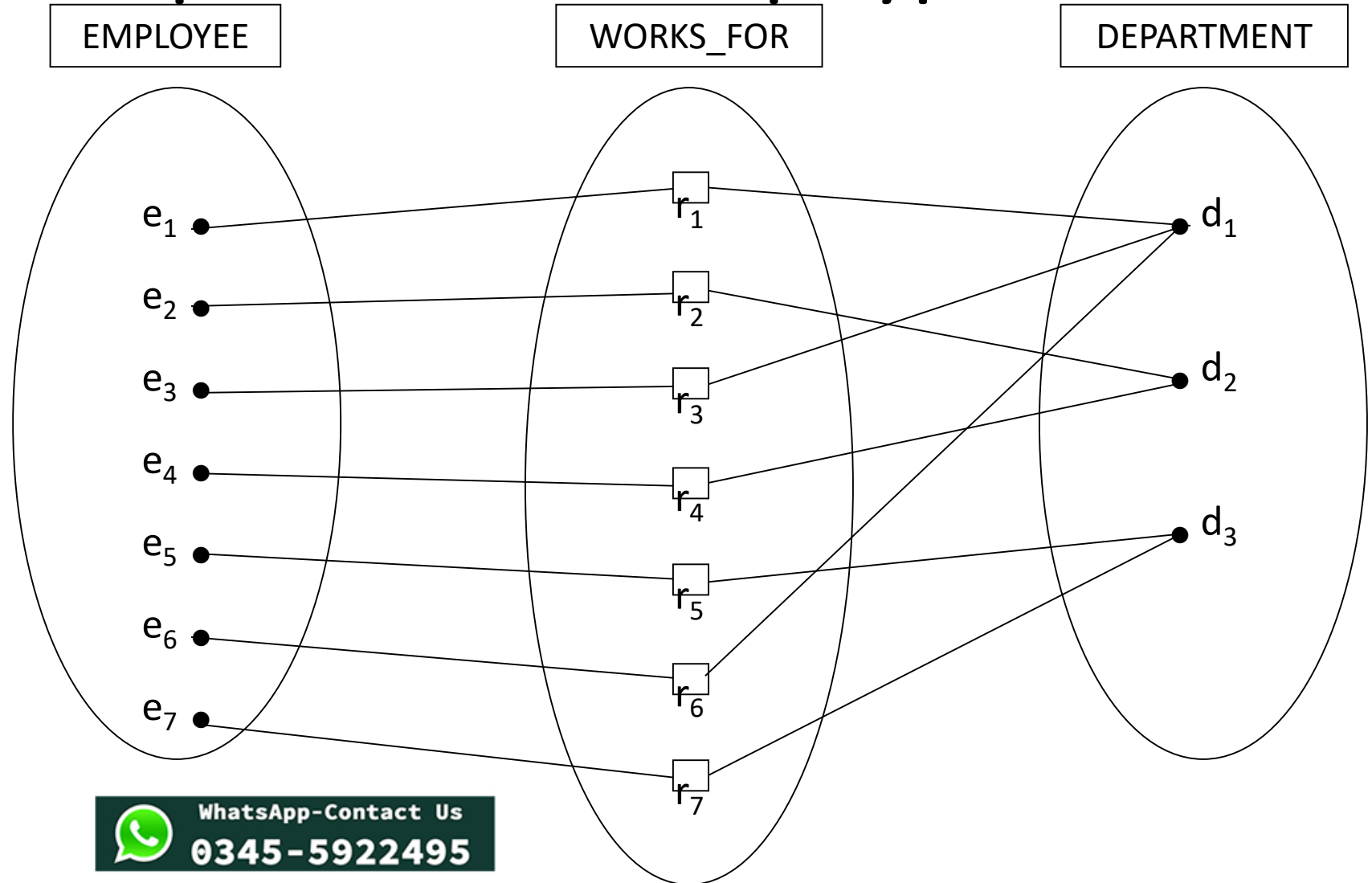
## Relationships & Relationship Types

- The *degree of a relationship type* is the *number of participating entity types*.
- Both **MANAGES** and **WORKS\_ON** are *binary relationships*.



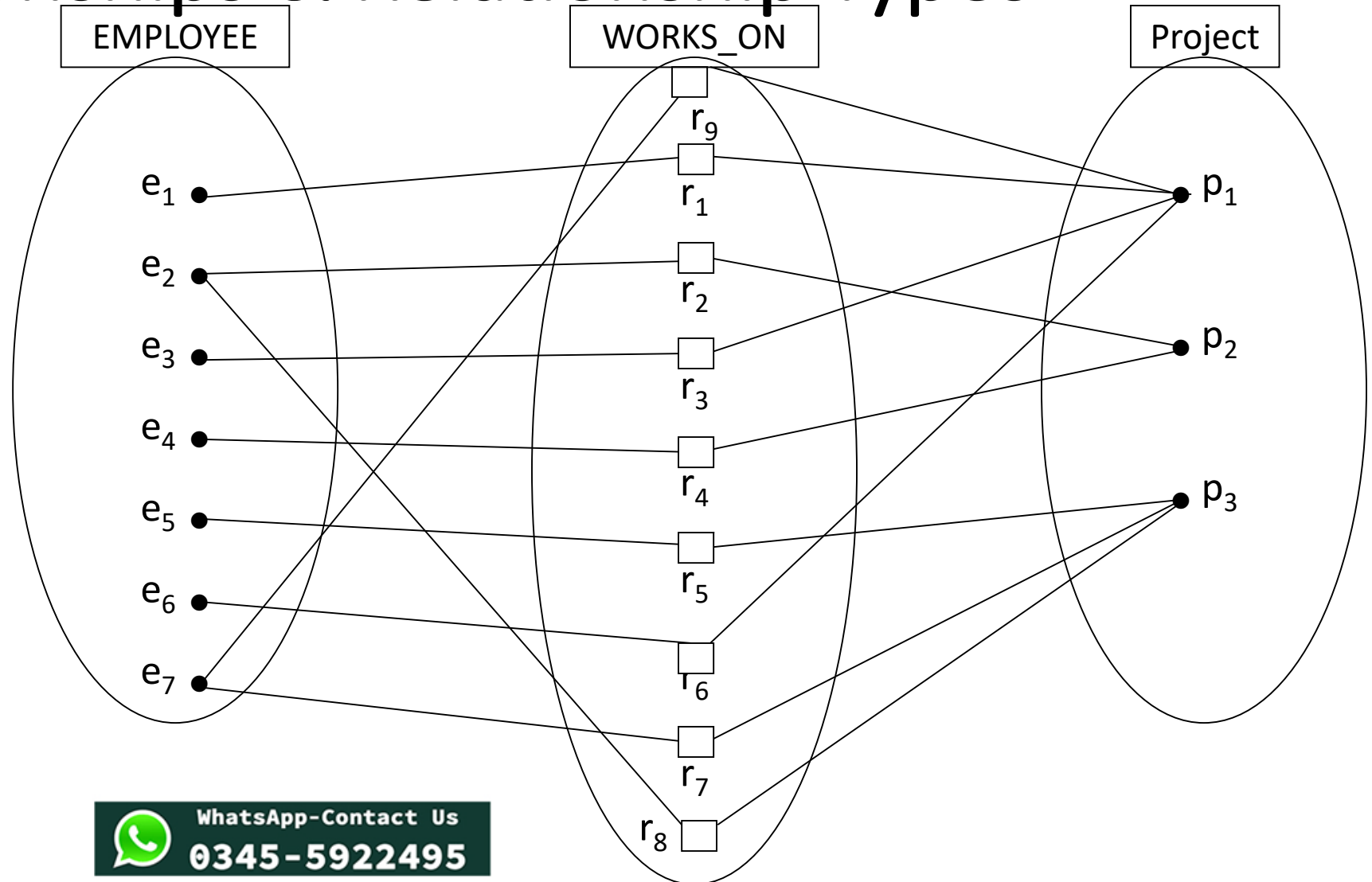
# Entity Relationship Model cont...

## Relationships & Relationship Types



# Entity Relationship Model cont...

## Relationships & Relationship Types



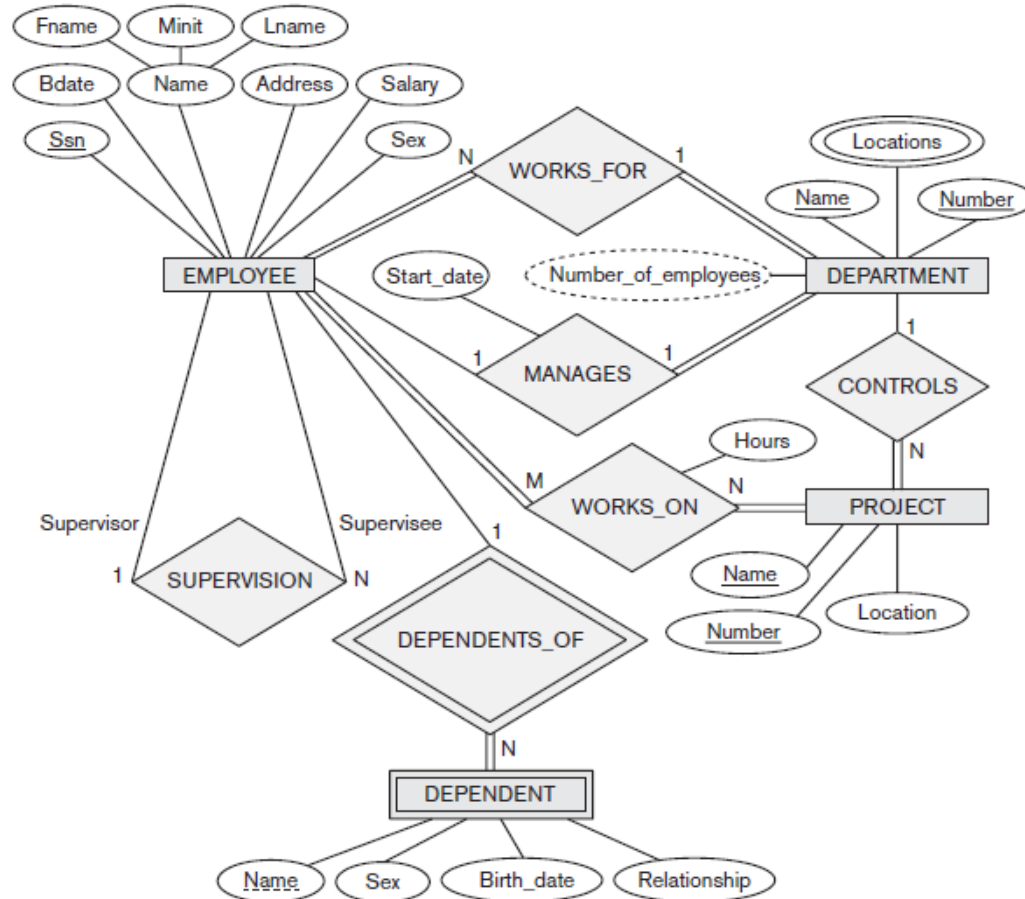
# Entity Relationship Model cont...

## Relationships & Relationship Types

- *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*.

# Entity Relationship Model cont...

## Relationships & Relationship Types



# Entity Relationship Model cont...

## Weak Entity Types

- Weak entity that **does not have a key attribute**. Weak entity also 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**

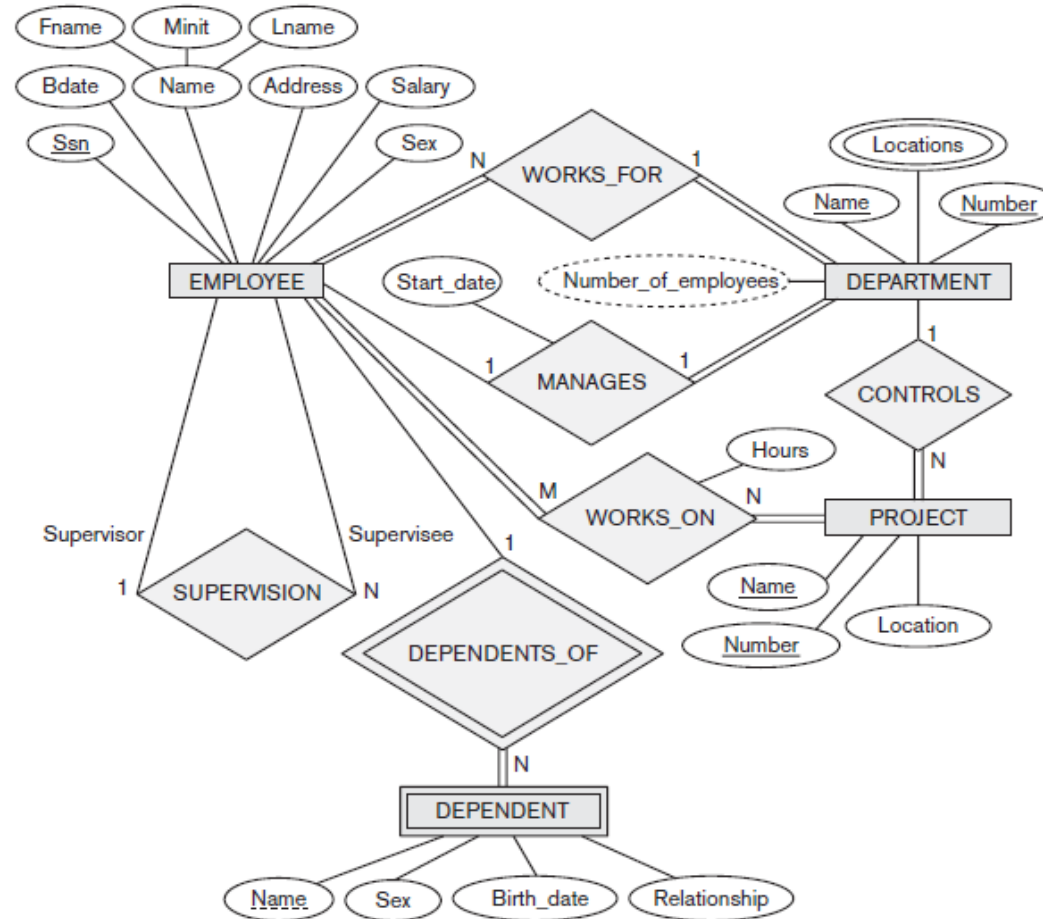
# Entity Relationship Model cont...

## Weak Entity Types

- **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**.

# Entity Relationship Model cont...

## Weak Entity Types



# Entity Relationship Model cont...

## Constraints on Relationships

- Constraints on Relationship Types, also known as **ratio constraints**, or **Maximum Cardinality**
- One-to-one (1:1)
- One-to-many (1:N) or Many-to-one (N:1)
- Many-to-many (M:N)



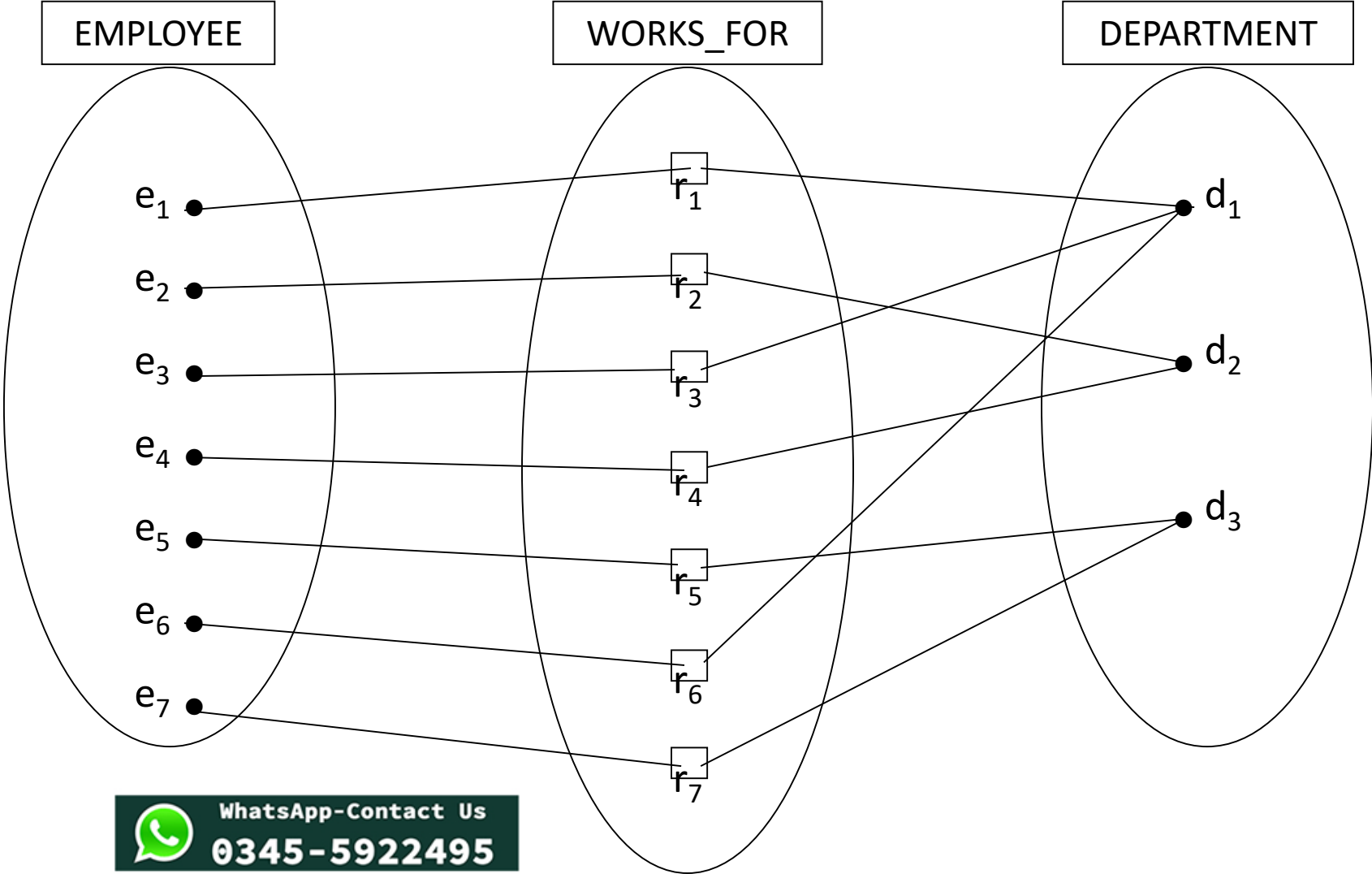
# Entity Relationship Model cont...

## Constraints on Relationships

- **Minimum Cardinality** (also called *participation constraint* or *existence dependency constraints*)
  - zero (**optional participation, not existence-dependent**)
  - one or more (**mandatory, existence-dependent**)

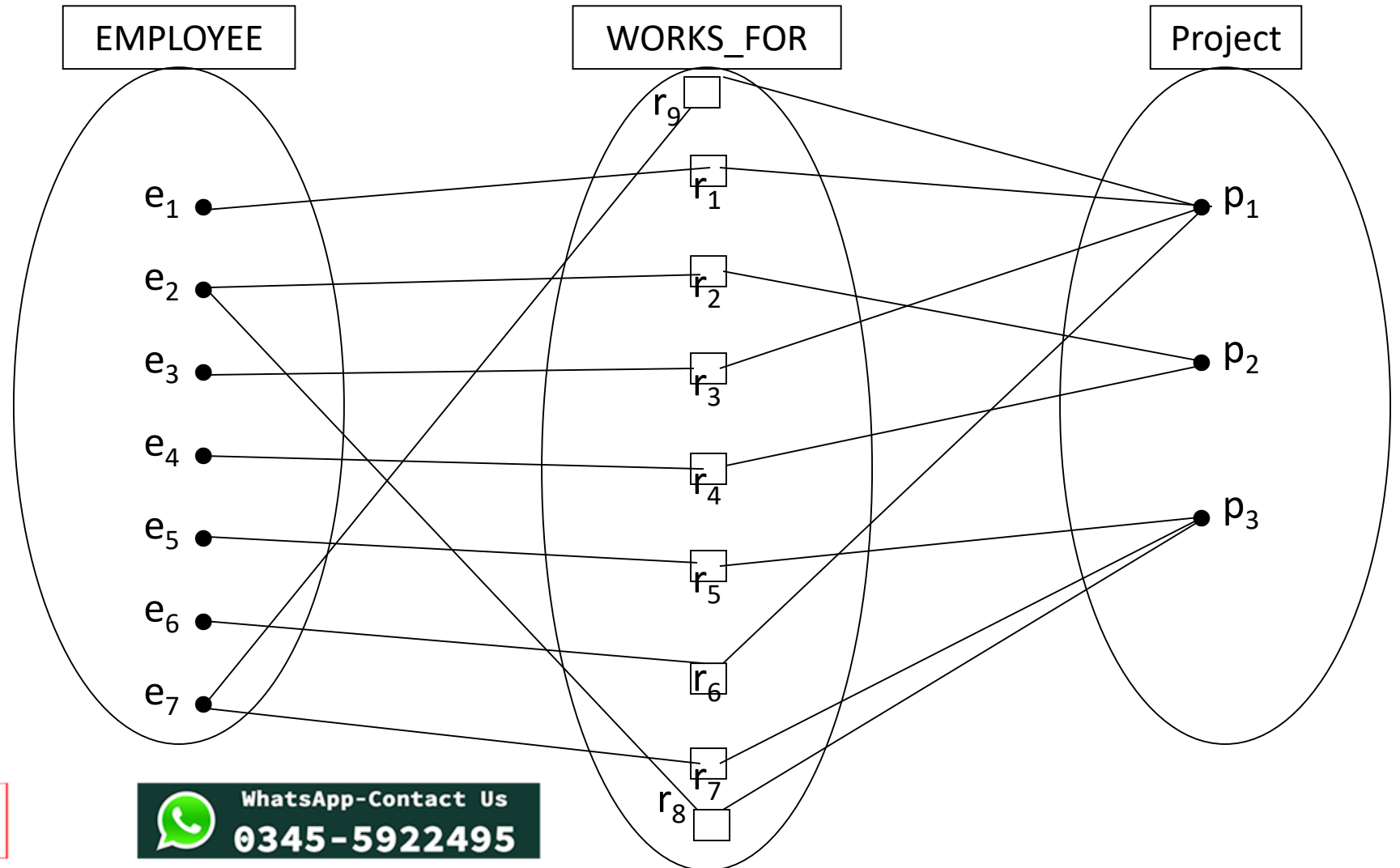
# Entity Relationship Model cont...

## Constraints on Relationships (N:1)



# Entity Relationship Model cont...

## Constraints on Relationships (M:N)



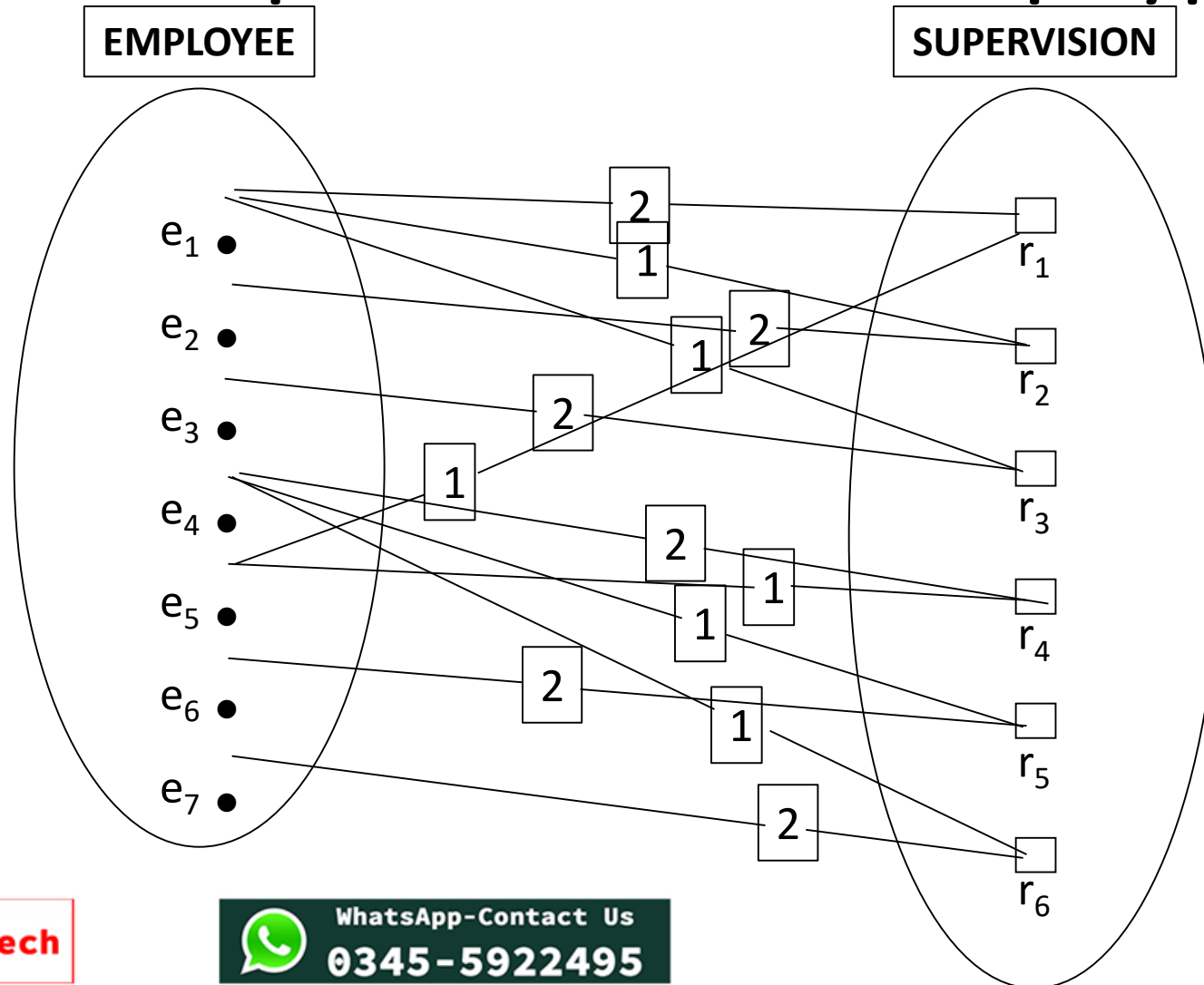
# Entity Relationship Model cont...

## Relationships and Relationship types

- 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.

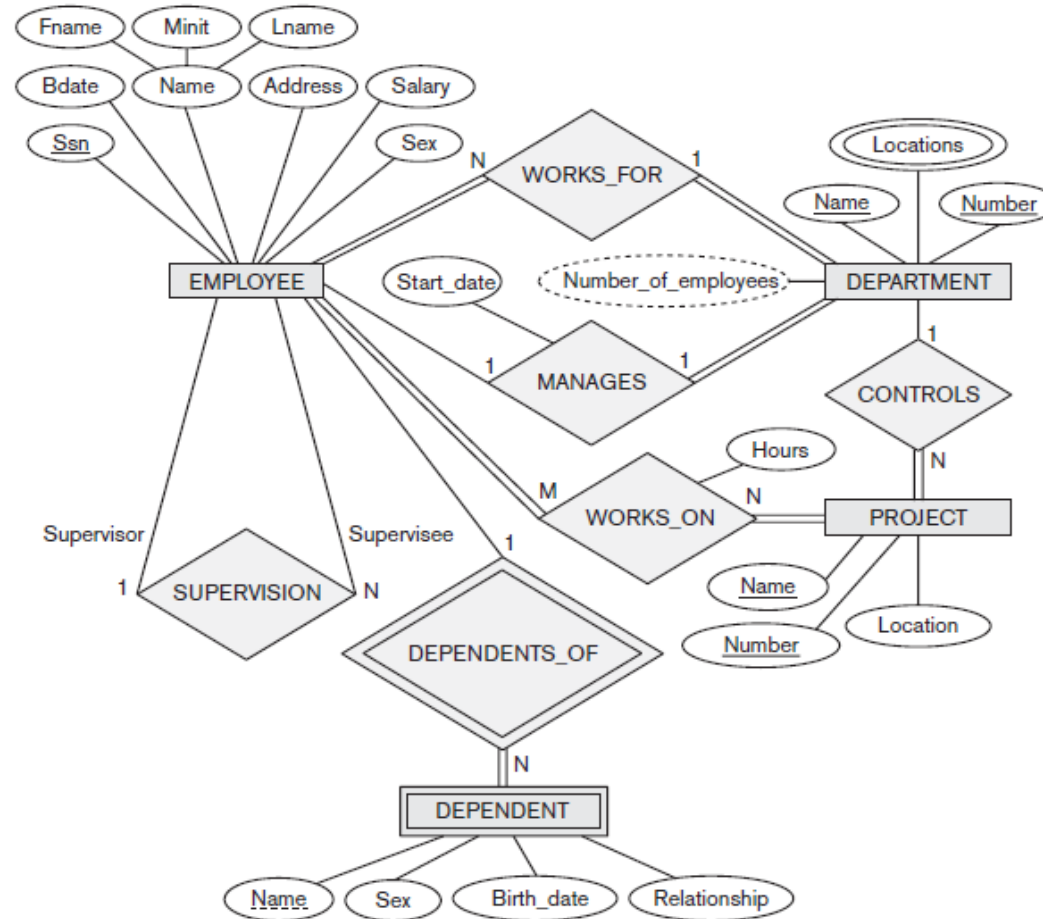
# Entity Relationship Model cont...

## Relationships and Relationship types



# Entity Relationship Model cont...

## Relationships and Relationship types



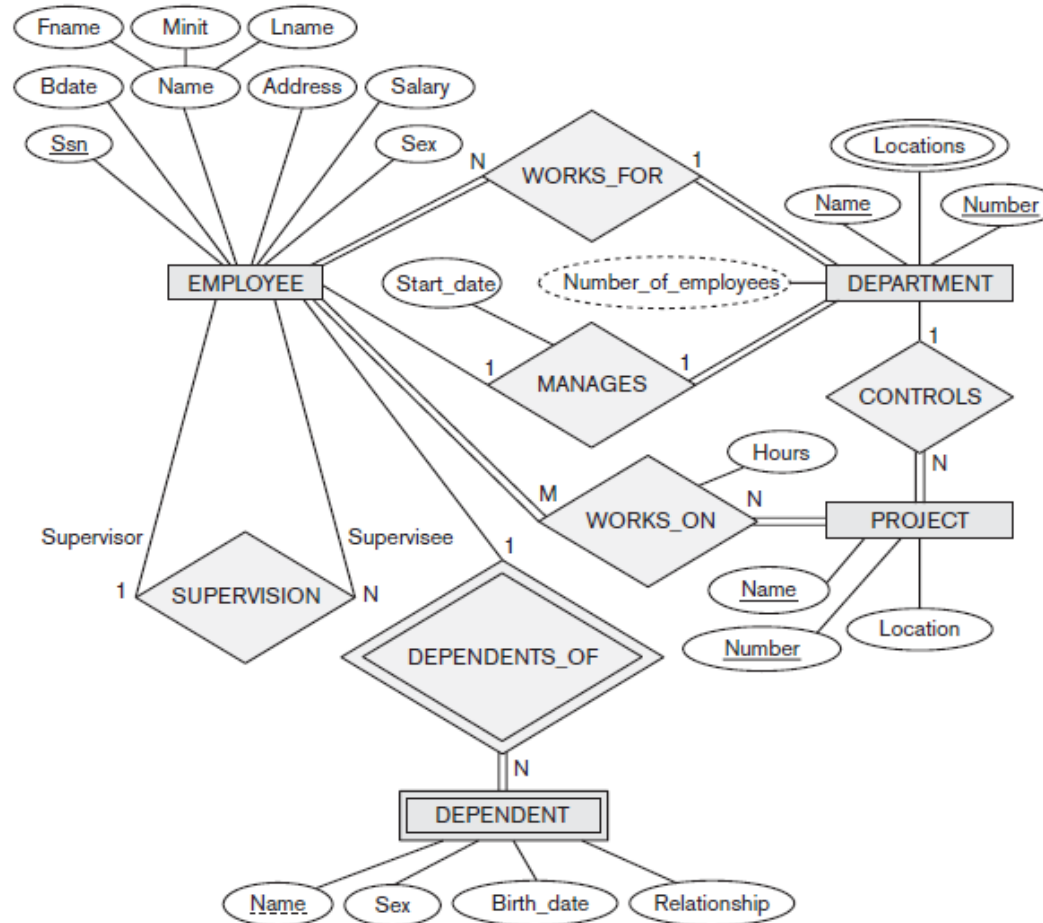
# Entity Relationship Model cont...

## 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.

# Entity Relationship Model cont...

## Attributes of Relationship types





# Entity Relationship Model cont...

## Structural Constraints (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***.

# Entity Relationship Model cont...

## Structural Constraints (semantics of relationships)

- Shown by double lining the link
- **NOTE:** These are easy to specify for Binary Relationship Types.

# Entity Relationship Model cont...

Alternative (min, max) notation for relationship structural constraints

- Specified on each participation of entity type E in 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

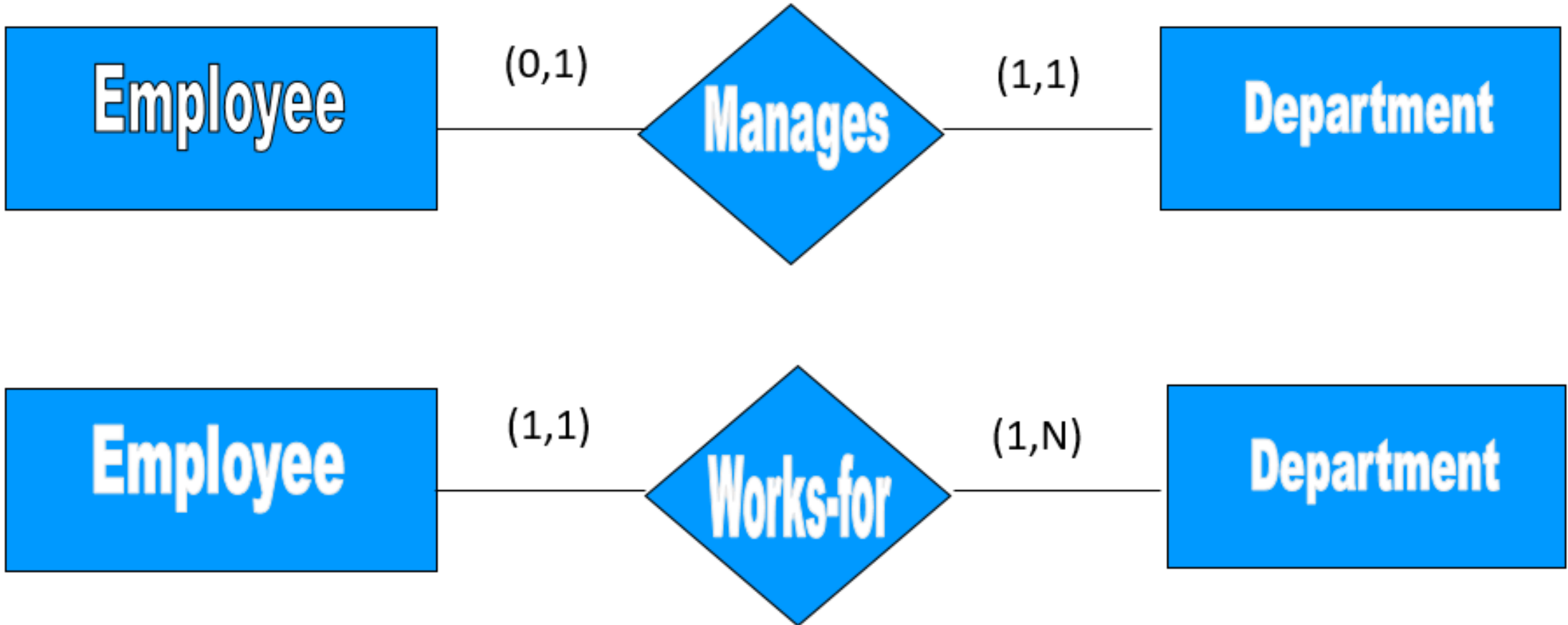
# Entity Relationship Model cont...

## 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 (0,n) for participation of DEPARTMENT in WORKS\_FOR

# Entity Relationship Model cont...

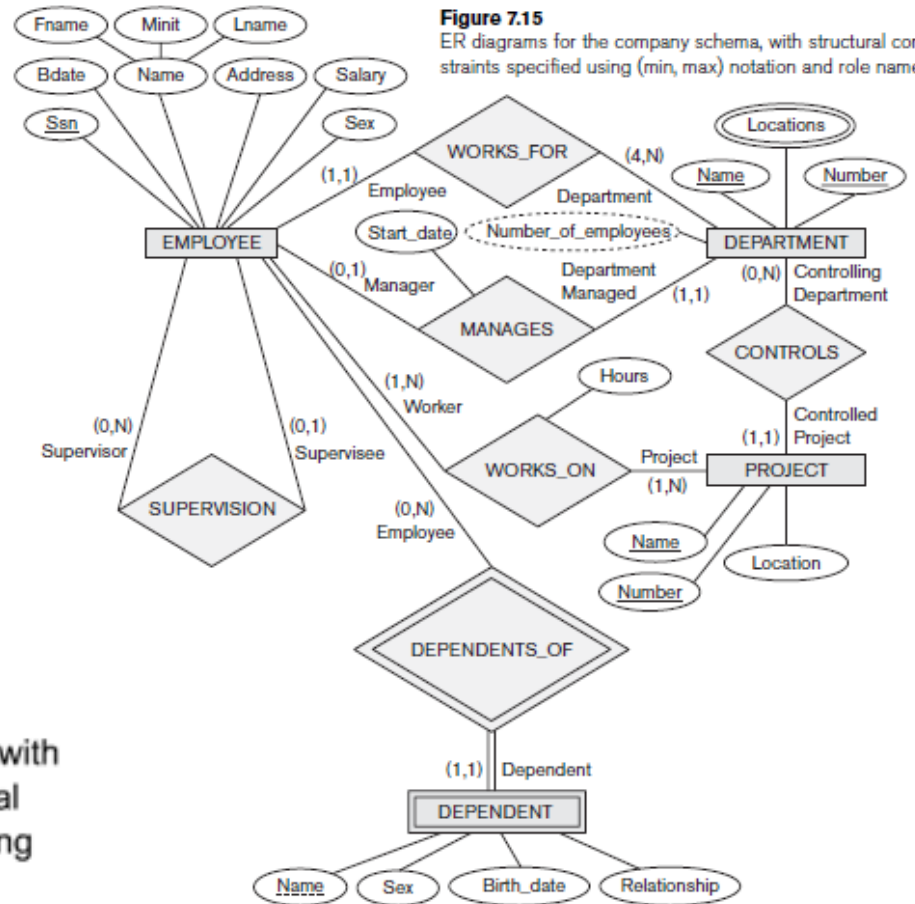
Alternative (min, max) notation for relationship structural constraints



# Entity Relationship Model cont...

Alternative (min, max) notation for relationship structural constraints

## Alternative ER Notations



**Figure 7.15**  
ER diagrams for the company schema, with structural constraints specified using (min, max) notation and role names.

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

# Entity Relationship Model cont...

## Relationships of Higher Degree

- Relationship types of degree 2 are called **binary**
- Relationship types of degree 3 are called **ternary** and of degree n are called **n-ary**
- In general, an n-ary relationship *is not* equivalent to n binary relationships

# Entity Relationship Model cont...

## Data Modeling Tools

- A number of popular tools that cover conceptual modeling and mapping into relational schema design. Examples: ERWin, S- Designer (Enterprise Application Suite), ER- Studio, etc.
- POSITIVES: serves as documentation of application requirements, easy user interface - mostly graphics editor support



# Entity Relationship Model cont...

## Problems with Current Modeling Tools

- **DIAGRAMMING**

- Poor conceptual meaningful notation.
- To avoid the problem of layout algorithms and aesthetics of diagrams, they prefer boxes and lines and do nothing more than represent (primary-foreign key) relationships among resulting tables.(a few exceptions)

# Entity Relationship Model cont...

## Problems with Current Modeling Tools

- **METHODOLOGY**

- lack of built-in methodology support.
- poor tradeoff analysis or user-driven design preferences.
- poor design verification and suggestions for improvement.

# Entity Relationship Model cont...

## Automated Database Design Tools

<b><u>COMPANY</u></b>	<b><u>TOOL</u></b>	<b><u>FUNCTIONALITY</u></b>
Embarcadero Technologies	ER Studio	Database Modeling in ER and IDEF1X
	DB Artisan	Database administration and space and security management
Oracle	Developer 2000 and Designer 2000	Database modeling, application development
Popkin Software	System Architect 2001	Data modeling, object modeling, process modeling, structured analysis/design
Platinum Technology	Platinum Enterprise Modeling Suite: Erwin, BPWin, Paradigm Plus	Data, process, and business component modeling
Persistence Inc.	Pwertier	Mapping from O-O to relational model
Rational	Rational Rose	Modeling in UML and application generation in C++ and JAVA
Rogue Ware	RW Metro	Mapping from O-O to relational model
Resolution Ltd.	Xcase	Conceptual modeling up to code maintenance
Sybase	Enterprise Application Suite	Data modeling, business logic modeling
Visio	Visio Enterprise	Data modeling, design and reengineering Visual Basic and Visual C++

# Entity Relationship Model cont...

## ERD for a Bank Database

