

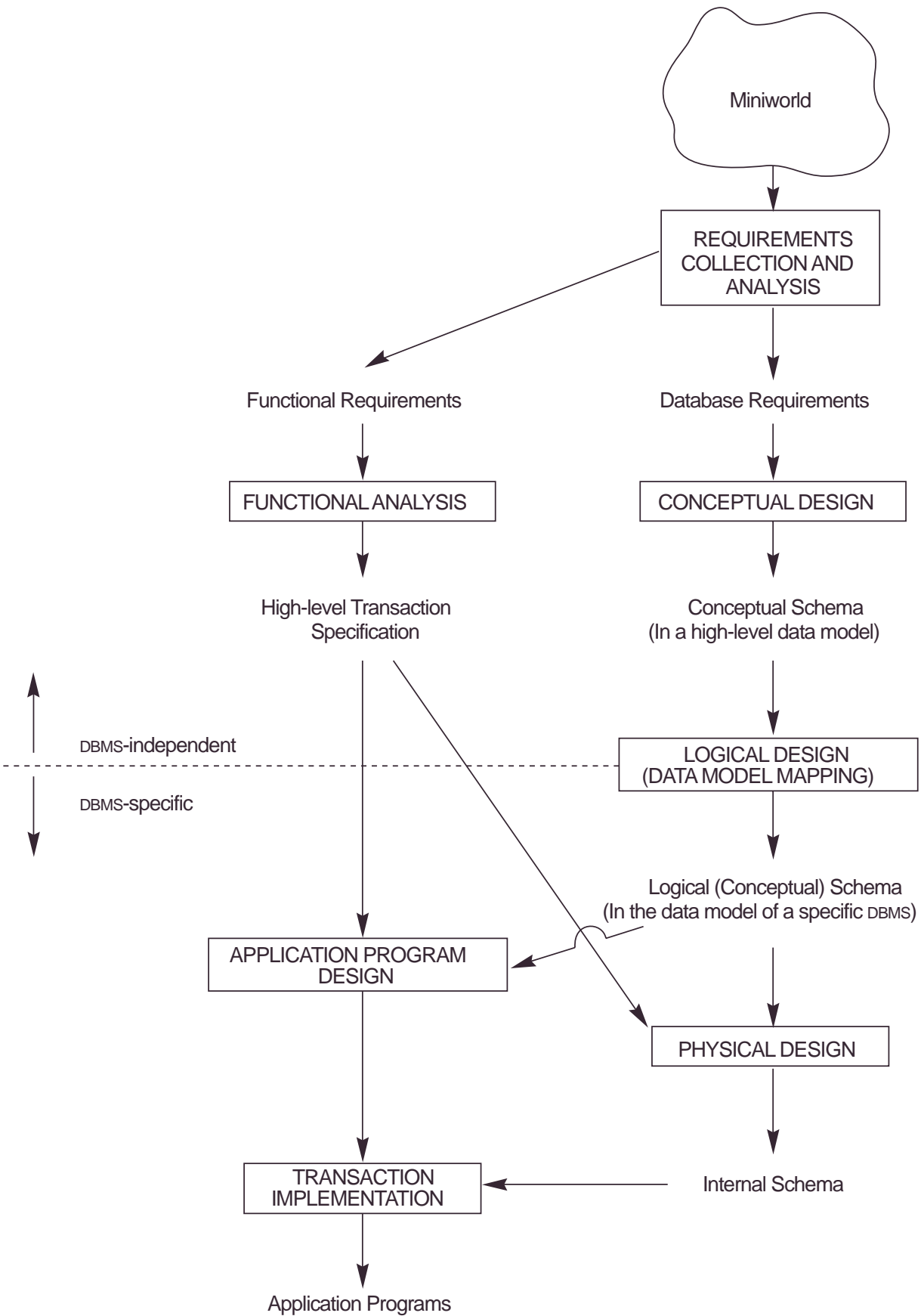
Chapter 3: Entity Relationship Model

Database Design Process

- Use a high-level conceptual data model (ER Model).
- Identify objects of interest (entities) and relationships between these objects
- Identify constraints (conditions)
- End result is an E-R Diagram that captures all entity, relationship types and constraints

Figure 3.1 Phases of Database Design

Figure 3.1 A simplified diagram to illustrate the main phases of database design.



Example Database Application (Company Database)

Company organized into **DEPARTMENTS**. Each department has unique name and a particular employee who manages the department. Start date for the manager is recorded. Department may have several locations.

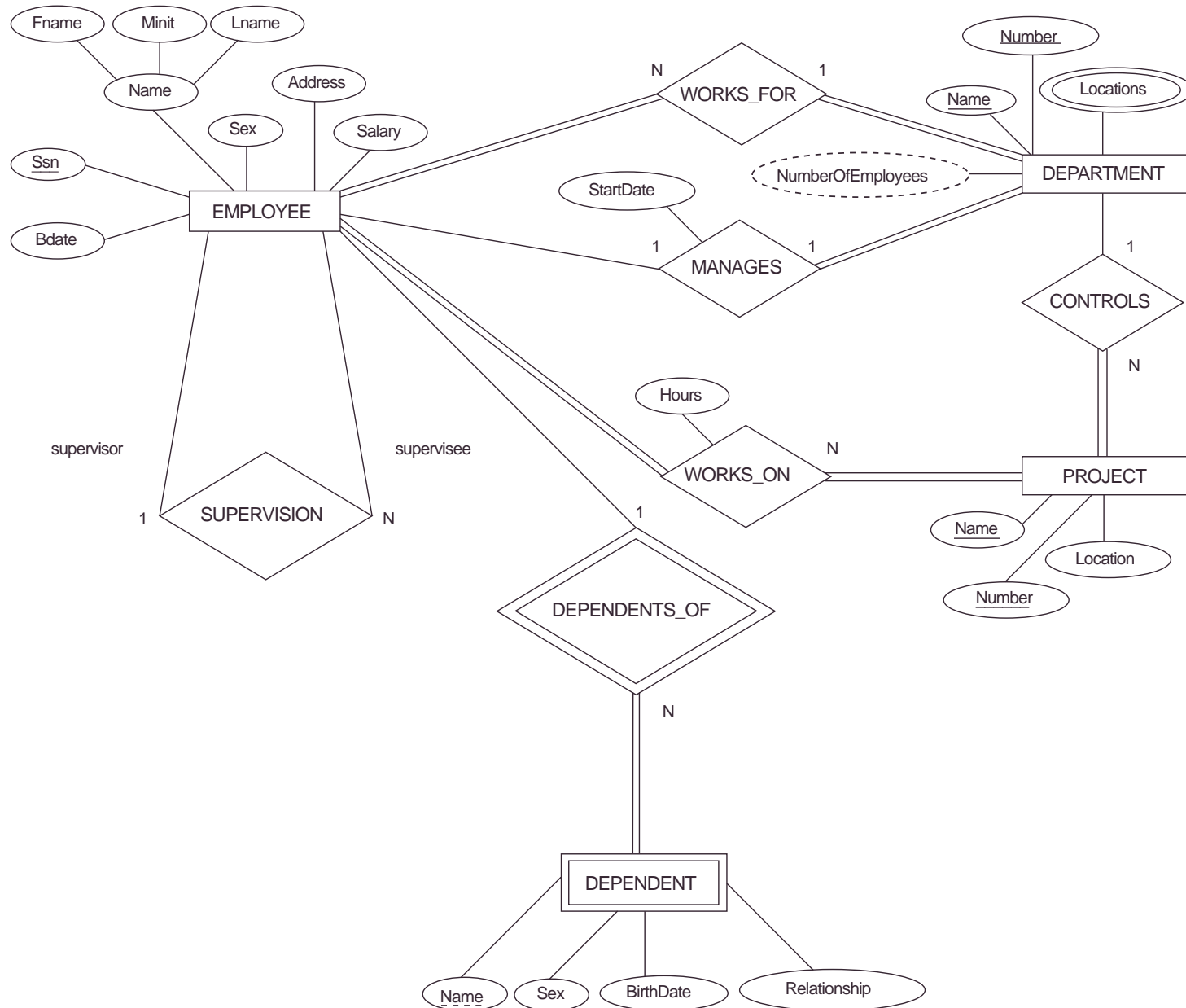
A department controls a number of **PROJECTS**. Projects have a unique name, number and a single location.

Company's **EMPLOYEEs** name, ssno, address, salary, sex and birth date are recorded. An employee is assigned to one department, but may work for several projects (not necessarily controlled by her dept). Number of hours/week an employee works on each project is recorded; The immediate supervisor for the employee.

Employee's **DEPENDENTs** are tracked for health insurance purposes (dependent name, birthdate, relationship to employee).

Figure 3.2: ER Diagram

Figure 3.2 ER schema diagram for the company database.



Entities and Attributes

Entity: an object in the real world with an independent existence.

Attribute: Property that describes an aspect of the entity.

Figure 3.3

Attribute types:

Simple vs Composite (Figure 3.4)

Single-valued vs Multi-valued (e.g. Locations for DEPARTMENT)

Stored vs Derived (e.g. NumberOfEmployees for DEPARTMENT)

Figure 3.5: example of a complex attribute with multi-valued and composite components

Null values for attributes: Not applicable, Unknown (Missing; not known if applicable)

Figure 3.3 Two entities, an employee e_1 and a company c_1 , and their attribute values.

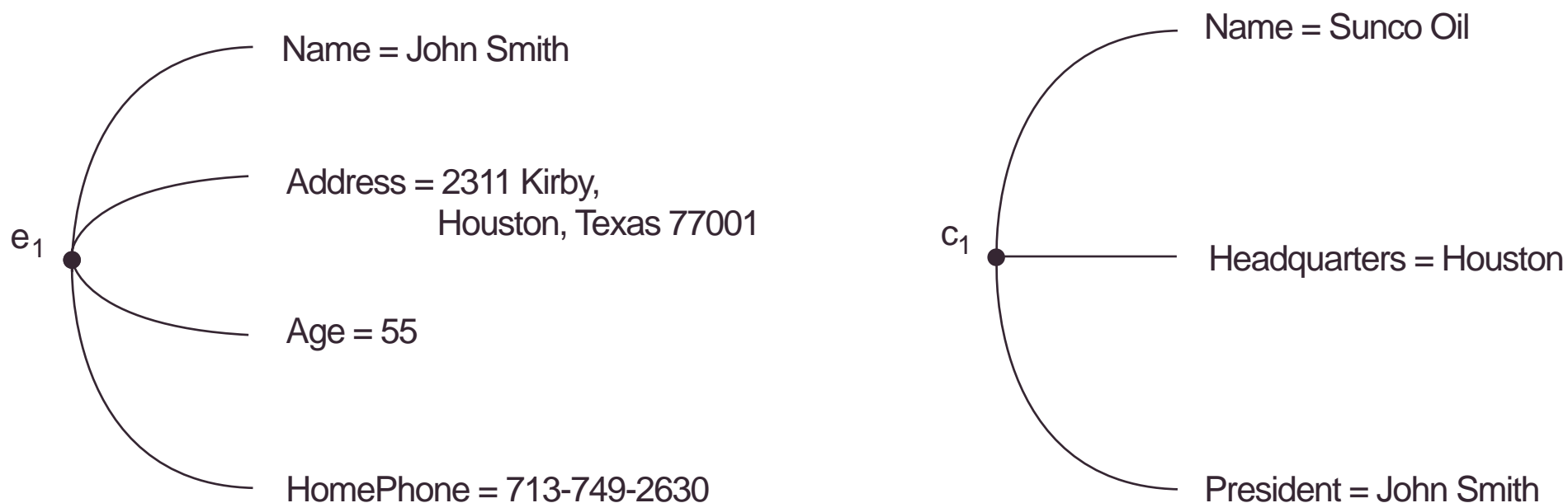


Figure 3.4 A hierarchy of composite attributes; the StreetAddress component of an Address is further composed of Number, Street, and ApartmentNumber.

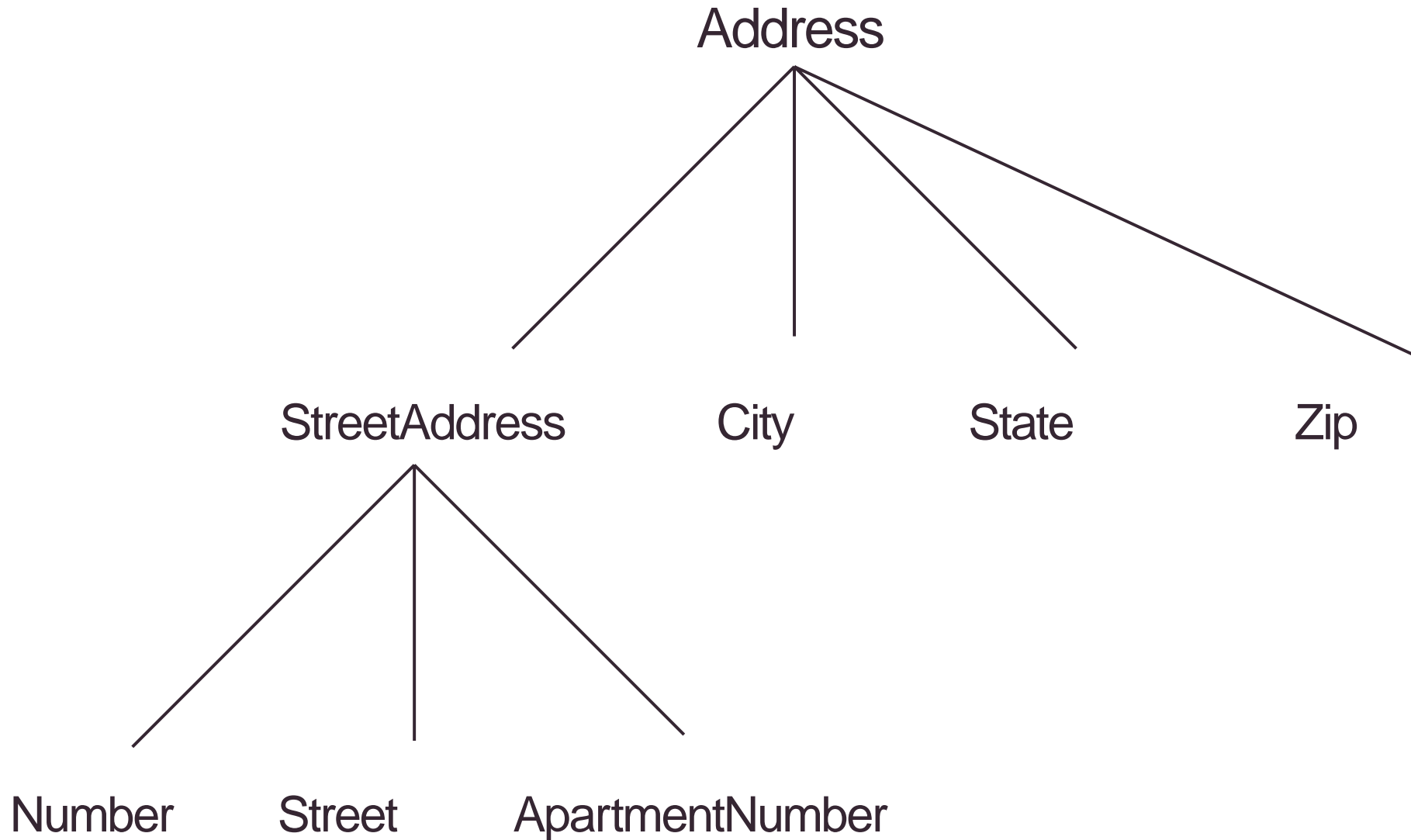


Figure 3.5 A complex attribute AddressPhone with multivalued and composite components.

```
{AddressPhone( {Phone(AreaCode,PhoneNumber)},  
Address(StreetAddress(Number,Street,ApartmentNumber),  
City,State,Zip) ) }
```


Entity Types, Value Sets, Key Attributes

An entity type defines a set of entities that have the same attributes.
See Figure 3.6

Rectangular box in ER Diagram denotes Entity Types

Ovals denote Attributes

double-ovals: multi-valued attribute

tree structured ovals: composite attribute

Entity Set = Set of all entities of the same type.

Key Attributes: uniquely identify each entity within an entity set
(these are underlined in the ER Diagram)

Value Sets: or Domains for attributes.

$A: E \rightarrow P(V)$ A:attribute, E:Entity set, V: Value set

$V = P(V_1) \times \dots \times P(V_n)$ for composite attributes

$A(e)$ denotes the value of attribute A for entity e

Figure 3.7 Car Entity Type

Figure 3.6 Two entity types named EMPLOYEE and COMPANY, and some of the member entities in the collection of entities (or entity set) of each type.

ENTITY TYPE NAME:

EMPLOYEE

COMPANY

Name, Age, Salary

Name, Headquarters, President

**ENTITY SET:
(EXTENSION)**

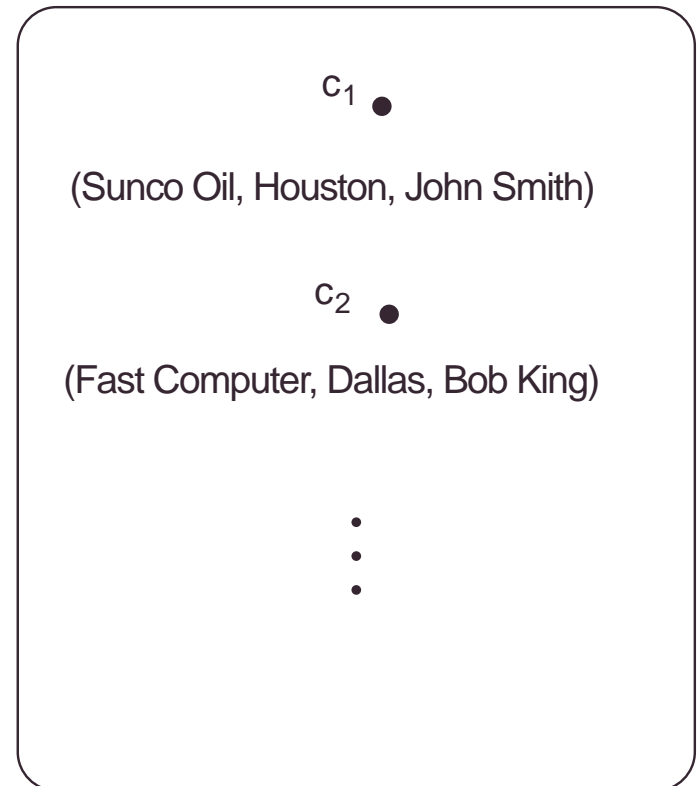
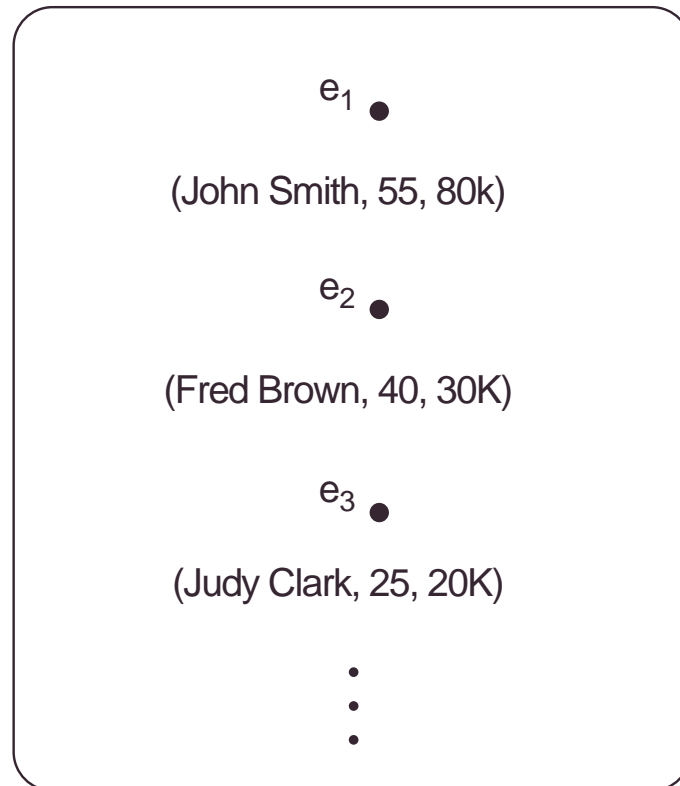


Figure 3.7 The CAR entity type, with two key attributes Registration and VehicleID. Multivalued attributes are shown between set braces { }. Components of a composite attribute are shown between parentheses ().

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

car₁ ●

((ABC 123, TEXAS), TK629, Ford Mustang, convertible, 1998, {red, black})

car₂ ●

((ABC 123, NEW YORK), WP9872, Nissan Maxima, 4-door, 1999, {blue})

car₃ ●

((VSY 720, TEXAS), TD729, Chrysler LeBaron, 4-door, 1995, {white, blue})

•
•
•

Initial design of the COMPANY DATABASE

Figure 3.8

4 entity types:

DEPARTMENT

EMPLOYEE

PROJECT

DEPENDENT

Not a perfect design! because it captures relationships between entities as attributes (in general not a good idea)

Figure 3.8 Preliminary design of entity types for the COMPANY database whose requirements are described in Section 3.2.

DEPARTMENT

Name, Number, {Locations}, Manager, ManagerStartDate

PROJECT

Name, Number, Location, ControllingDepartment

EMPLOYEE

Name (FName, MInit, LName), SSN, Sex, Address, Salary, BirthDate, Department, Supervisor, {WorksOn (Project, Hours)}

DEPENDENT

Employee, DependentName, Sex, BirthDate, Relationship

Relationships, Roles, Structural Constraints

Relationship type: R among n Entity types E_1, \dots, E_n

defines a set of associations among entities from these types.

each association will be denoted as:

(e_1, \dots, e_n) where e_i belongs to E_i , $1 \leq i \leq n$.

ex. WORKS_FOR relationship in Figure 3.9

Degree of relationship = n (usually $n = 2$, binary relationship)

Ternary relationship: Figure 3.10

Relationships as attributes (e.g. Dept -- Empl relationship

can be viewed as two attributes one in Dept. and the other in

Empl)

Figure 3.9 Some instances of the WORKS_FOR relationship between EMPLOYEE and DEPARTMENT.

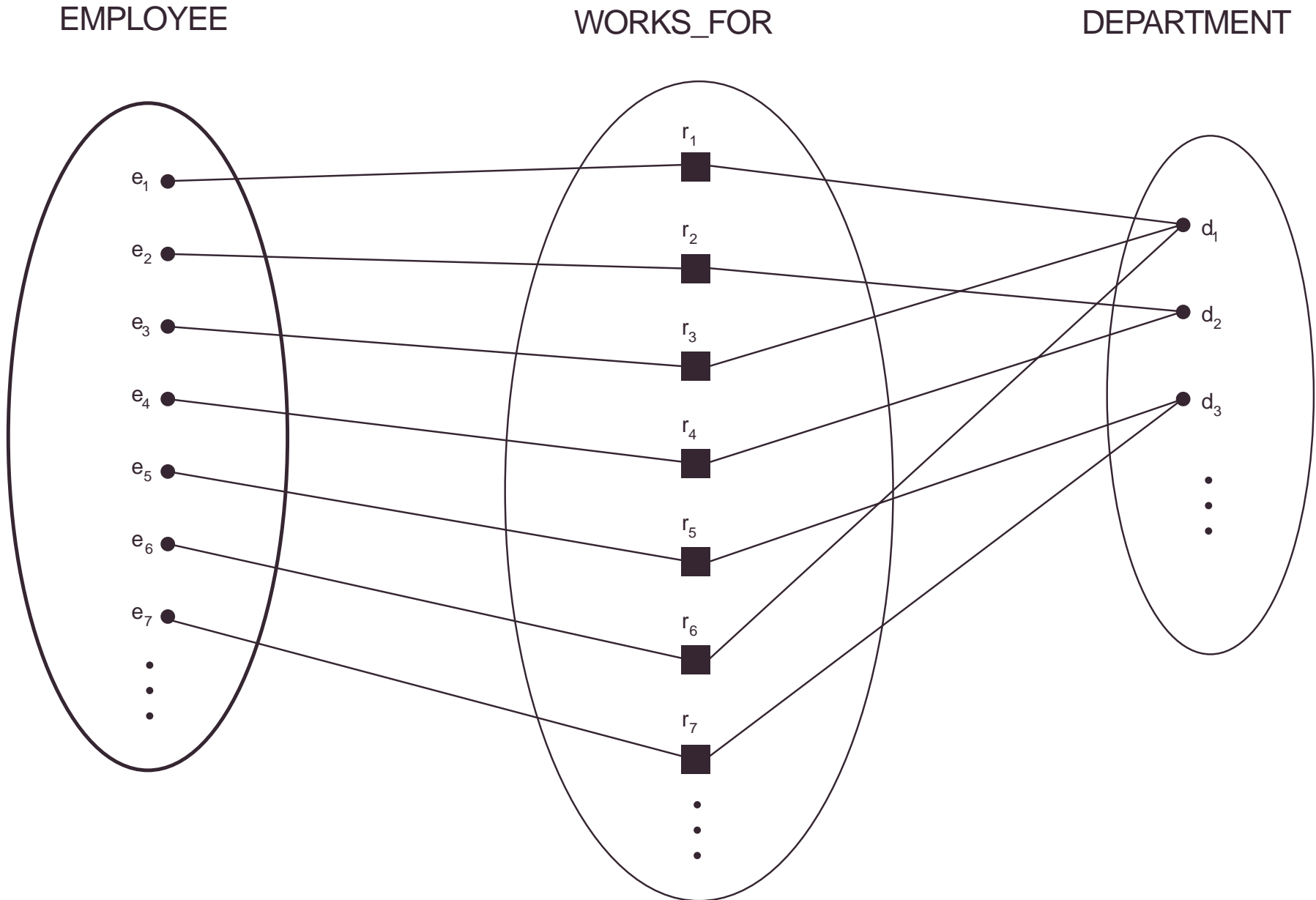
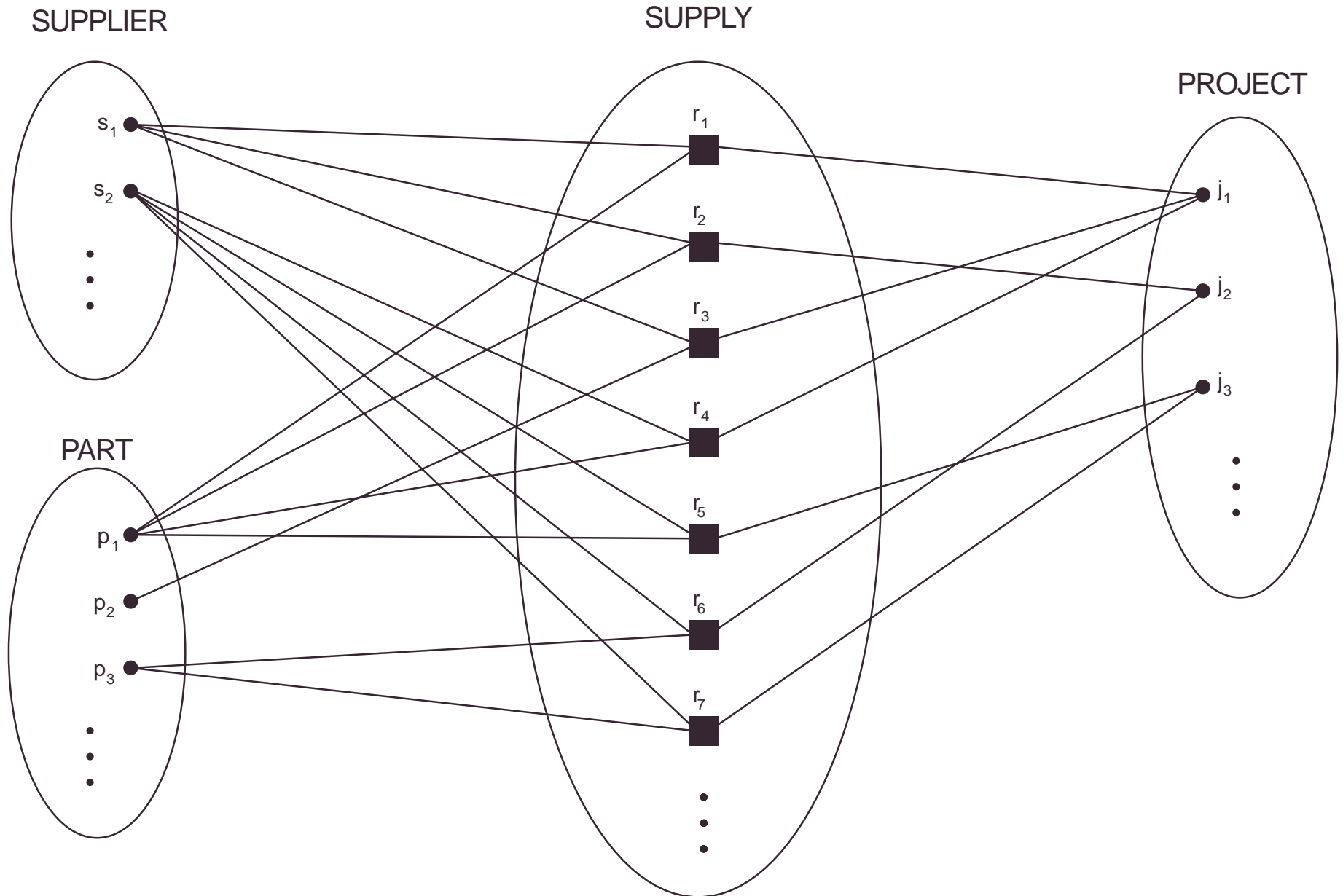


Figure 3.10 Some relationship instances of a ternary relationship SUPPLY.

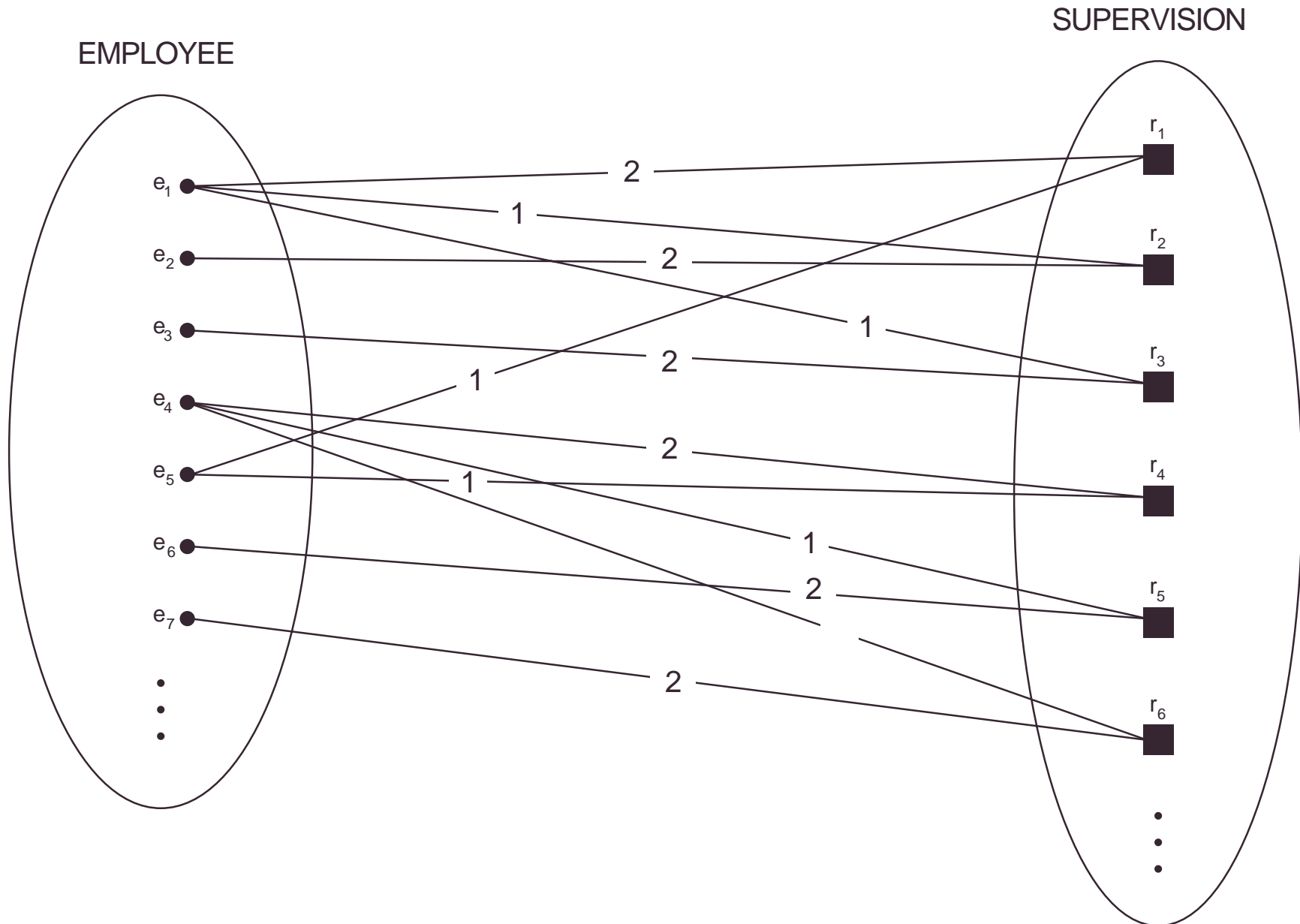


Role names

Each entity participating in a relationship has a ROLE.
e.g. Employee plays the role of worker and Department
plays the role of employer in the WORKS_FOR relationship
type

Role names are more important in recursive relationships
ex. Figure 3.11

Figure 3.11 The recursive relationship SUPERVISION, where the EMPLOYEE entity type plays the two roles of supervisor (1) and supervisee (2).



Structural Constraints on Relationships

2 types:

Cardinality Ratio Constraint (1-1, 1-N, M-N)

Participation Constraint

- * total participation (existence dependency)

- * partial participation

Figures 3.12 and 3.13

In ER Diagrams:

- total participation is denoted by double line and

- partial participation by single line

- cardinality ratios are mentioned as labels of edges

Figure 3.12 The 1:1 relationship MANAGES, with partial participation of employee and total participation of DEPARTMENT.

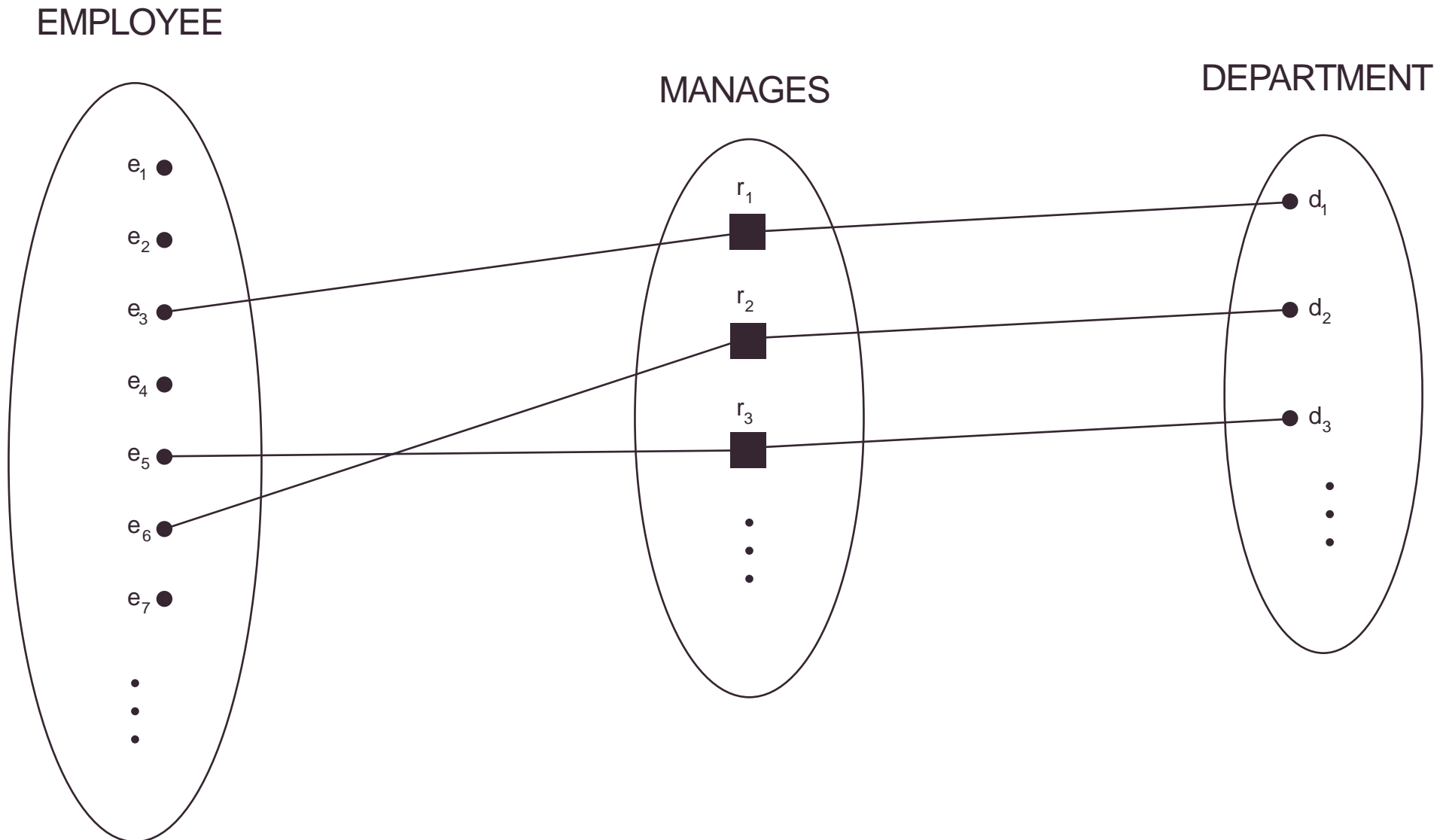
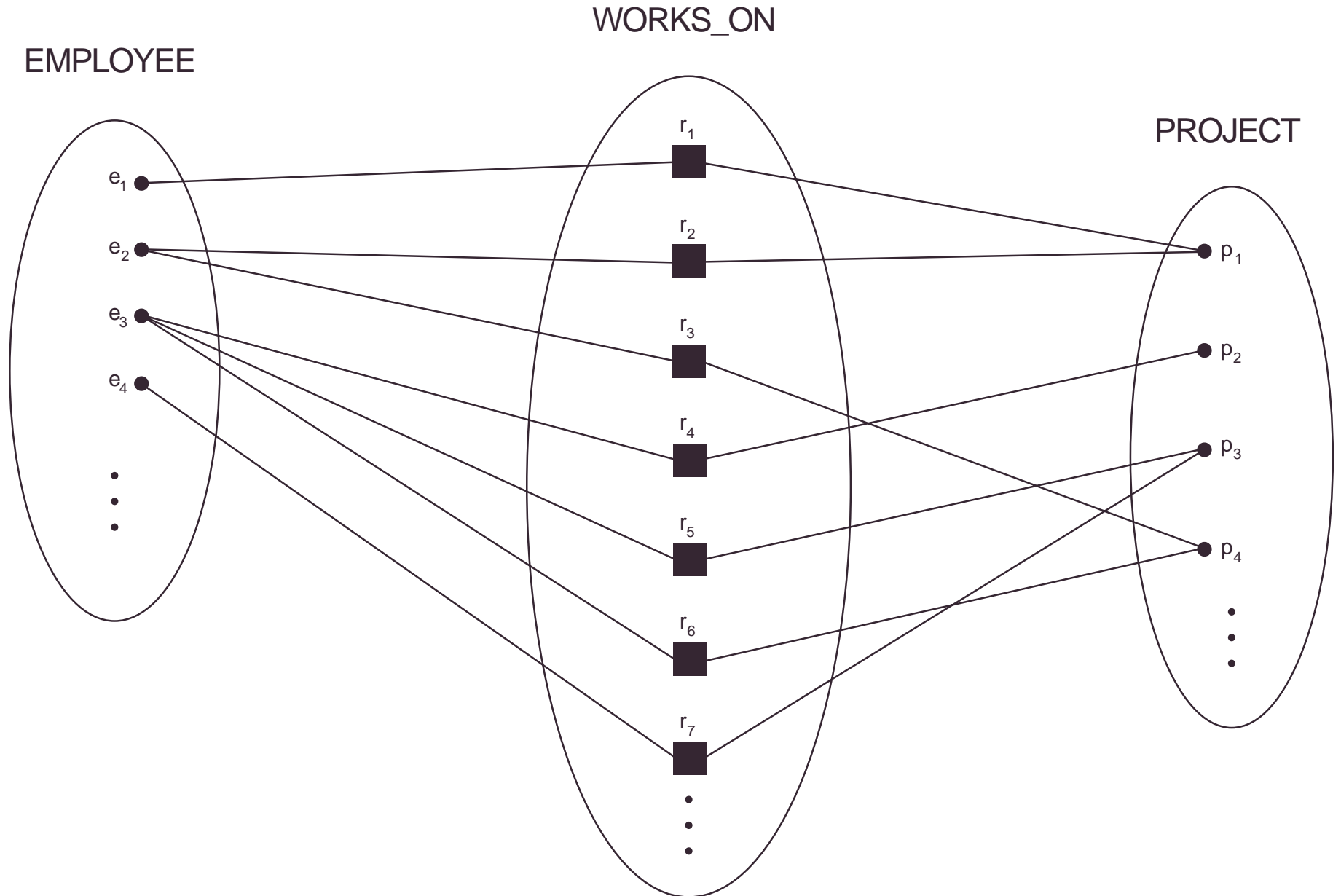


Figure 3.13 The M:N relationship WORKS_ON between EMPLOYEE and PROJECT.



Attributes of relationships:

e.x. Hours attribute for WORKS_ON relationship

If relationship is 1-N or 1-1, these attributes can be be migrated to the entity sets involved in the relationship.

1-N: migrate to N side

1-1: migrate to either side

Weak Entity Types:

Entity Types that do not have key attributes.

Such entities are identified by being related to other entity sets called **identifying owner**.

This relationship is called **identifying relationship**.

Partial key: attributes that uniquely identify entities within the identifying relationship.

A weak entity type always has TOTAL participation.

Ex. DEPENDENT is a weak entity type.

Notation for ER Diagrams:

Fig 3.14, 3.15

(Min,Max) notation encapsulates both types of structural constraints. This is more general than previous notation.

Min ≥ 1 implies TOTAL participation

Min = 0 implies PARTIAL participation

Figure 3.14 Summary of ER diagram notation.



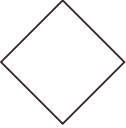
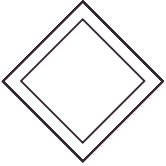


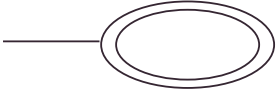
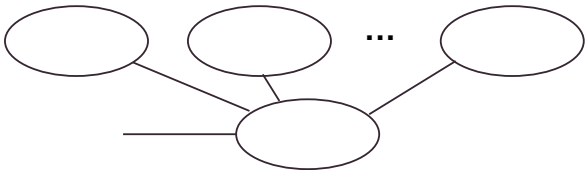

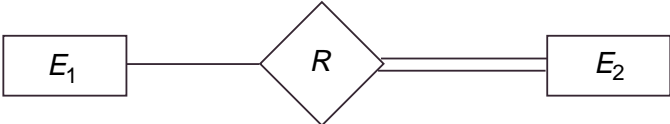
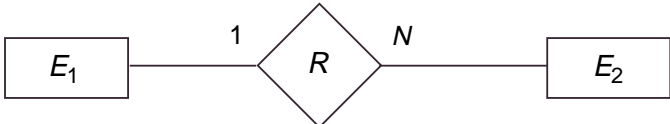
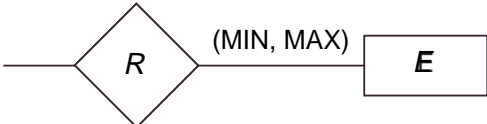
Symbol	Meaning
	ENTITY TYPE
	WEAK ENTITY TYPE
	RELATIONSHIP TYPE
	IDENTIFYING RELATIONSHIP TYPE
	ATTRIBUTE
	KEY ATTRIBUTE
	MULTIVALUED ATTRIBUTE
	COMPOSITE ATTRIBUTE
	DERIVED ATTRIBUTE
	TOTAL PARTICIPATION OF E_2 IN R
	CARDINALITY RATIO 1: N FOR $E_1:E_2$ IN R
	STRUCTURAL CONSTRAINT (min, max) ON PARTICIPATION OF E IN R

Figure 3.15 ER diagram for the COMPANY schema, with all role names included and with structural constraints on relationships specified using the alternate notation (min, max).

