Conceptual Database Design

1. Conceptual Database Design

Appl $\longrightarrow$ E-R $\longrightarrow$ Relational DB

Database Design

Entity-Relationship Model

- The Entity-Relationship (ER) model is a high-level conceptual data model (Chen in 1966).
- ER is used mainly as a design tool.

Entity-Relationship Model(cont)

- *Entity type*: Group of object with the same properties
- *Entity*: member of an entity type - analogous to an object.
- *Attribute*: a property of object
- *Relationship*: among objects
  - ER can model "n-way" relationship,
  - ER models a relationship and its inverse by a single relationship.

1.1 Entity and Attributes

- *Entities* represent things in the real word.
- *Attributes* describe properties of entities.
- Attributes may be
  – simple(atomic) e.g. sex = ’Female’, or
  – composite e.g. name consists of title (Dr), Initials (C.C.), family name (Chen).

1.1 Entity and Attributes(cont)

- Each entity has values for each attribute.
- Attributes may be
  - *single-valued* e.g. student number, name, or
  - *multivalued* e.g. keywords = neural networks, computer graphics, databases.

1.1 Entity and Attributes(cont)

- Each simple attribute has a *value set (domain)*: the set of possible values for that attribute.
- In a composite attribute $A = (A_1, \ldots, A_n)$, suppose that $V_1, \ldots, V_n$ are the domains of $A_1, \ldots, A_n$.
- The domain V of A is $V_1 \times \ldots \times V_n$.
- Mathematically, an attribute A of an entity type E is a function

$$A : E \rightarrow \wp(V)\ .$$

- where V is the domain of A, and $\wp$(V) is the power set of V
- For single-valued attributes, $A(e)$ must be a singleton.

1.1 Entity and Attributes(cont)

- An attribute can have a null value if, for example:
  - there is no suitable value e.g. a student may have no interests: keywords = NULL
  - the true value is not known e.g. the marriage date of a person is not known: marriage date = NULL.
- A derived attribute is one whose value can be derived from other attributes and entities. e.g. number of students.

1.1 Entity and Attributes(cont)

- An *entity* type is a set of entities with the same attributes.
- It is described by an *entity* schema: a name and a list of attributes.
- The set of individual entity *instances* at a particular moment in time is called an extension of the entity type.

1.1 Entity and Attributes(cont)

Schema (Intension)	RESEACHER Name, Payroll_no, No_of_students, Keywords	DEPARTMENT Name
Instances (Extension)	(Dr C.C. Chen, 230-0013, 3, Neural Networks) (Dr R. Wilkinson, 231-0091, 1, Databases)	Computer Science Psychology Management

1.1 Entity and Attributes(cont)

- An entity type usually has a *key*: a set of attributes that uniquely identifies an entity. For example:
  - {payroll number} is a key of RESEARCHER,
  - {name} is a key of DEPARTMENT.
- There may be more than one possible key.
- An important constraint is the key constraint: in any extension of the entity type, there cannot be two entities having the same values for their key attributes.

1.1 Entity and Attributes(cont)

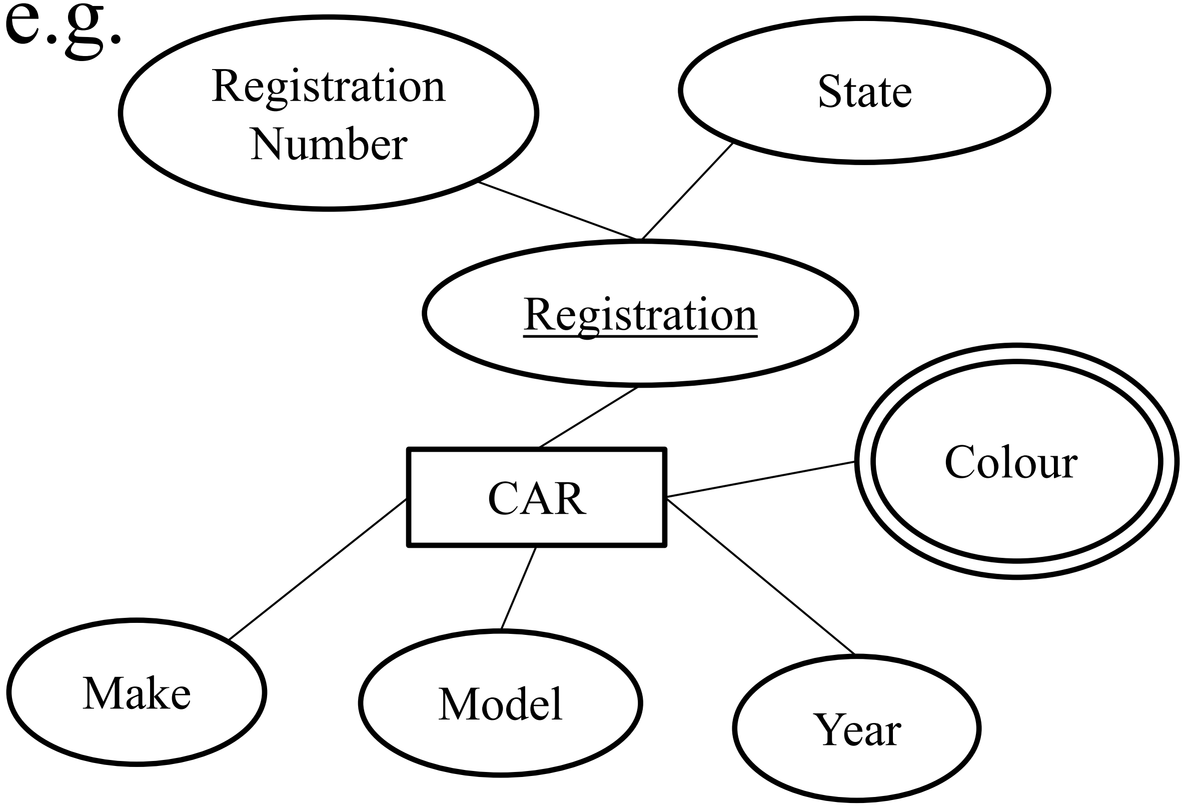
- We can describe schemata with composite attributes using ()’s and with multi-valued attributes using {}’s. e.g.

1.1 Entity and Attributes(cont)

CAR Registration(Registration No, State), Make, Model, Year, {Colour}
((ARQ) 595, Vic), Datsun, 120Y, 1972, {green}) ((8HR) 696, WA), Mazda, 929, 1979, {grey, black})

1.1 Entity and Attributes(cont)

- Entities and their attributes can also be described with Entity-Relationship Diagrams (ERDs). e.g.

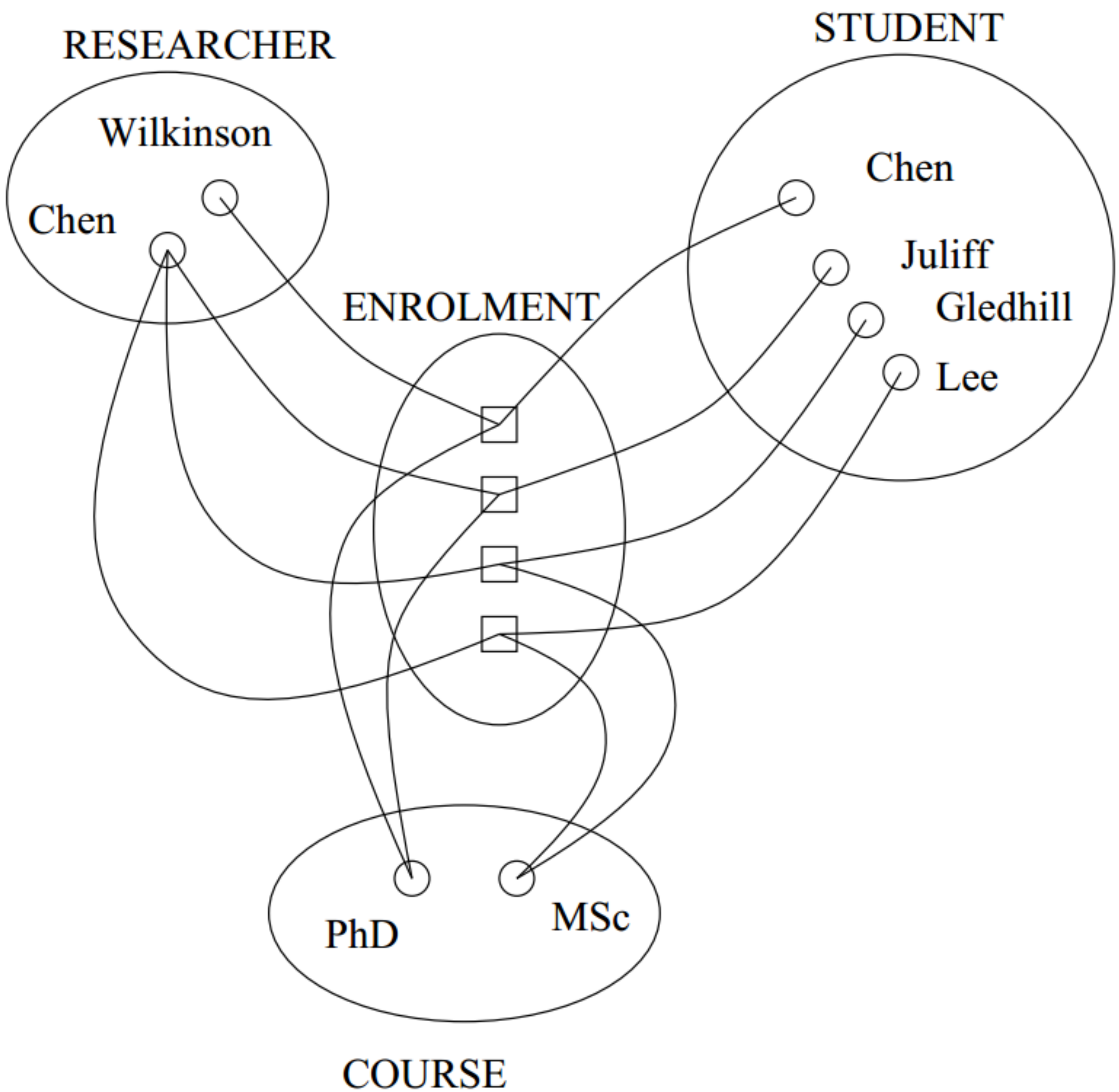


1.2 Relationships

- A *relationship* represents an association between things.
- A *relationship* type R among n entity types $E_1, \ldots, E_n$ is a set of associations among entities from these types.
- Mathematically, a relationship type R among entity types $E_1, \ldots, E_n$ is a subset of $E_1 \times \ldots \times E_n$.
- Each instance $r = (e_1, \ldots, e_n)$ in R is a relationship.

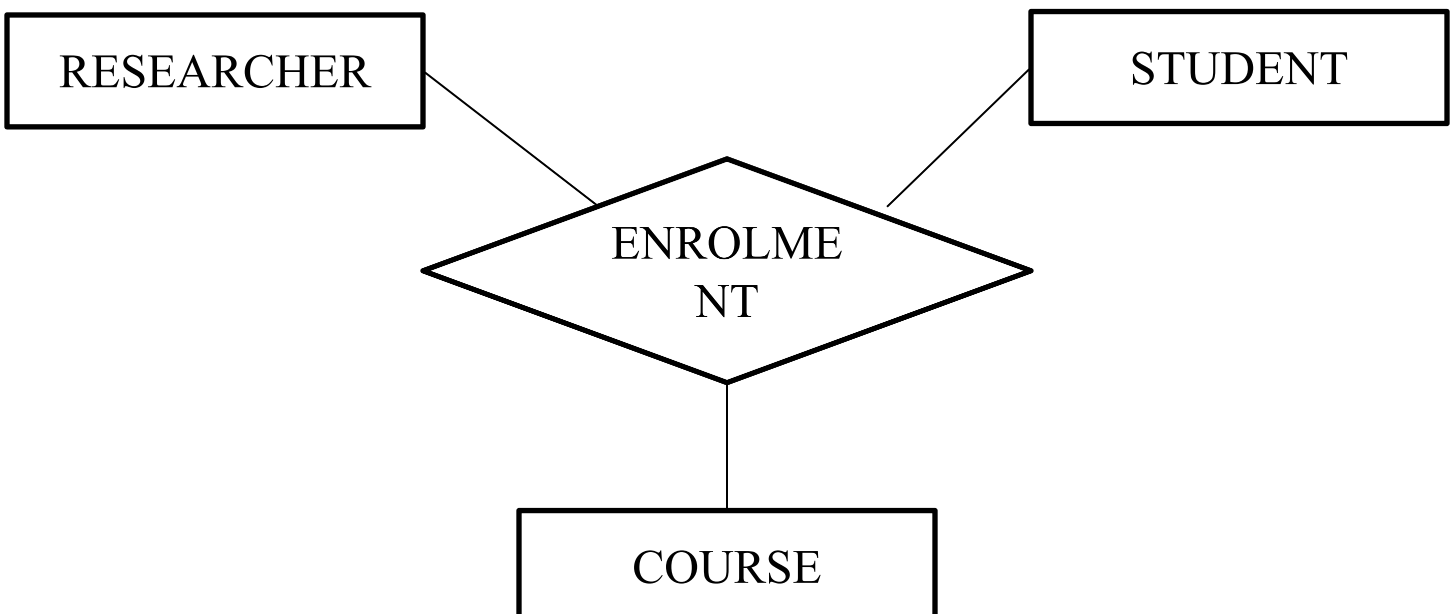
1.2 Relationships(cont)

- We say that $E_1, \ldots, E_n$ participate in R.
- Similarly if $r = (e_1, \ldots, e_n)$ is an instance of R, we say that each e_i participates in r.
- The *degree* of R is the number of participating entity types. For example,
  - ENROLMENT could be a ternary (degree 3) relationship between RESEARCHER, STUDENT and COURSE.
- We can illustrate this using an occurrence diagram:


RESEARCHER
Wilkinson
Chen
STUDENT
Chen
Juliff
Gledhill
Lee
ENROLMENT
PhD
MSc
COURSE

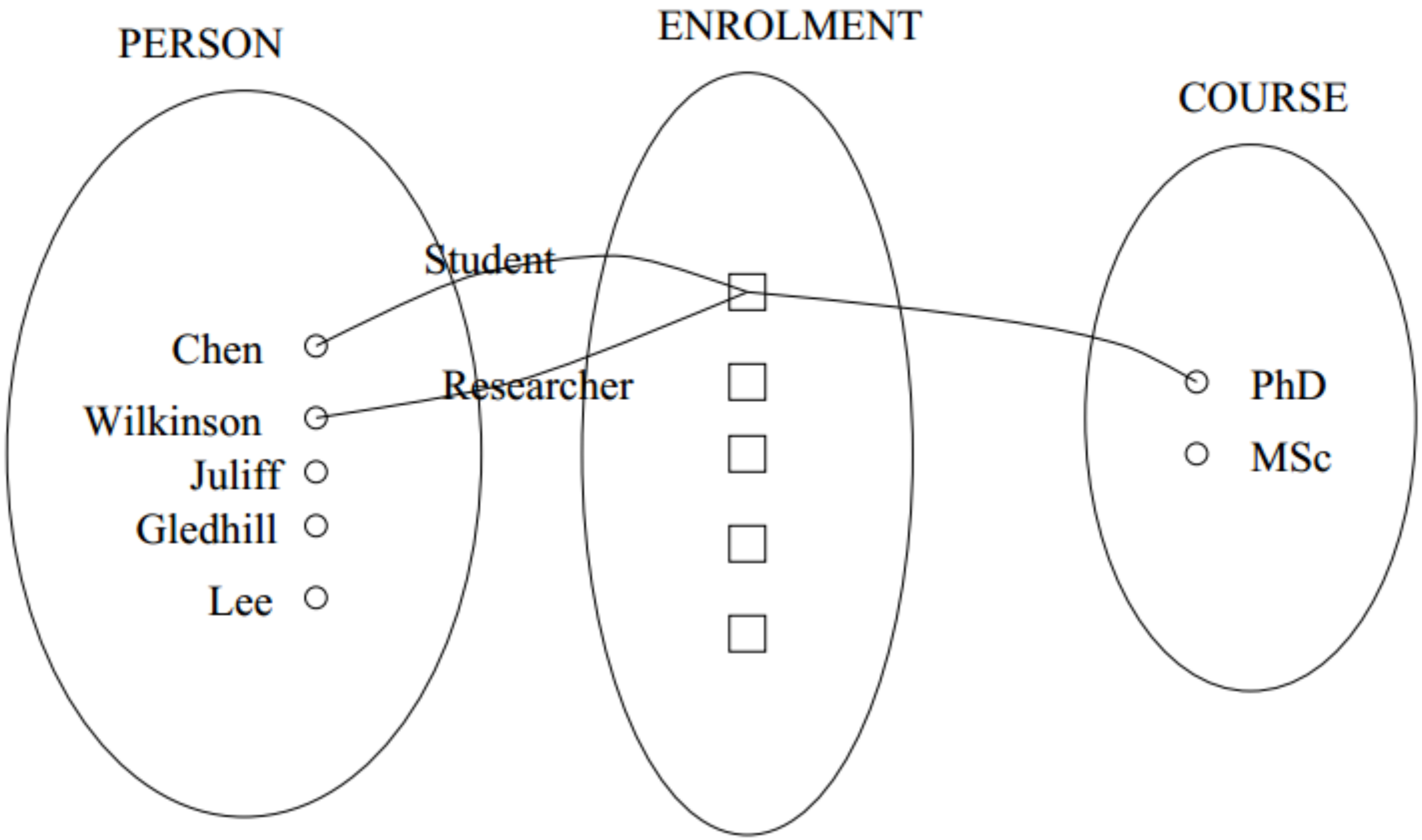
1.2 Relationships(cont)

- Entities and their relationships can also be represented using Entity-Relationship diagrams:



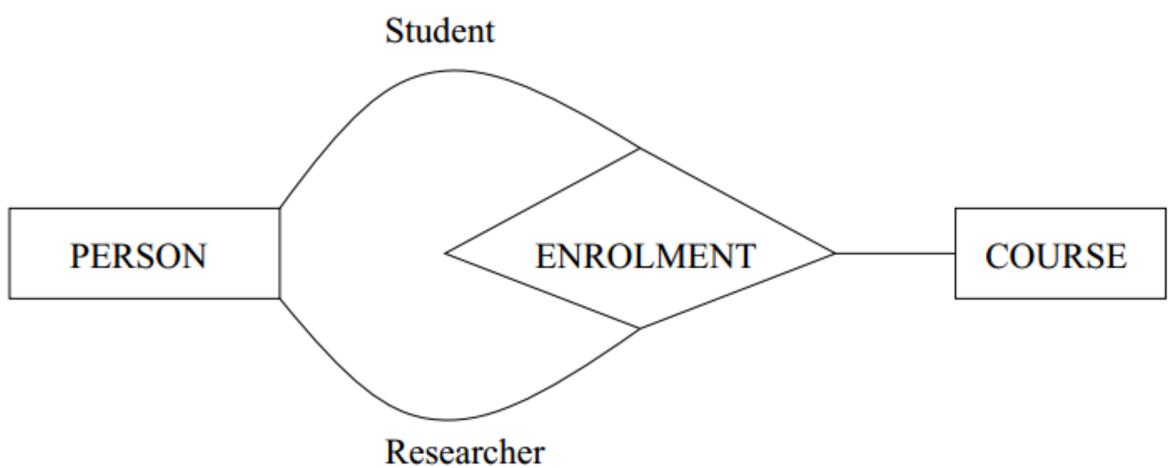
1.2 Relationships(cont)

- Each entity type that participates in a relationship plays a particular *role* in the relationship.
- An entity type can play
  - different roles in different relationships, or
  - more than one role in a relationship.
- A role name can be used to distinguish these.
- For example, ENROLMENT could be a relationship between PERSON(as researcher), PERSON(as student) and COURSE as in the diagram below:


PERSON
ENROLMENT
COURSE
Student
Chen
Researcher
Wilkinson
Juliff
Gledhill
Lee
PhD
MSc

1.2 Relationships(cont)

- Or, using an ERD:



- This is called a recursive relationship.

1.3 Weak entity types

- Some entity types do not have a key of their own.
- Such entity types are called weak entity types.
- Entities of a weak entity type can be identified by a partial key and by being related to another entity type - *owner.*
- The relationship type between a weak entity type to its owner is the *identifying relationship* of the weak entity type.

1.3 Weak entity types(cont)

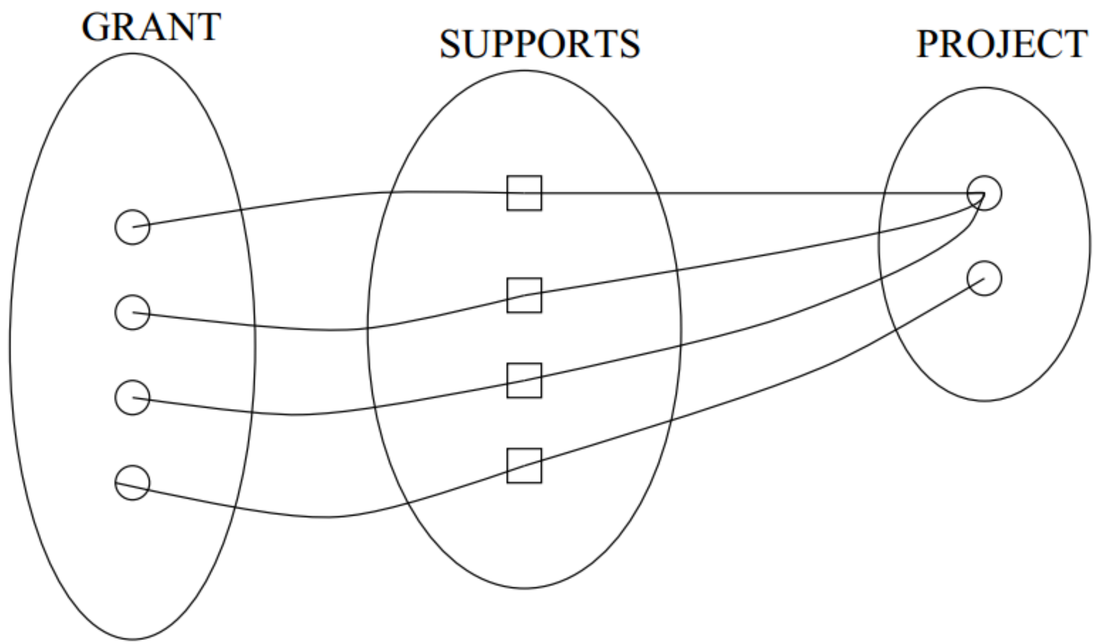
- For example, a TAX PAYER entity may be related to several DEPENDENT, identified by their names.
- In this example, DEPENDENT is called a weak entity, {Name} is a partial key for it. The identifying relationship between DEPENDENT and TAX PAYER is IS DEPENDENT OF. TAX PAYER is said to *own* DEPENDENT.

1.4 Constraints on relationship types

- Relationship types usually have certain constraints that limit the possible combinations of entities participating in relationship instances.
- They should reflect the correct factors
- *Cardinality ratio constraint*: specifies the number of relationship instances an entity can participate in.
- Example: A research grant supports only one research project, but a research project may be supported by many grants. PROJECT:GRANT is a 1 : N relationship.

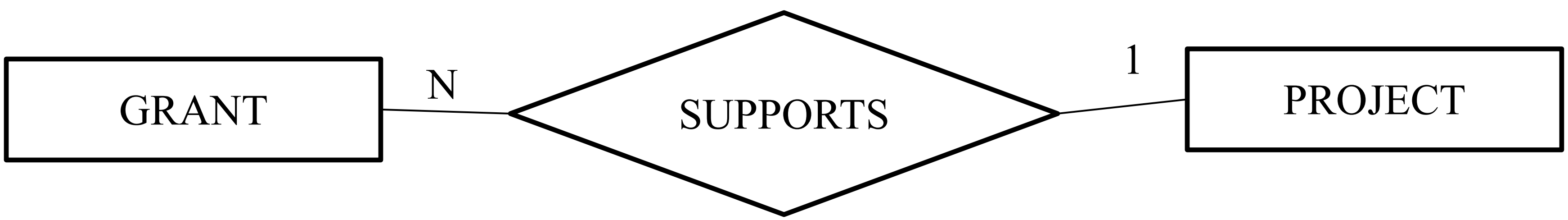
1.4 Constraints on relationship types(cont)

- This is illustrated in the occurrence diagram below:



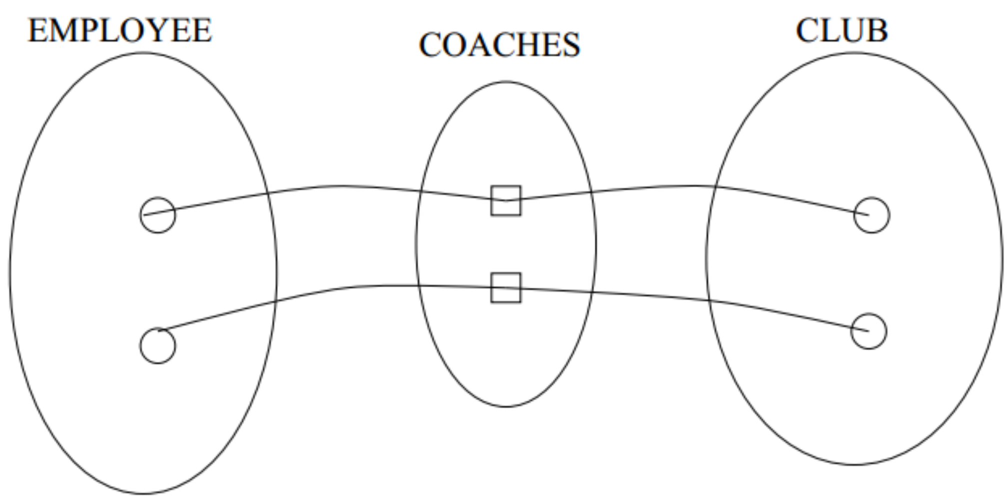
1.4 Constraints on relationship types(cont)

- We can also show this in an ERD:



1.4 Constraints on relationship types(cont)

- Example: Consider a database of AFL (here substitute your favourite team sport) statistics. The relationship of head coaches to clubs is an example of a 1 : 1 relationship.

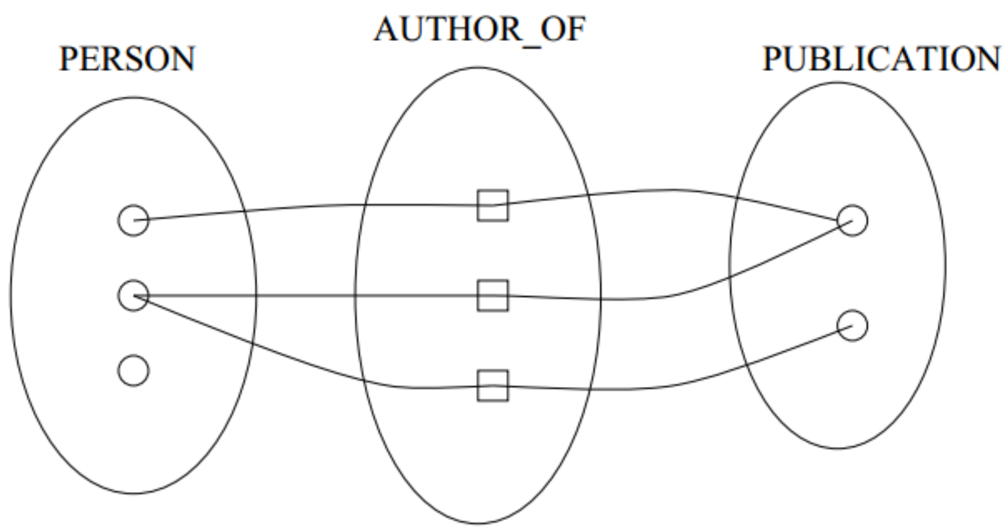


1.4 Constraints on relationship types(cont)

- With an ERD:

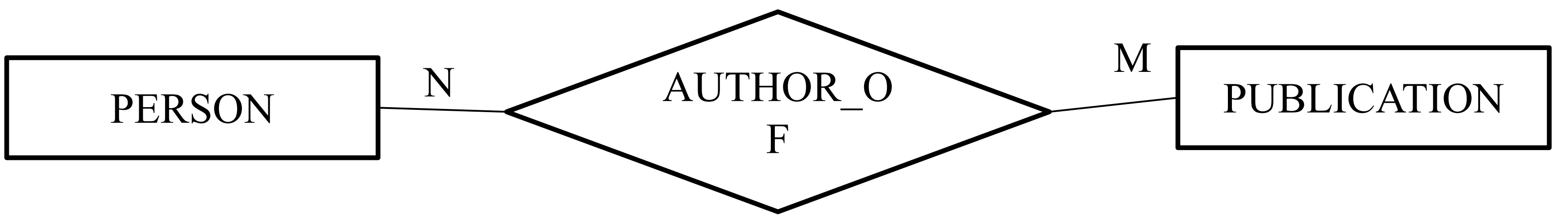
1.4 Constraints on relationship types(cont)

- Example: An example of an N : M relationship is authorship of publications:



1.4 Constraints on relationship types(cont)

- The equivalent ERD:



1.2.4 Constraints on relationship types(cont)

- Another kind of constraint that can be represented using the ER model is a
  - *Participation constraint*: participation of an entity in a relationship can be:
    - *total*: every entity must participate e.g. every publication has an author.
    - *partial*: not necessarily total. e.g. not every person has publications.

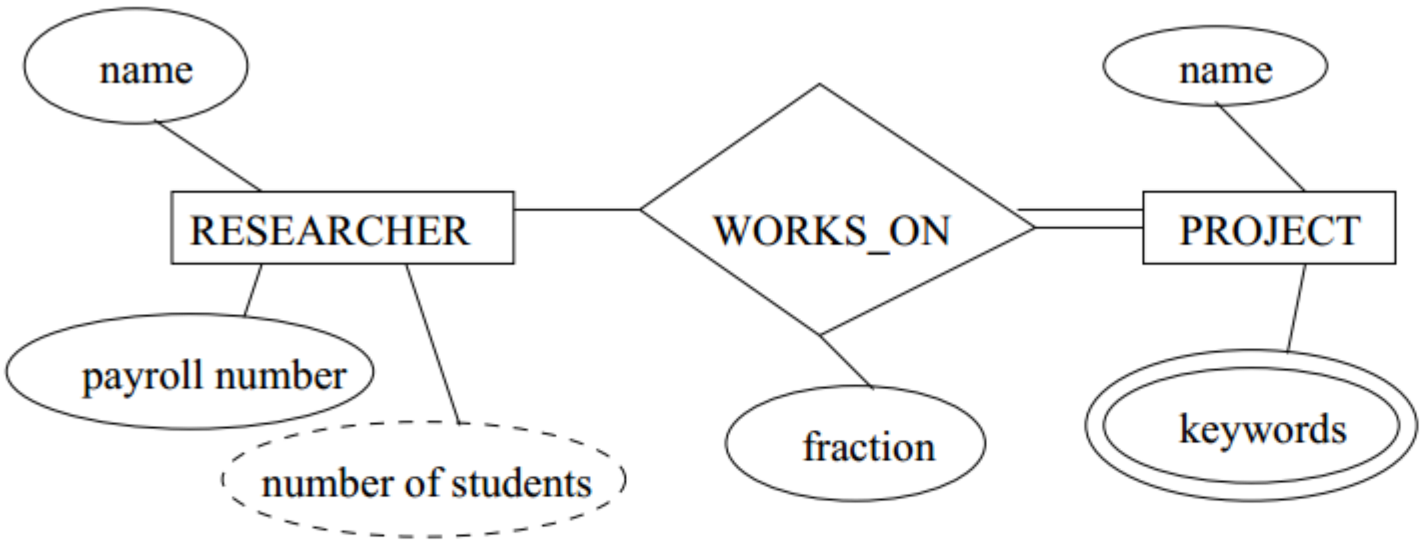
1.4 Constraints on relationship types(cont)

- This can be shown with an ERD like the one below:

1.5 Attributes of relationship types

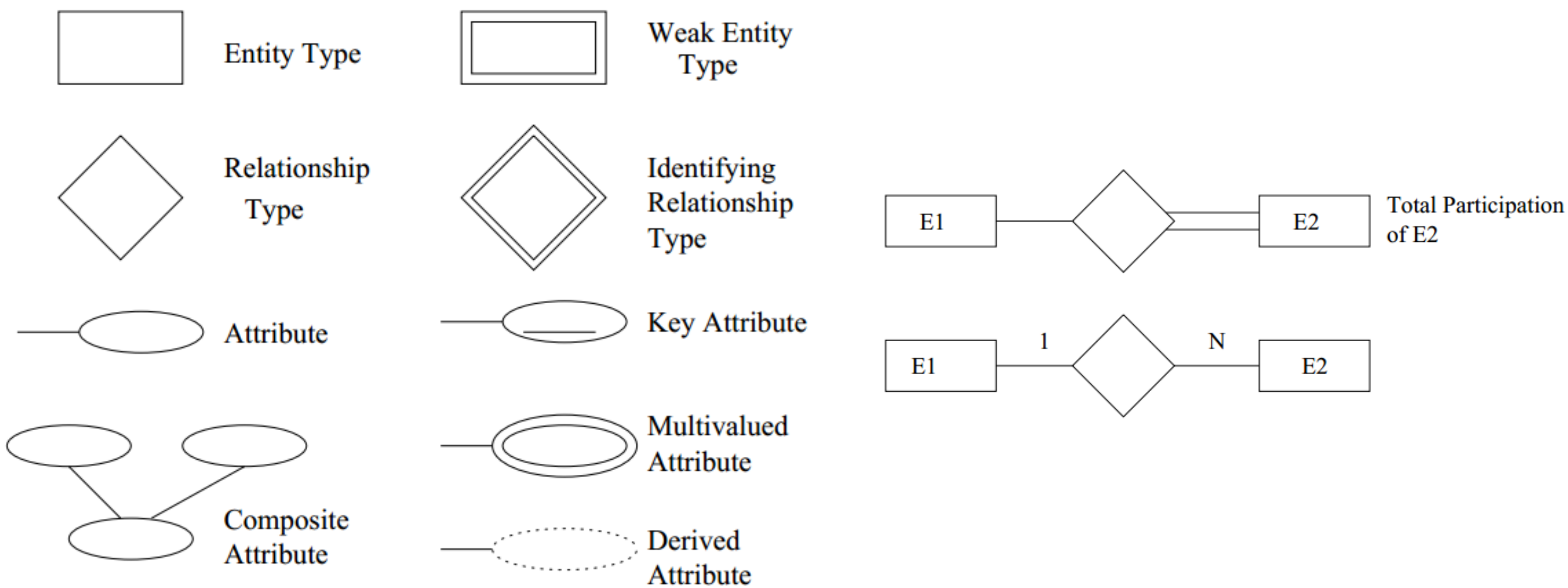
- Relationship types can have attributes – for example,
  - a researcher may work on several projects. The fraction of her time devoted to a particular project could be an attribute of the WORKS ON relationship type.
- This can be shown in an ERD as below:

1.5 Attributes of relationship types(cont)



1.5 Attributes of relationship types(cont)

- The notation used for ERDs is summarised in Elmasre/Navathe Figure 3.15.



1.6 Enhanced ER (EER) model

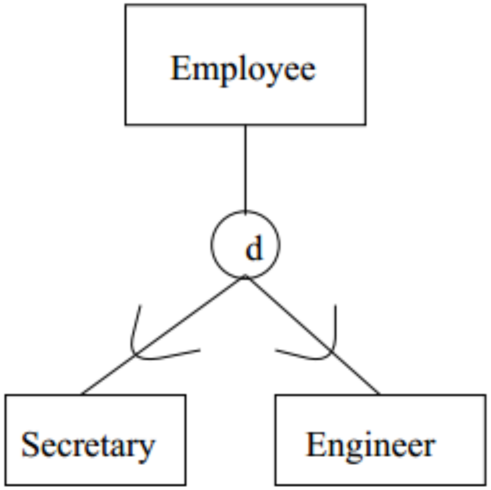
- Designers must use additionally modelling concepts to
  - represent the requirements from applications as accurately and explicitly as possible.

1.6 Enhanced ER (EER) model(cont)

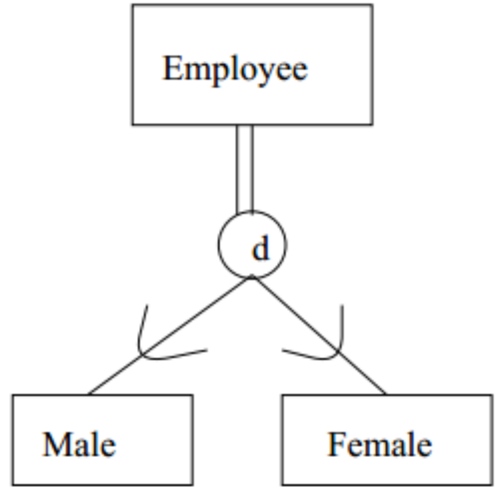
- There are many extensions to the ER model. We will look at one:
  - *Specialisation*: the process of defining a set of subclasses of an entity type; this entity type is called the superclass of the specialization.
  - *Generalisation*: a reverse process of specialisation.
- A subclass inherits all the attributes of the superclasses.

1.6 Enhanced ER (EER) model(cont)

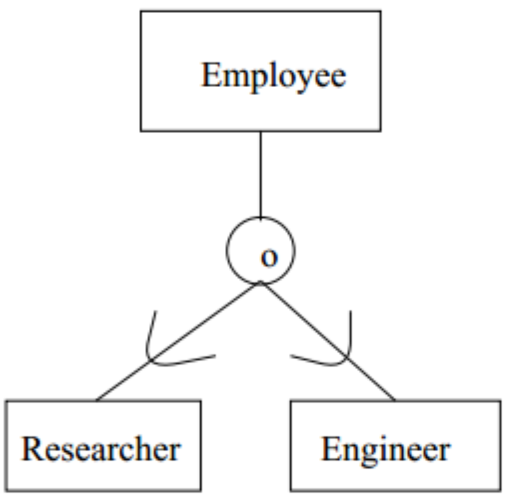
- A specialisation involves the following aspects:
  - Define a set of subclasses of an entity type.
  - Associate additional specific attributes with each subclass.
  - Establish additional specific relationship types between each subclass and other entity types, or other subclasses.
- A subclass may have multiple superclasses.
- A specialisation:
  - may be either total or partial; and
  - may be either disjoint or overlapping.



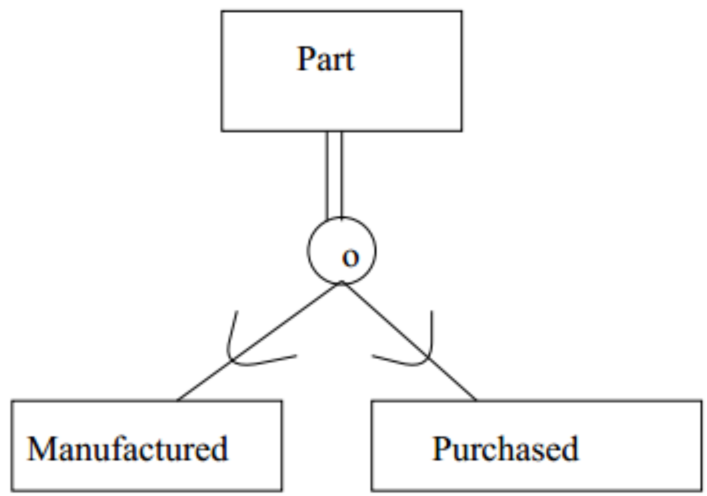
Partial disjoint



Total disjoint



Partial Overlapping



Total Ovelapping

1.7 Design Principles

- Faithfulness: reflect reality.
- Avoid redundancy.
- Picking the right kind of element.