Conceptual Database Design

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

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.

Entity and Attributes

Entities represent things in the real world.

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).

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.

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.

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.

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.

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

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.

Entity and Attributes(cont)

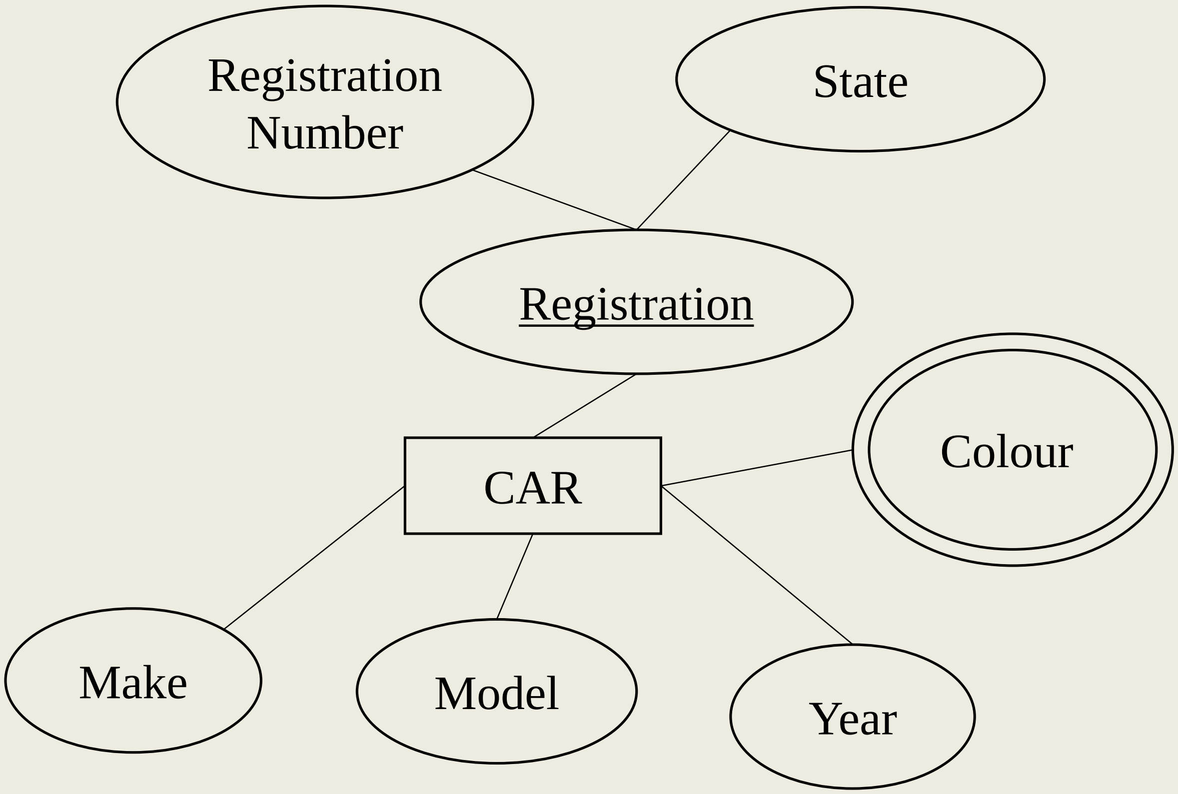
We can describe schemata with composite attributes using ()'s and with multi-valued attributes using {}'s. e.g.

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})

Entity and Attributes(cont)

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



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.

Relationships(cont)

We say that $E_1, \dots, E_n$ participate in R.

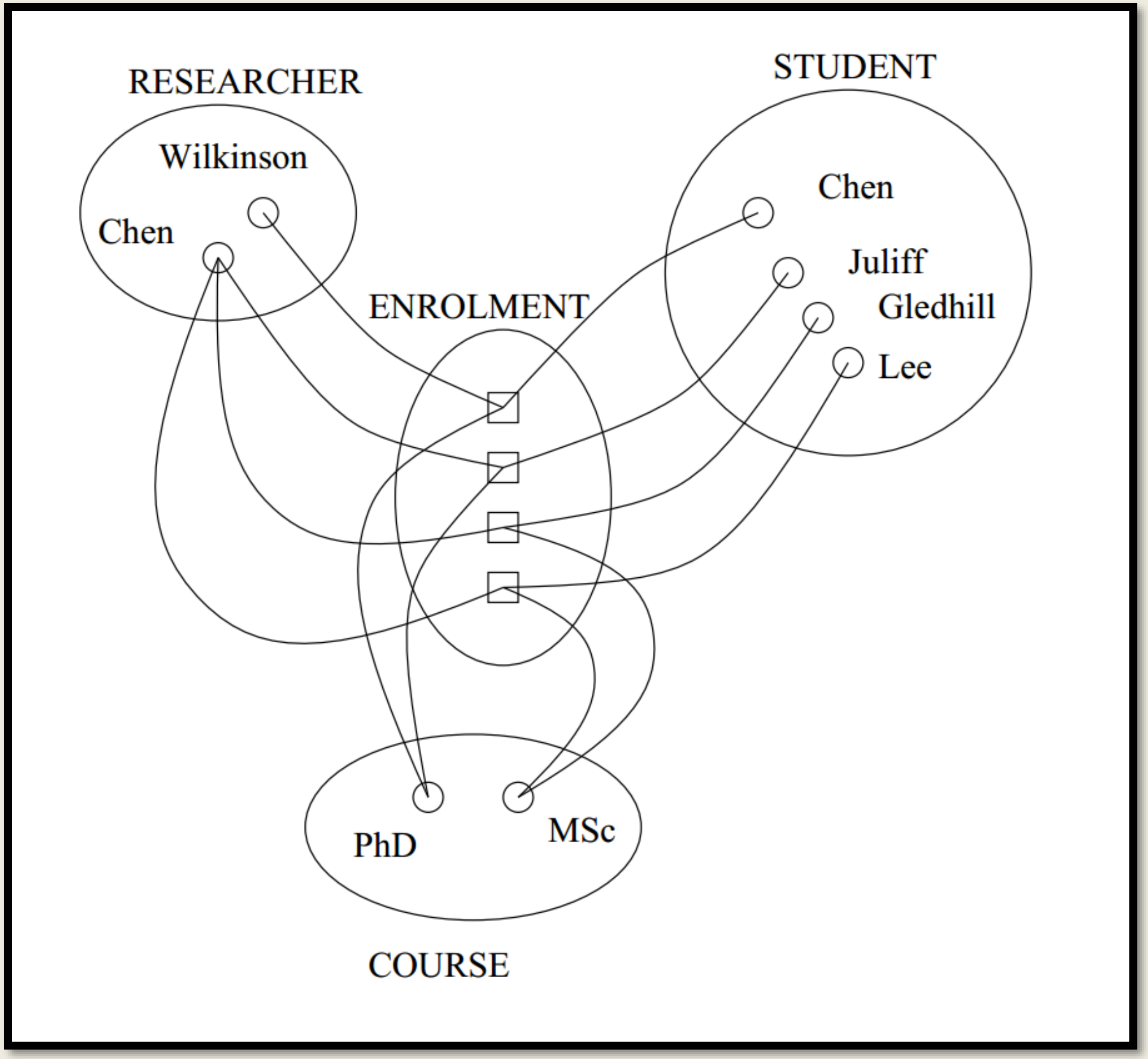
Similarly if $r = (e_1, \dots, e_n)$ is an instance of R, we say that each e_i participates in r.

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.

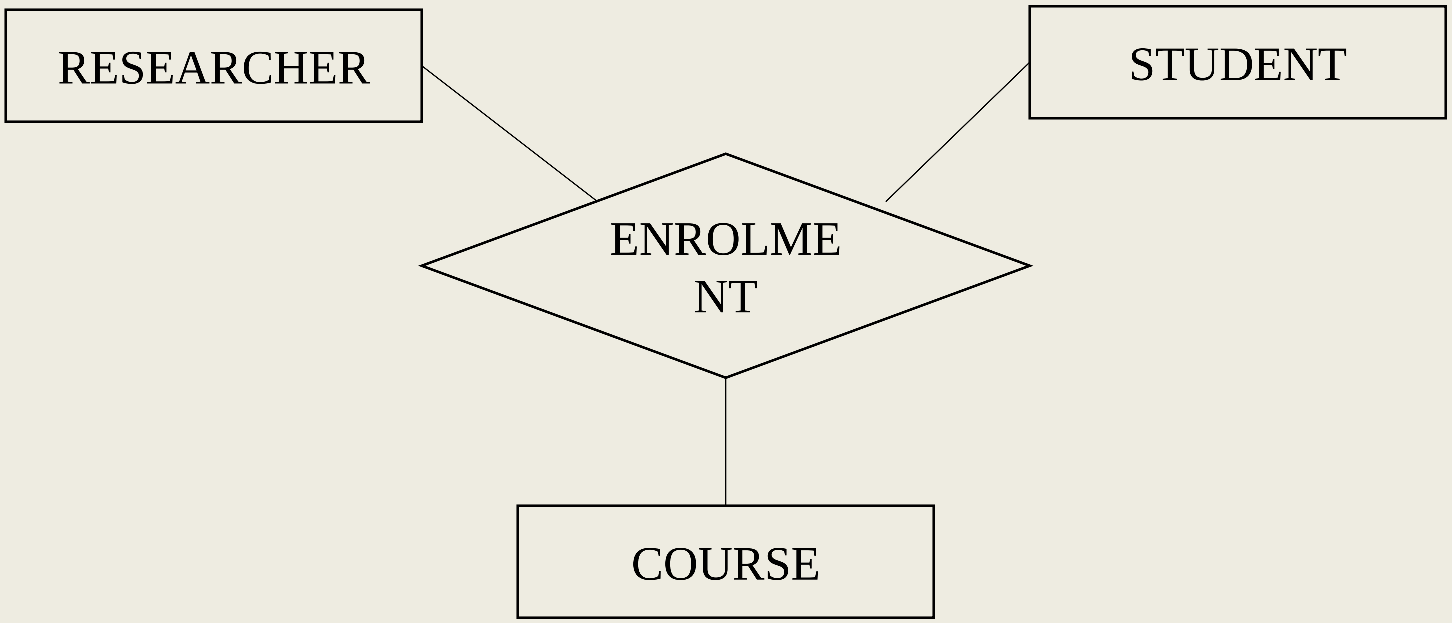
We can illustrate this using an occurrence diagram:

Relationships(cont)



Relationships(cont)

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



Relationships(cont)

Each entity type that participates in a relationship plays a particular *role* in the relationship.

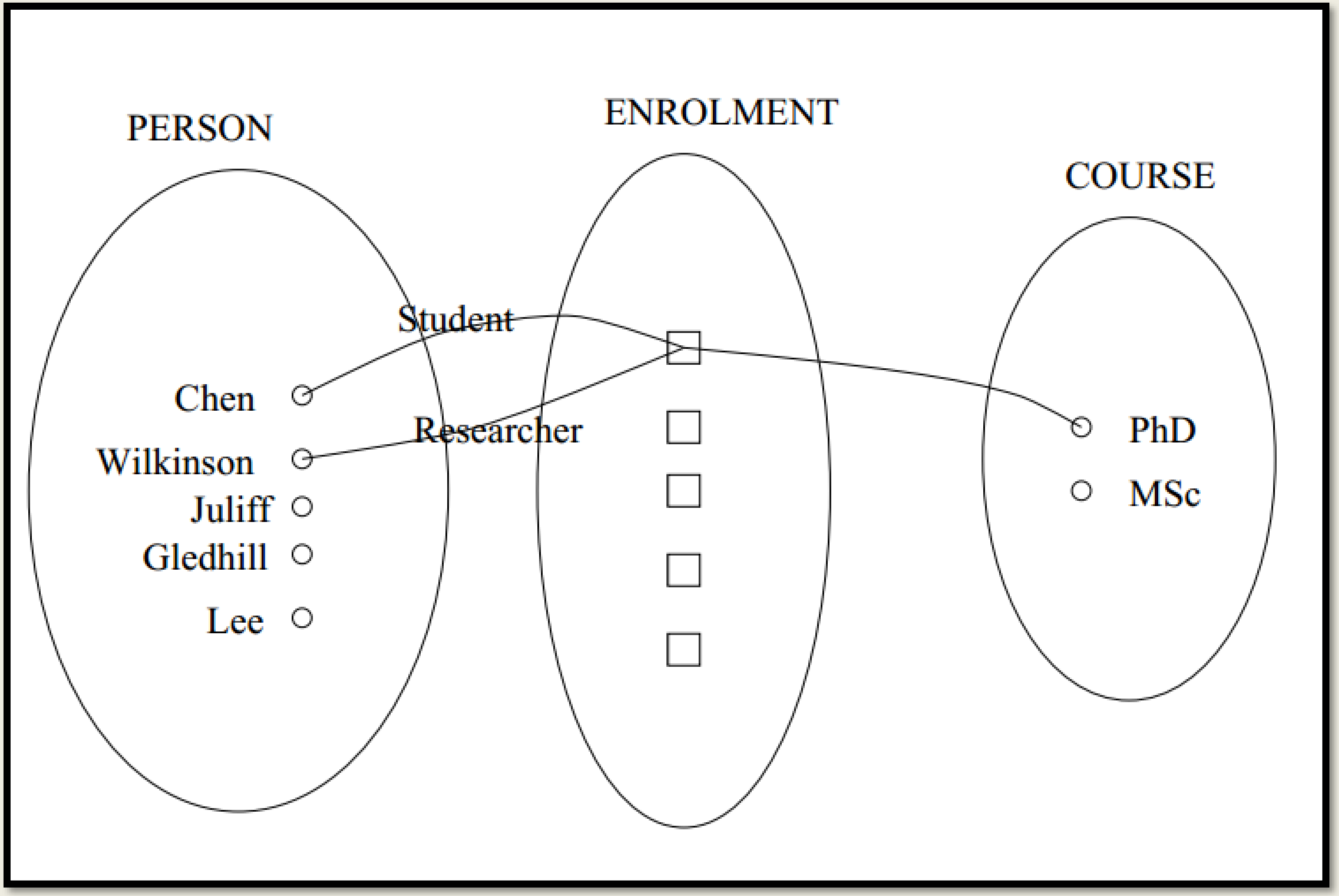
An entity type can play

- different roles in different relationships, or
- more than one role in a relationship.

A role name can be used to distinguish these.

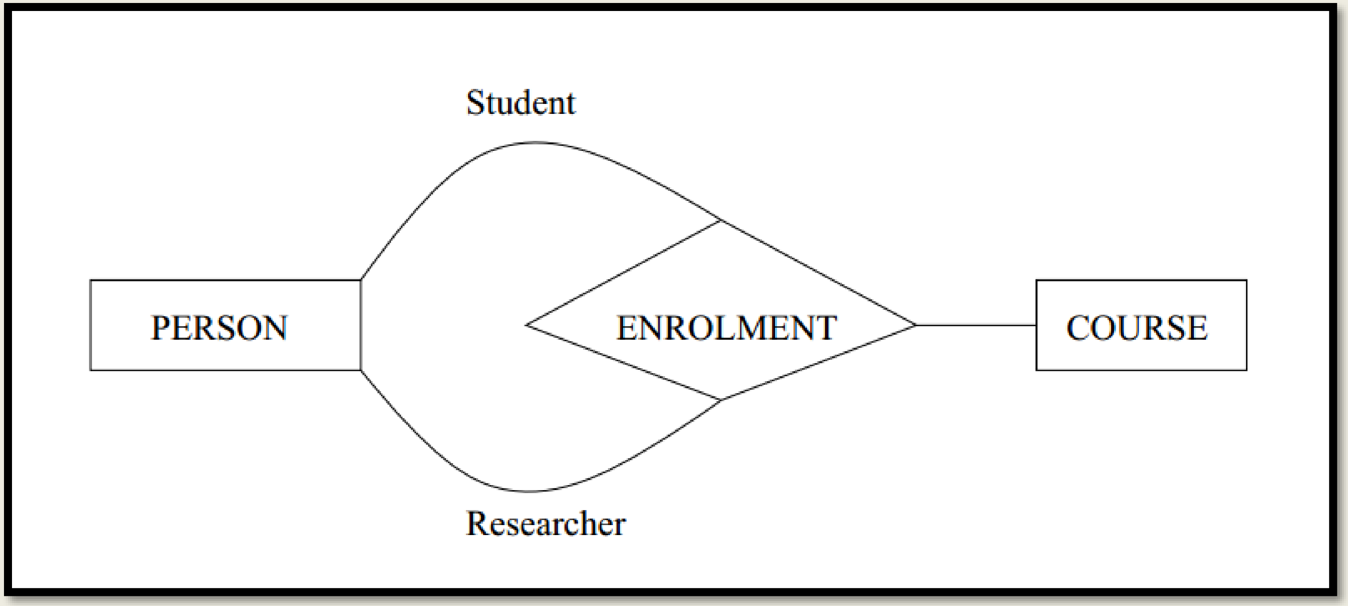
For example, ENROLMENT could be a relationship between PERSON(as researcher), PERSON(as student) and COURSE as in the diagram below:

Relationships(cont)



Relationships(cont)

Or, using an ERD:



This is called a recursive relationship.

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.

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.

Constraints on relationship types

Relationship types usually have certain constraints that limit the possible combinations of entities participating in relationship instances.

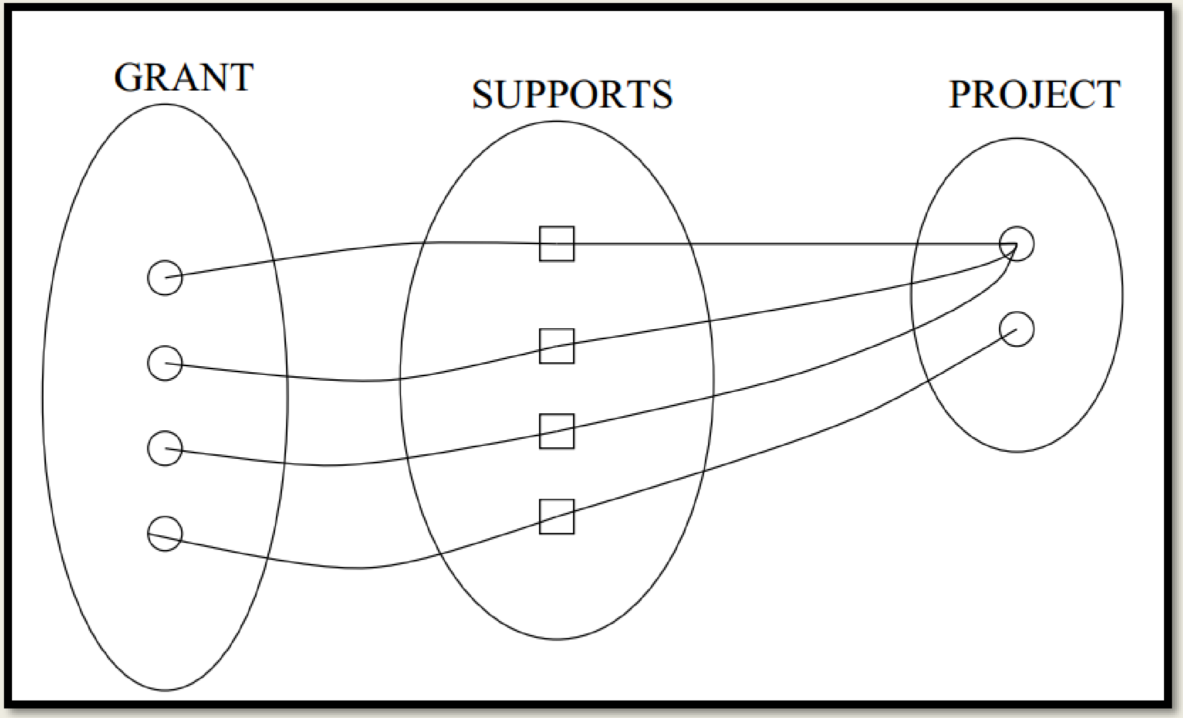
They should reflect the correct factors

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.

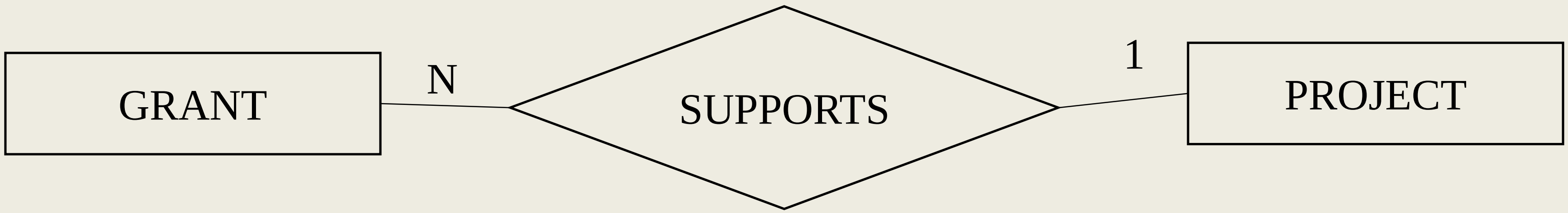
Constraints on relationship types(cont)

This is illustrated in the occurrence diagram below:



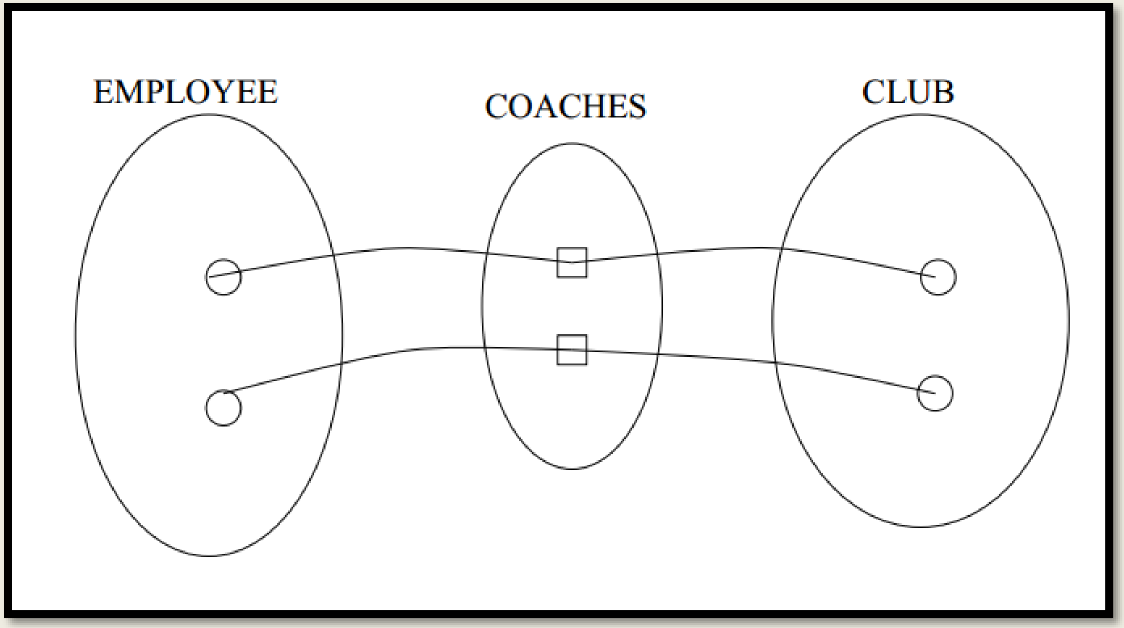
Constraints on relationship types(cont)

We can also show this in an ERD:



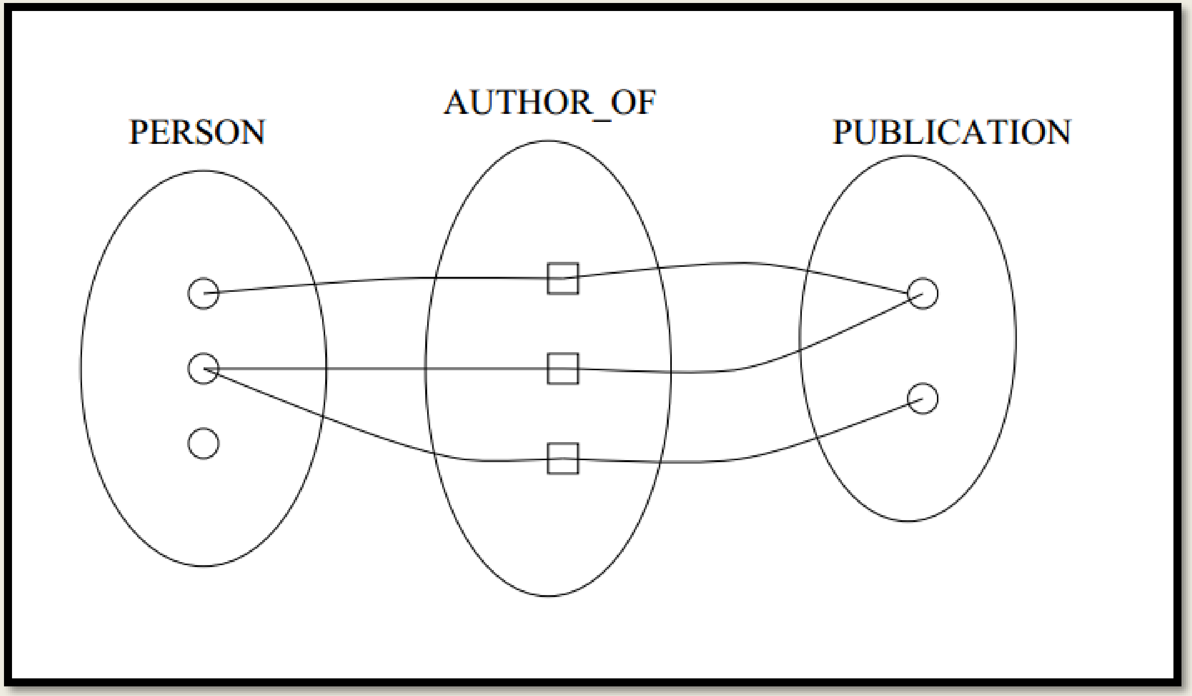
Constraints on relationship types(cont)

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.



Constraints on relationship types(cont)

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



Constraints on relationship types(cont)

The equivalent ERD:

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.

Constraints on relationship types(cont)

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

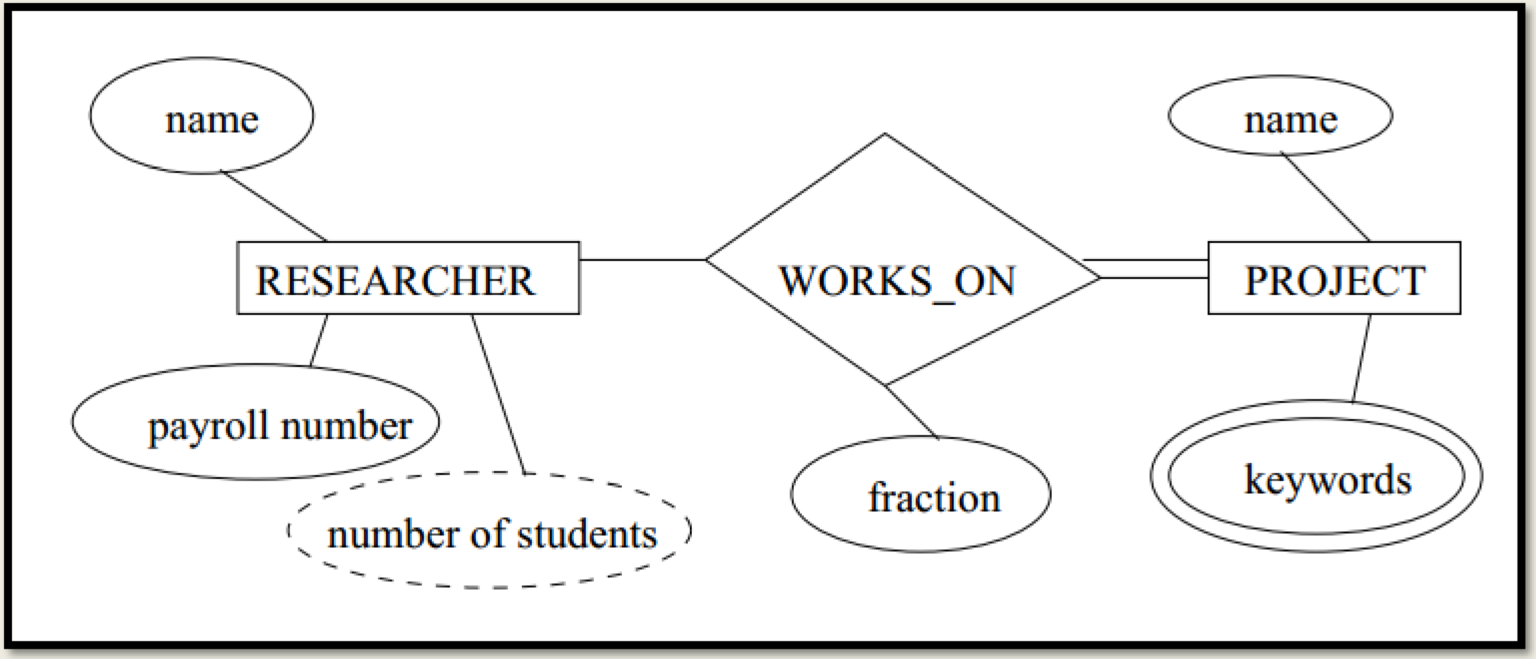
Attributes of relationship types

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.

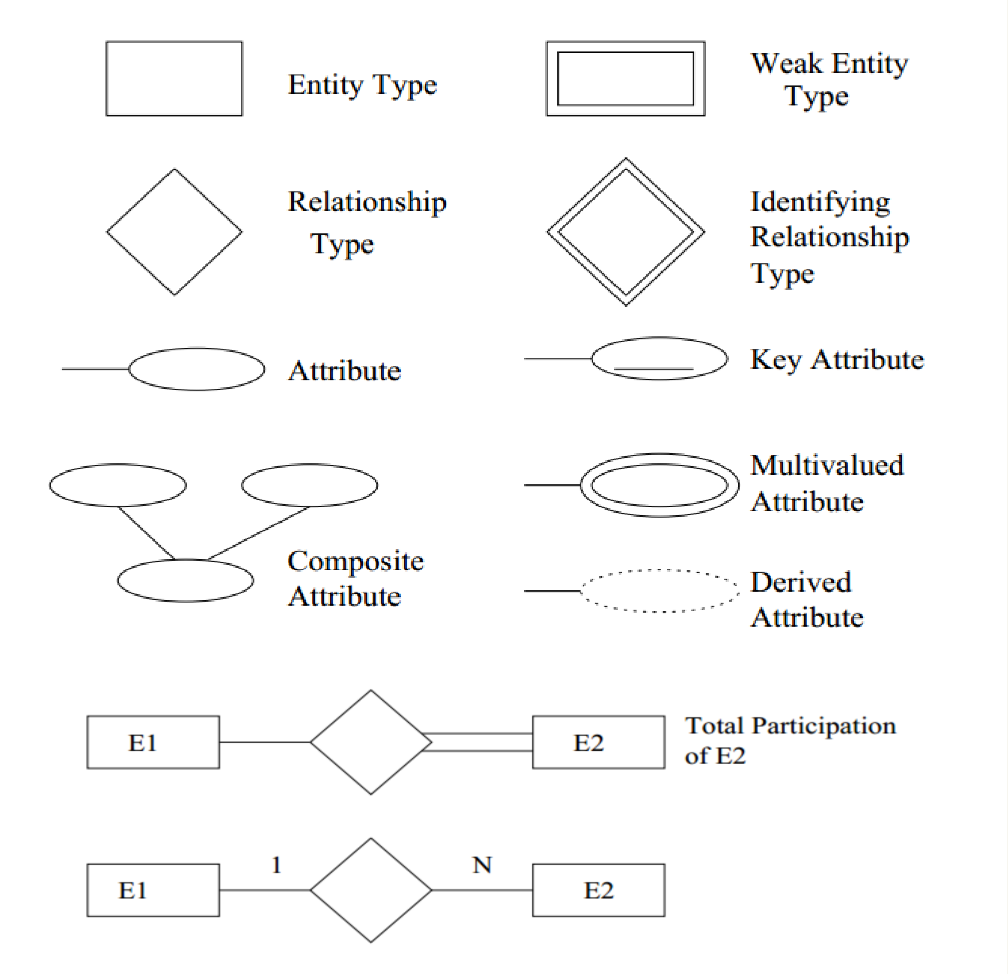
This can be shown in an ERD as below:

Attributes of relationship types(cont)



Attributes of relationship types(cont)

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



Enhanced ER (EER) model

Designers must use additionally modelling concepts to

- represent the requirements from applications as accurately and explicitly as possible.

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.

Enhanced ER (EER) model(cont)

A specialisation involves the following aspects:

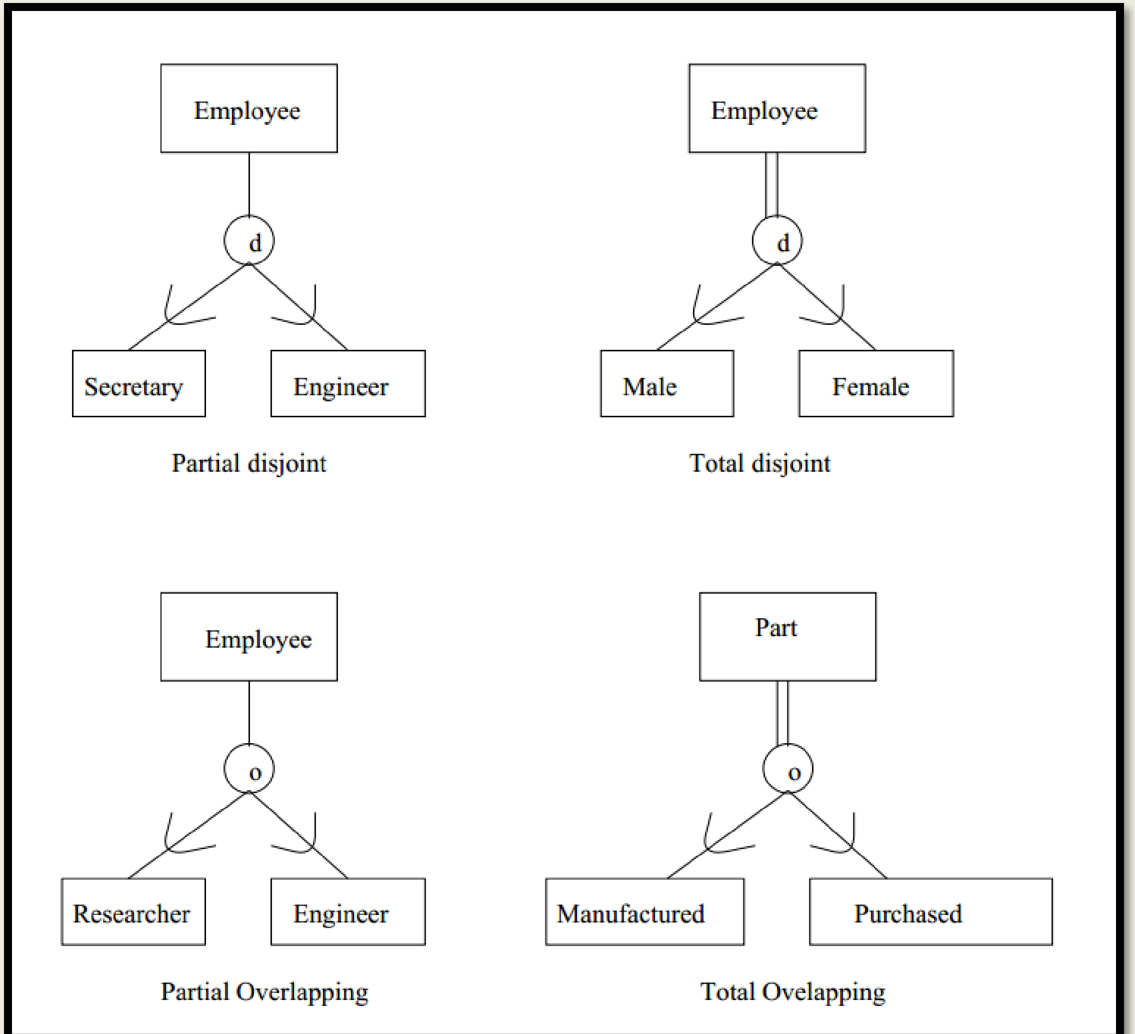
- Define a set of subclasses of an entity type.
- Associate additional specific attributes with each subclass.
- Establish additional specific relationship types between each subclass and other entity types, or other subclasses.

A subclass may have multiple superclasses.

A specialisation:

- may be either total or partial; and
- may be either disjoint or overlapping.

Enhanced ER (EER) model(cont)



Design Principles

Faithfulness: reflect reality.

Avoid redundancy.

Picking the right kind of element.