CSCU9B3

Database Principles and Applications

ER Modelling

The Entity-Relationship (ER) Model

- ***Ritchie: Chapter 3, Connolly & Begg: Chapter 5***
- The Entity-Relationship (ER) Model is a high-level *conceptual* data model.
  - It was originally developed in the 1970s to facilitate database design.
- *Recap*: Conceptual data models serve two main purposes:
  - To support a user's perception of data.
  - To conceal the technical aspects of database design.
  - They are also independent of the particular DBMS used to implement the database.
- The basic concepts of the ER model include:
  - *Entities*
  - *Attributes*
  - *Relationships*
- These concepts are represented **pictorially** in an ER diagram.

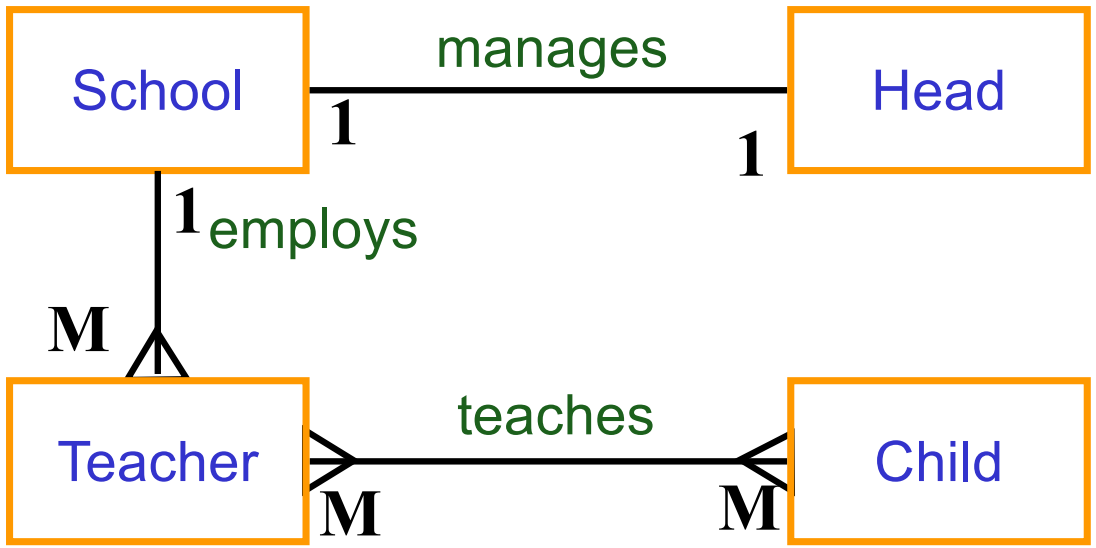
Entities and Relationships - I

- An example of a basic ER diagram is shown below:

- The entities *Student* and *School* are shown as rectangles.
- The relationship *attends* is shown as a labelled connection between the entities.
- We can read this diagram in two ways:
  - One Student "attends" one School (1:1 relationship from point of view of Student).
  - One School "is attended by" one Student (1:1 relationship from point of view of School).

Entities and Relationships - II

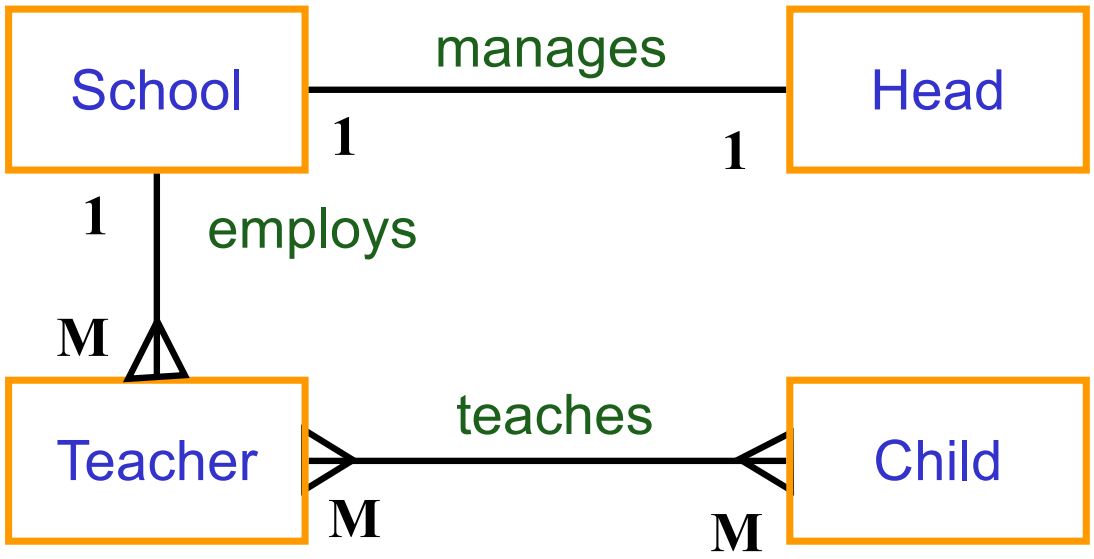
- ER diagrams express relationships between *entity types*.
  - Each entity box in an ER diagram refers to a set of entities, for example a set of students.
  - Each member in the set is potentially involved in the specified relationships.
- Here is a more complex ER diagram:



Cardinality of Relationships

- In the previous example, some of the connecting lines terminate in a splayed *crowsfoot* arrangement.
  - This is used to denote the *cardinality* of a relationship.
- The cardinality specifies, for one member of the first entity set, the possible number of members it can be related to in a second entity set.
- There are three possibilities:
  - 1:1 One to one e.g. *head* manages *school*
  - 1:M One to many e.g. *school* employs *teacher*
  - M:M Many to many e.g. *teacher* teaches *child*
- The *crowsfoot* device is used to indicate the *many* end of a relationship.

Interpreting ER Diagrams - I



- We can interpret this ER diagram as follows:
  - One *head* manages only one *school* (1:1 from point of view of head) and each *school* has only one *head* (1:1 from point of view of school)
  - One *school* employs many *teachers*, (1:M from point of view of school) but one *teacher* is employed by only one *school* (1:1 from point of view of teacher)
  - One *teacher* teaches many *children* (1:M from point of view of teacher) and each *child* is taught by many *teachers*. (1:M from point of view of child) – hence this relationship is M:M overall (both ways/points of views)

Interpreting ER Diagrams - II

- We always interpret each relationship in an ER diagram from the point of view of one instance of the entity.

  Even in the case of the M:M relationship "*teacher* teaches *child*", we interpret this as:

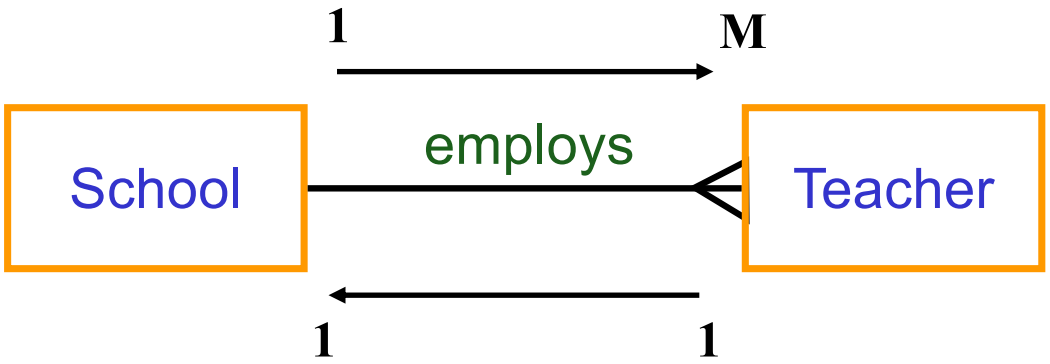
  - one teacher teaches many children (1:M from the point of view of one teacher)
  - one child is taught by many teachers (1:M from the point of view of one child)

- Thus, we always express entity names in the singular to help us remember the above rule.
  - e.g. *teacher* rather than *teachers*.

- For a given relationship we should always be able to make two interpretations.
  - We can interpret the relationship in one direction ("teaches"), and we can interpret it in the reverse direction ("is taught by").

Optionality and Participation - I

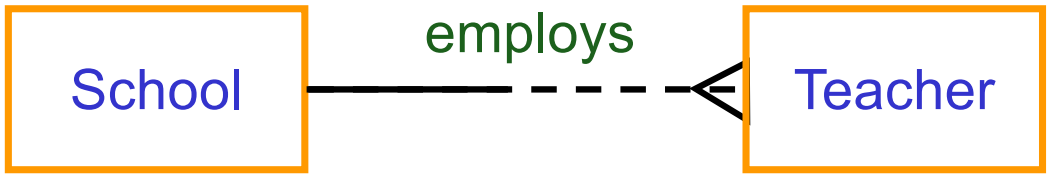
- Consider the 1:M relationship from our earlier example:



- We interpret this as:
  - One school employs one or more teachers. (1:M relationship from point of view of one school)
  - One teacher is employed by only one school. (1:1 relationship from point of view of one teacher)
- However, it may be that some teachers are not employed by any school.
  - We say that the *employed by* relationship is *optional* from the point of view of the teacher.
  - That is, a particular teacher, may or may not by employed by a school.

Optionality and Participation - II

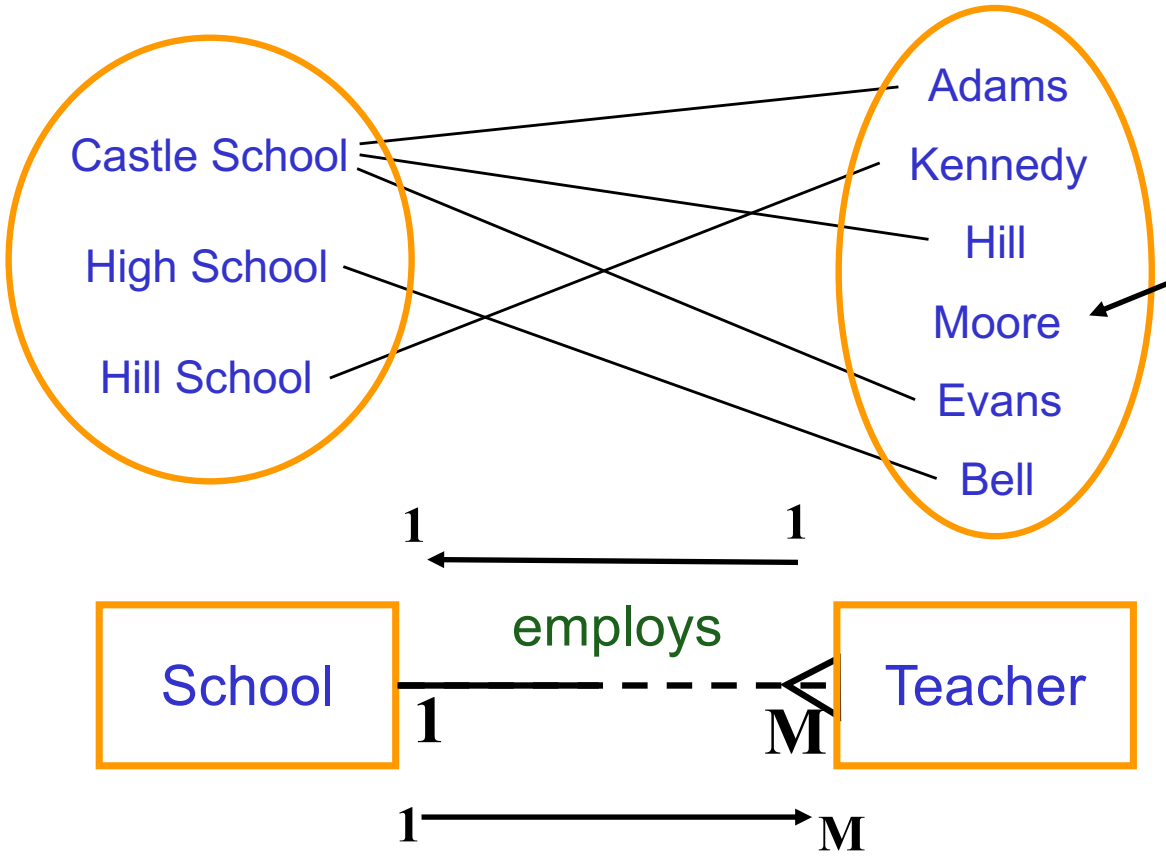
- To express the idea of *optionality* in an ER diagram, we need to draw or relationship connectors slightly differently.
- For example:



- In this diagram, the DASHED portion of the (half) line (connecting to the Teacher entity in the ER diagram above) signifies that a teacher may optionally be employed by a school
- However, from the point of view of a particular school, it is vital that the school employs at least one teacher.
  - Thus, schools must always employ teachers.
  - This is indicated by the SOLID HALF of the connector attached to *School* above

Visualising Relationships

- Relationships represent a mapping from one entity set to another.
  - For example a 1:M relationship map an entity in one set to one or more entities in another set.
- We can visualise a relationship using a mapping diagram:



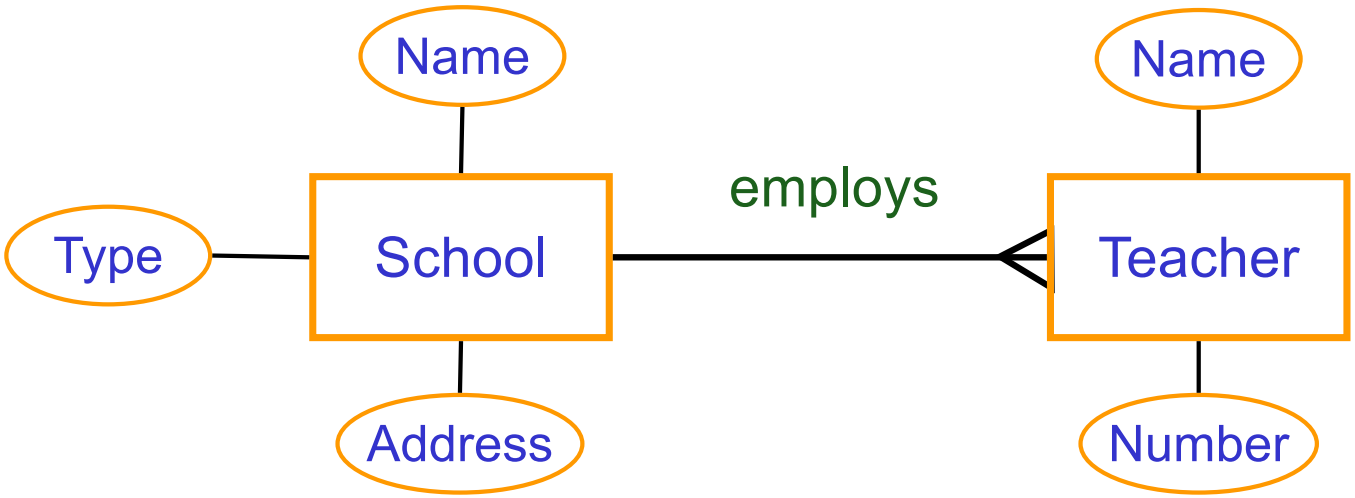
Not employed by any school (i.e. teacher's participation in the relationship is optional rather than mandatory – which is indicated by dashed half line connecting to the teacher entity in the ER diagram)

Displaying Attributes in ER Models-I

- The ER diagrams that we have seen up until now have simply showed structure.
- We now expand slightly by thinking about the properties or *attributes* of each entity.
- For example, in the school example possible attributes are:

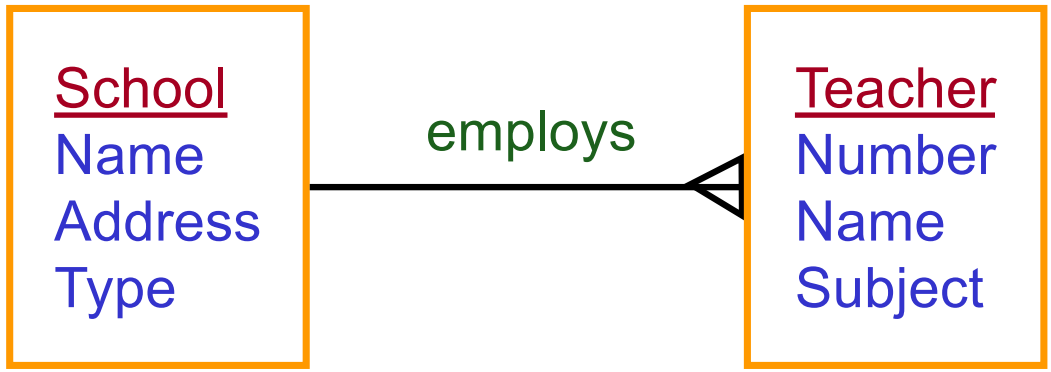
  Name, Address, Type of School, Name and Number of Teacher.

  – We can show this information in an ER diagram as follows:



Displaying Attributes in ER Models-II

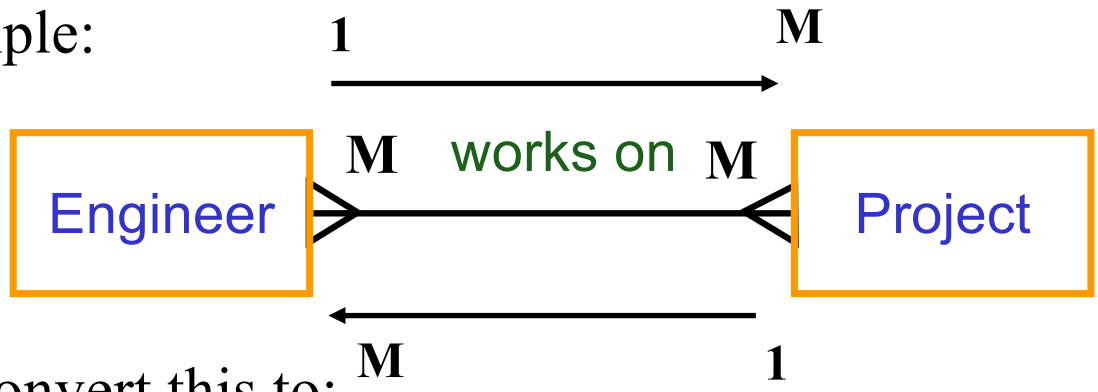
- In practical ER diagrams, displaying attributes in the manner shown on the previous slide tends to clutter the diagram.
- An alternative notation for displaying attributes is shown below:



- In practice, we often have to create ER diagrams from a description, either verbal or written, of what is required.
  - The textbook contains numerous examples of these.

Many-to-Many Relationships - I

- On first analysis of a given system, some relationships may appear to be M:M.
- Sometimes it is possible to convert a M:M relationship into two 1:M relationships.
- For example:



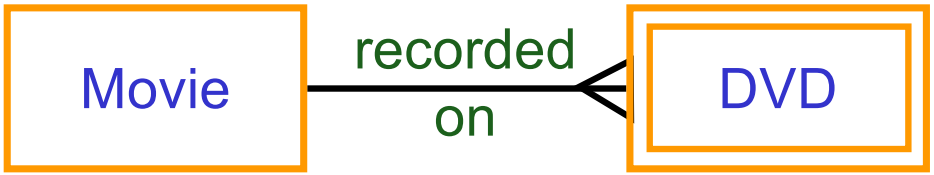
- We can convert this to:

Many-to-Many Relationships - II

- The previous example effectively turns the original M:M relationship into an entity.
  - As it happens, this *Contract* entity is something that is reasonably natural to represent.
  - It may well have its own attributes that we feel are important.
- It is a good idea to examine all M:M relationships to see if they can be converted as shown.
  - Often this reveals a hidden entity that has been overlooked.
  - *It simplifies the process of translating an ER model of a system into a set of relations for use with a relational database* – see next

Weak Entities

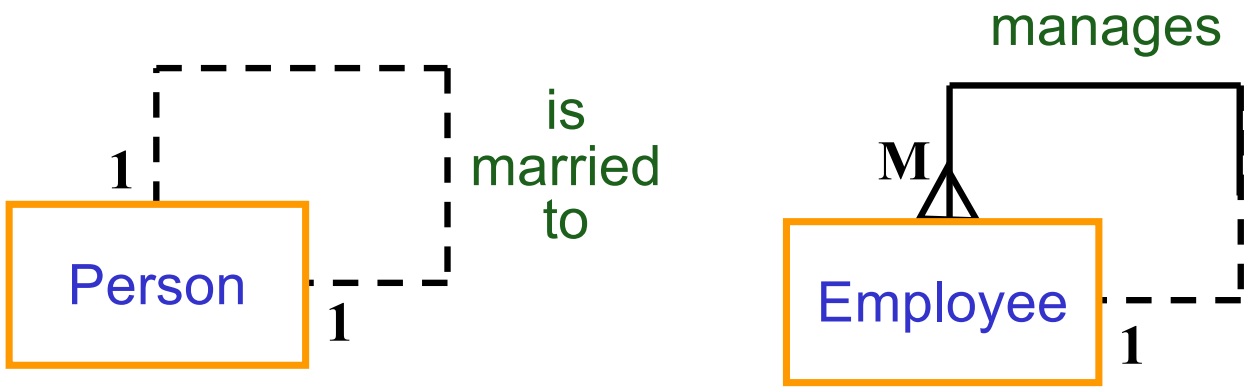
- A *weak entity* is one which cannot exist without the existence of some other entity.
- For example, in a video hire shop, we may have the following ER diagram:



- This represents the fact that a given movie must be recorded on one or more DVDs, and a given DVD must contain a particular film.
  - So we cannot have DVDs for which there is no corresponding movie.
  - If we delete a movie from our database, we would also like to delete all of the information about the DVDs containing that movie.
  - Thus, *DVD* is a weak entity since it depends on a corresponding movie.

Unary Relationships

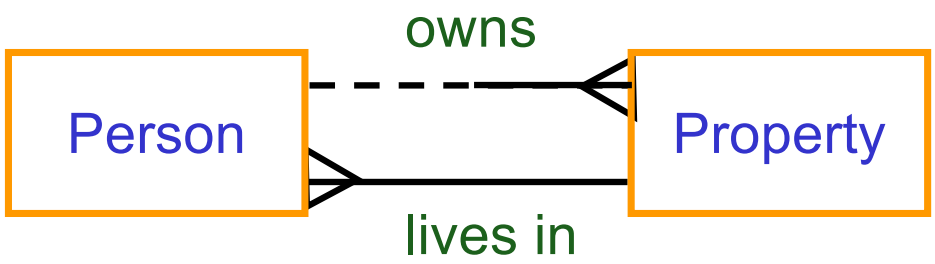
- We said earlier that a relationship expresses a mapping between an entity from one set and one or more entities from another set.
- We sometimes need to show a relationship between entities from the same set. Some typical examples are:



- Left: A person is optionally married to one other person.
- Right: An employee manages zero or more other employees. Each employee is managed by one other employee.

Multiple Relationships Between Entities

- So far we have had only one relationship between any two entities.
- However, there is nothing to stop us having more than one if it makes sense to do so.
  - For example, if two entities can be related to each for different reasons simultaneously.
- Here is a typical example:

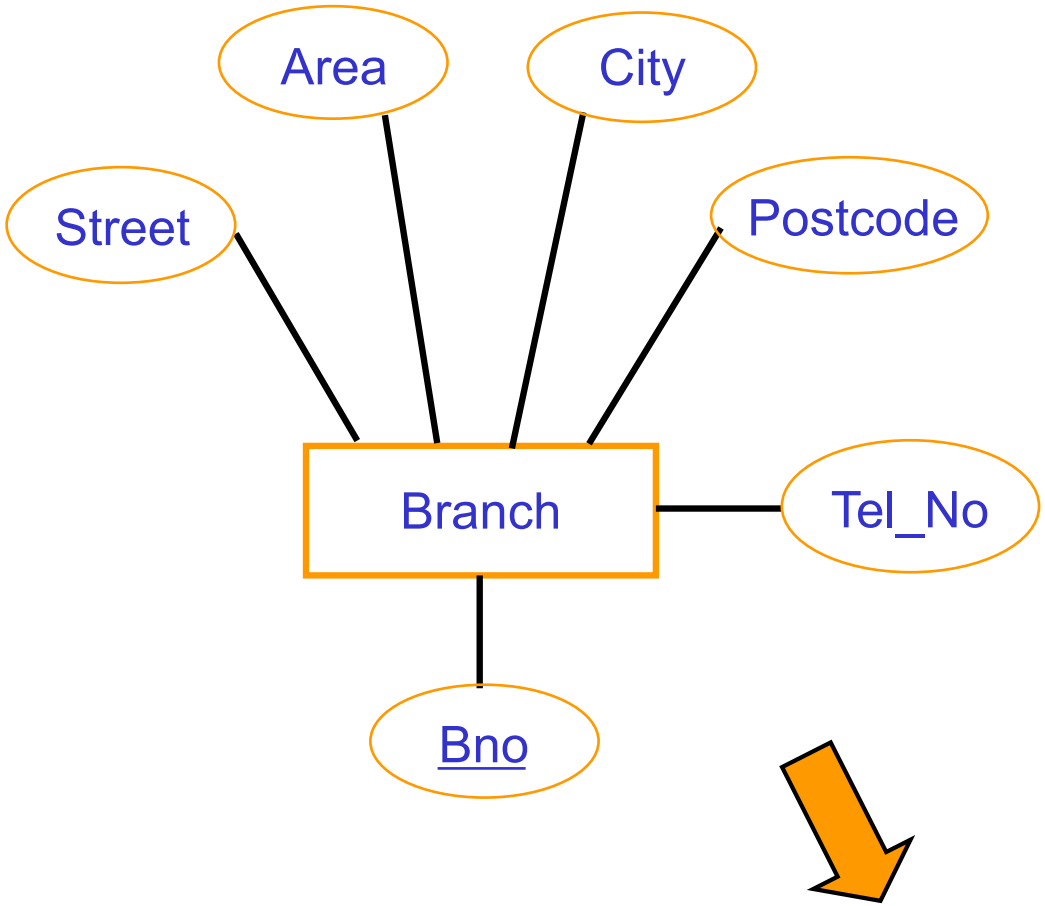


- Here we consider that owning a property is a separate concept from living in it. Thus, we represent this using separate relationships.

Converting an ER model to Relations

- How can we translate an ER model into a set of relations?
- We start by defining a number of relations to represent each of the entities present in our ER model.
- Columns are then added to each relation to represent the attributes of the corresponding entity.
- Relationships are represented using *foreign keys*, or possibly a separate relation.
- Identify primary and foreign keys (if any) in each relation.
  - This last step normally happens in parallel with the rest of the steps.
- We will work through some examples to see how the conversion process works.

Converting Entities Into Relations



Branch (Bno, Street, Area, City, Postcode, Tel_No)

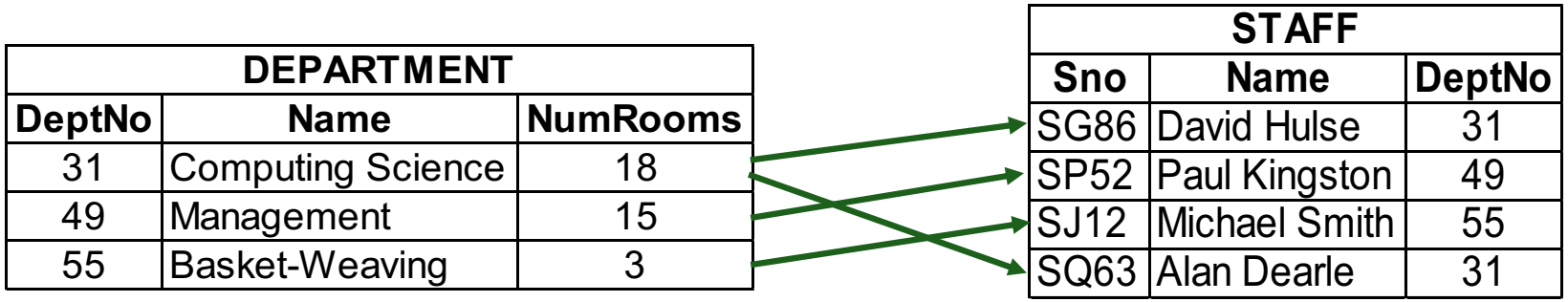
Representing Relationships - I

- Relationships are represented differently depending on their cardinality (1:1, 1:M, or M:M).
- Consider a 1:M relationship such as:

- To represent this relationship we start off with the two relations:
  - *Dept(Dno, Name, NumRooms)*
  - *Staff(Sno, Name)*
- These relations simply represent the two entities and some sample attributes.
- To create the relationship we must link each staff member to his/her corresponding department by embedding a *foreign key*.

Representing Relationships - II

- Thus we extend the *Staff* relation (which is the Many side) to include an extra field, the foreign key *DeptNo*.
- This produces the following result:



DEPARTMENT

DeptNo	Name	NumRooms
31	Computing Science	18
49	Management	15
55	Basket-Weaving	3

STAFF

Sno	Name	DeptNo
SG86	David Hulse	31
SP52	Paul Kingston	49
SJ12	Michael Smith	55
SQ63	Alan Dearle	31

- By embedding *DeptNo* as a foreign key in the *Staff* relation, we create a 1:M relationship from departments to staff members.
- This is illustrated in the diagram since each staff member can be associated with only one department, but each department may have many associated staff members.
- Always be careful about which relation the foreign key is added to (it is always the relation on the Many side of the relationship!).

Representing Many-to-Many Relationships

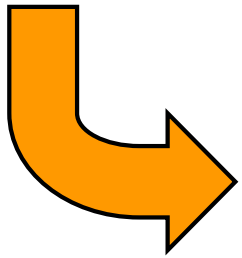
- To handle a many-to-many relationship, such as the *Viewing* relationship between *Properties* and *Renters*, we introduce a separate relation to represent the M:M relationship:

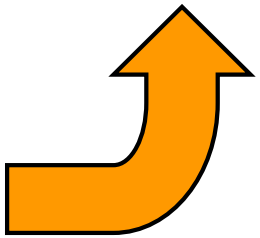
PROPERTY

Pno	*Street*	*Area*	*City*	*Rent*
PA14	16 Holhead	Dee	Aberdeen	650
PL94	6 Argyll St	Kilburn	London	400
PG21	18 Dale Rd	Hyndland	Glasgow	600

RENTER

Rno	*Name*	*Address*
CR76	John Kay	56 High St
CR74	Mike Ritchie	18 Tain St
CR62	Mary Tregear	5 Tarbot Rd





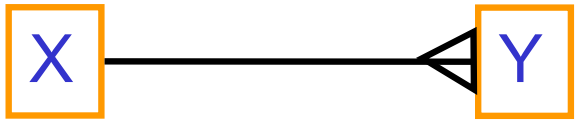
VIEWING

Pno	*Rno*	*Date*	*Time*
PA14	CR74	09/02/97	9:00
PA14	CR76	21/02/97	11:15
PG21	CR74	15/06/97	3:45
PL94	CR62	18/08/97	9:00

- The *Viewing* relation holds foreign keys from each of the entities in the M:M relationship. We also add some extra fields as this happens to be convenient and natural.

Summary: Rules for Relationships - I

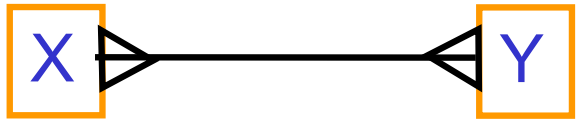
- Consider two relations *X* and *Y* with primary keys *keyx* and *keyy*.
- To create a 1:M relationship from X to Y:



we embed *keyx* (the primary key of the *one* side) as a foreign key in *Y* (the *many* side):

X (*keyx*, …) *Y* (*keyy*, …, *keyx*)

- To create a M:M relationship between *X* and *Y*:



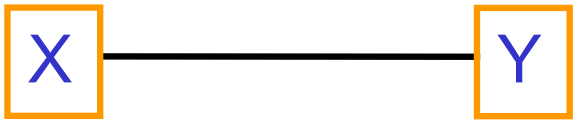
we create a third relation, say *Z*, containing the primary keys from both sides of the relationship:

X (*keyx*, …) *Z* (*keyx*, *keyy*) *Y* (*keyy*, …)

Note that this means creating a whole new relation

Summary: Rules for Relationships - II

- To create a 1:1 relationship from X to Y:



Where *X* and *Y* are two relations with primary keys *keyx* and *keyy*. There are two ways to create a 1:1 relationship from X to Y.

- Option 1: Use separate tables (Recommended Option for you to follow!)

  A foreign key is used to link the tables. For example, we may insert *keyx* into Table Y, **or** insert *keyy* into Table X

  that is, use: X (keyx, …, keyy) OR *Y (keyy, …, keyx)*

- Option 2: Use a single table for both entities
  - we can do this if the relationship is mandatory for at least one of X and Y
  - what is the primary key of the combined table - (see Ritchie page 59)

End of Lecture

Would you like to ask anything?

Don’t forget to read the notes again, and Ritchie Chapter 3.

There will be a tutorial on ER modelling.