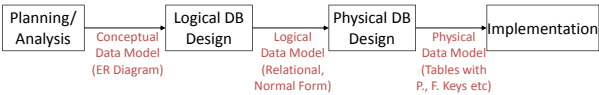# Chapter 4:
Entity-Relationship (ER) Data Modelling

- Introduction
- ER Definitions
- ER Notation
- Relationships
- ER Examples

Introduction to ER Modelling

- An *Entity-relationship model* (ERM) is an abstract and conceptual representation of data.
- ER modelling is a DB modelling method, used to produce a type of *conceptual schema* of a system.
- Diagrams created by this process are called *ER diagrams*.
- Sequence: *Conceptual data model* (i.e. ER) is, at a later stage (called *logical design*), mapped to a *logical data model*, (e.g. *relational model*); this is mapped to a physical model in *physical design.*
- ER Model used to interpret, specify & document requirements for DBs irrespective of DBMS being used.

Planning/ Analysis		Logical DB Design		Physical DB Design		Implementation
	Conceptual Data Model (ER Diagram)		Logical Data Model (Relational, Normal Form)		Physical Data Model (Tables with P., F. Keys etc)	

ER Definitions

- *Entity (Instance)*:
  - An instance of a physical object in the real world.
  - *Entity Class*: Group of objects of the same type.
  - E.g. Entity Class "Student", Entities "John", "Trish" etc
- *Attributes*:
  - Properties of Entities that describe their characteristics.
  - Types:
    - *Simple*: Attribute that is not divisible, e.g. age.
    - *Composite*: Attribute composed of several simple attributes, e.g. address (house number, street, district)
    - *Multiple* : Attribute with a set of possible values for the same entity, e.g. Phone (home, mobile etc.) or email
    - *Key*: Uniquely Ids the Entity e.g. PPSN, Chassis No.
  - *Value Set* (or *domain*): Each simple attribute associated with a VS that may be assigned to that attribute for each individual entity, e.g. age = integer, range [18,…65]

Student

Age

House no.

Address — Street

District

Phone

Worker — PPSN
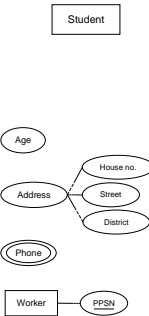
ER Definitions (cont'd)

- *Relationships*:
  1. Are bi-directional (ie can be put 2 ways)
  2. *Degree*:
     - *binary* (i.e. involve only two entities),
     - *ternary* (i.e. involve three participating entities).
  3. Cardinality: Entity types may be linked in more than one way.
  4. May have properties (attribs).
  5. Can be Recursive.

Lecturer — Lectures — Student
Binary

2. Lecturer — Recommends — Course
   Textbook
   Ternary

4. Price
   Bar — sells — Beers

5. Marries
   Person

1:1 Man —1—— Marries ——1— Woman

1:m Lecturer —1—— Teaches ——m— Students

n:m Student —n—— Enrols on ——m— Courses
3.

Keys/Key Attributes

- Some definitions:
  - *Super Key* – Set of attributes uniquely identifying a row
  For SP {S#,P#,QTY} or {S#,P#}
  - *Candidate Key* – (Irreducible) combination of attributes which is a unique identifier within a table. For SP {S#,P#}
  - *Primary Key* - One of the candidate keys. For SP {S#,P#}
  - *Alternate Key* - The candidate key(s) (if any) not chosen as the primary key.
  - *Foreign Key* - A (combination of) attribute(s) in one relation whose value(s) are required to equal in the primary key of another relation.

PK for S
(FK for SP)

S

S#	SName	Status	City
S1	Smith	20	Paris
S2	Jones	10	Paris
S3	Blake	30	Rome

PK for P
(FK for SP)

P

P#	PName	Colour	Weight	City
P1	Nut	Red	12	London
P2	Bolt	Green	17	Paris
P3	Screw	Blue	27	Rome
P4	Screw	Red	14	London

SP

S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S2	P1	300
S2	P2	400
S3	P2	200

PK for SP

ER Example 1: Entity With Attributes

- "*A student has a student number (identifying), a name, an address (with street number, street and district) and several phone numbers*"

Student Number
Name
Student — Address — House no.
           Street
Phone   District

ER Example 2:
Relationship Cardinality Ratios

- Ordinary Notation

| Husband | 1 — Divorces — 1 | Wife |

| Student | 1 — Owns — N | Book |

| Student | N — Borrows — M | Book |

- Crow's Feet Notation

| Student | Owns | Book |

| Student | Borrows | Book |

Relationship Cardinality Ratio Questions

| Patient | Has GP | Doctor |

| Doctor | Performs | Operation |

| Doctor | Specialise In | Disease |

| Needle | Injected Into | Patient |

Recursive Relationship Examples

Marries

Person

N — Likes — M

Person

1 — Supervises — N

Supervisor   Supervisee

Employee

- Note
  - Use of roles in recursive relationship "Supervises"
  - Cardinality Ratios

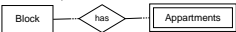## More ER Definitions

- The following are not part of core or lowest common denominator notation:
    - Weak Entity:
        - One which cannot be id'ed by attributes alone
        - E.g. book editions; dependent children,
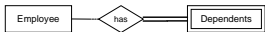   - ID-Dependent Entity:
        - Special case of Weak Entity where id includes entity id it depends on
        - E.g. Individual appartments in a block
        - Block: Identifier `BldgName`, Appartment: Identifier {`BldgName,ApptNo`}
    - Derived Attribute
        - Attribute whose values are generated from other attribute
        - E.g. AcctBalance=TotalCredit – TotalDebit

## More ER Definitions (cont'd)

- Total/Partial Participation
    - Partial: Entity's Existence doesn't require existence of associated entity in a relationship. E.g. Employee Entity doesn't require Dependents
    - Total: Entity's Existence requires that of associated entity
    - Note: Doesn't have to be W.E. to require Total Participation e.g. Employee Works on Project is Total on both sides.
- Extended ER Model
    - Sub-/Super-types:
        - Used to denote "is a" relationship: Employee is either Hourly or Salaried
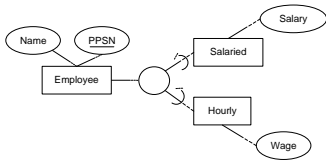
ER Example 3: A Hospital Case

- *"Patients are treated in a single ward by the doctors assigned to them. Usually each patient will be assigned a single doctor, but in rare cases they will have two. Heathcare assistants also attend to the patients, a number of these are associated with each ward."*
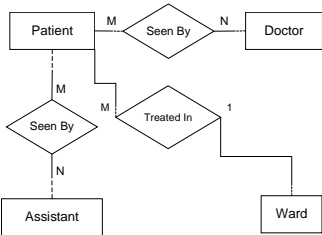
ER Example 4: Football Club

- *"A football <u>club</u> has a name and a ground and is made up of <u>players</u>. A player can play for only one club and a <u>manager</u>, represented by his name manages a club. A footballer has a registration number, name and age. A club manager also buys players. Each club plays against each other club in the league and matches have a date, venue and score."*
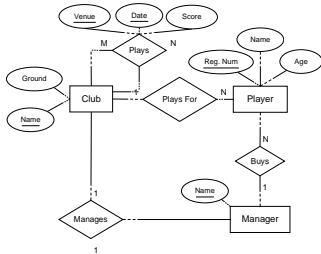
ER Example 5: Bus Company

- *"A Bus Company owns a number of busses. Each <u>bus</u> is allocated to a particular <u>route</u>, although some routes may have several busses. Each route passes through a number of <u>towns</u>. One or more drivers are allocated to each <u>stage</u> of a route, which corresponds to a journey through some or all of the towns on a route. Some of the towns have a <u>garage</u> where busses are kept and each of the busses are identified by the registration number and can carry different numbers of passengers, since the vehicles vary in size and can be single or double-decked. Each route is identified by a route number and information is available on the average number of passengers carried per day for each route. <u>Drivers</u> have an employee number, name, address, and sometimes a telephone number."*

- Entities (bold face)
  - **Bus** - Company owns busses and will hold information about them.
  - **Route** - Buses travel on routes and will need described.
  - **Town** - Buses pass through towns and need to know about them
  - **Driver** - Company employs drivers, personnel will hold their data.
  - **Stage** - Routes are made up of stages
 - **Garage** - Garage houses buses, and need to know where they are.

ER Example 5: Bus Company (cont'd)

- **Entities** and their *Relationships* (Cardinality)
  - A bus is allocated to a route and a route may have several buses.
    - **Bus-Route** (m:1) *is serviced by*
  - A route comprises of one or more stages.
    - **Route-Stage** (1:m) *comprises*
  - One or more drivers are allocated to each stage.
    - **Driver-Stage** (m:1) *is allocated*
  - A stage passes through some or all of the towns on a route.
    - **Stage-Town** (m:n) *passes-through*
  - A route passes through some or all of the towns
    - **Route-Town** (m:n) *passes-through*
  - Some of the towns have a garage
    - **Garage-Town** (1:1) *is located in*
  - A garage keeps buses and each bus has one `home' garage
    - **Garage-Bus** (m:1) *is garaged*

ER Example 5: Bus Company (cont'd)

- **Attributes** (<u>key attributes</u>)
  - **Bus** (<u>reg-no</u>, make, size, deck, no-pass)
  - **Route** (<u>route-no</u>, avg-pass)
  - **Driver** (<u>emp-no</u>, name, address, tel-no)
  - **Town** (<u>name</u>)
  - **Stage** (<u>stage-no</u>)
  - **Garage** (<u>name</u>, address)

ER Example 5: Bus Company (cont'd)
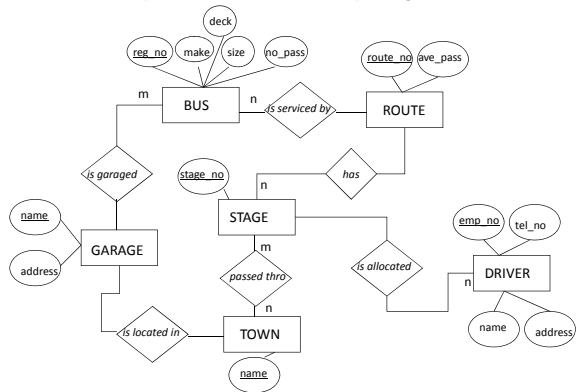
ER Example 6: University Database

- *"A <u>lecturer</u>, identified by his or her number, name and room number, is responsible for organising a number of course <u>modules</u>. Each module has a unique code and also a name and each module can involve a number of lecturers who deliver part of it. A module is composed of a series of <u>lectures</u> and because of economic constraints and common sense, sometimes lectures on a given topic can be part of more than one module. A lecture has a time, room and date and is delivered by a lecturer and a lecturer may deliver more than one lecture. <u>Students</u>, identified by number and name, can attend lectures and a student must be registered for a number of modules. We also store the date on which the student first registered for that module. Finally, a lecturer acts as a tutor for a number of students and each student has only one tutor."*

ER Example 6: University Database (cont'd)

- **Entities** and their Attributes (<u>key</u>)
    - **Lecturer** (<u>Number</u>, Name, Office)**, Student (<u>Number</u>,** Name)
    - **Module** (<u>Code</u>, Name), **Lecture** (<u>Room</u>, <u>Date</u>, <u>Time</u>)
- **Entities** and their Relationships **(Cardinality)** *italics*
    - "A lecturer is responsible for organising a number of course modules"
    - **Lecturer-Module** (1:N) *is responsible for*
    - "Each module can involve a number of lecturers who deliver part of it."
    - **Lecturer-Module** (N:M) *lectures*
    - "A Module is composed of a series of Lectures and Lectures on a given topic can be part of more than one Module."
    - **Module-Lecture** (N:M) *is part of*
    - "A Lecture is delivered by a Lecturer and a lecturer may deliver more than one lecture."
    - **Lecturer-Lecture** (1:N) *delivers*
    - "Students, can attend Lectures"
    - **Student-Lecture** (N:M) *attend*
    - "and a Student must be registered for a number of Modules"
    - **Student-Module** (N:M) *registers* (Attribute: Date)
    - "Lecturer acts as a tutor for a number of Students and each Student has only one tutor"
    - **Lecturer-Student** (1:N) *tutors*

ER Example 6: University Database (cont'd)

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