Principles of Databases

Entity-Relational Data Modeling

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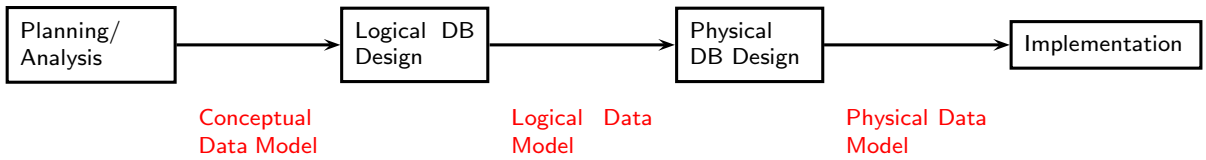
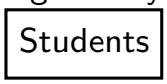
Introduction to ER Modeling

- An *Entity-Relationship Model* (ERM) is an abstract and conceptual representation of data.
- ER modellng is a DB method used to produce a type of conceptual schema of a system.
- The diagrams produced are called *ER diagrams*.
- ER Model is used to interpret, specify and document requirements for databases irrespective of the DBMS being used.
- Sequence: Conceptual Data Model (*ER diagrams*) → Logical Data Model (*relational model*) → Physical Design



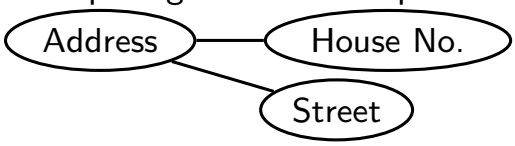
ER Definitions

- *Entity (Instance):*
  - An entity is an instance of a physical object in the world.
  - *Entity Class*: A group of objects of the same type.
    - e.g. Entity Class: Students Entities: John, Mary



- *Attributes*:
  - Properties of entities that describe their characteristics.
  - Types:
    - *Simple*: An attribute that is not divisible, e.g. Age

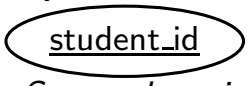
    - *Composite*: An attribute comprising of several simple attributes, e.g. address



    - *Multiple*: An attribute that can multiple values for the same entity, e.g. phone number

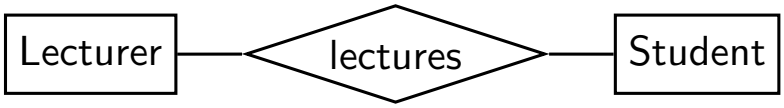
ER Definitions (2)

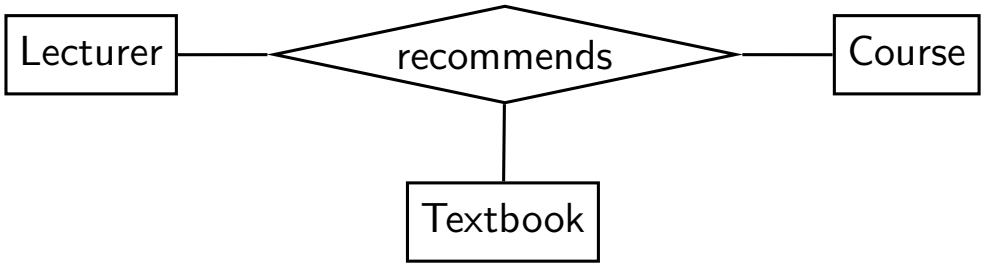
    - *Key*: An attribute that uniquely identifies an entity.

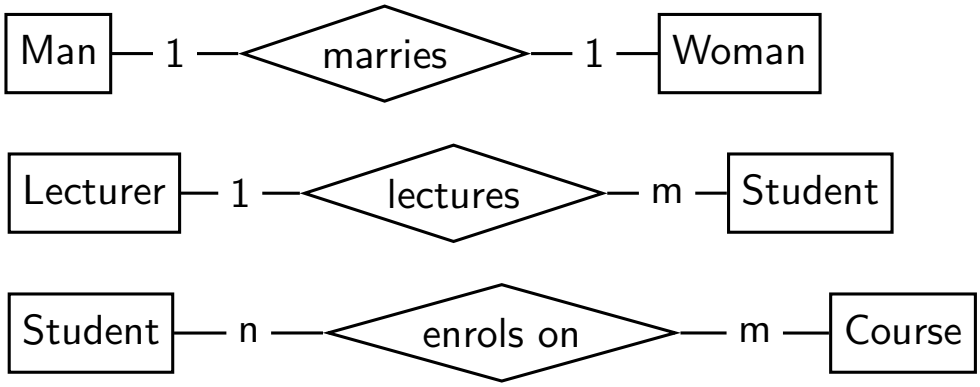


  - *Value Set* or *domain*: Each simple attribute has a range of values that may be assigned to that attribute for each individual entity., e.g. Age = integer, range[18,...85]
- *Relationships*:
  1. Relationship are bi-directional, they can be phrased both ways.
  2. *Degree*:
     - *binary* involving two entities.
     - *ternary* involving three entities.
  3. *Cardinality*: Defines how many entities are involved in a relationship.
  4. Relationships may have properties (attributes).
  5. Relationships can be recursive.

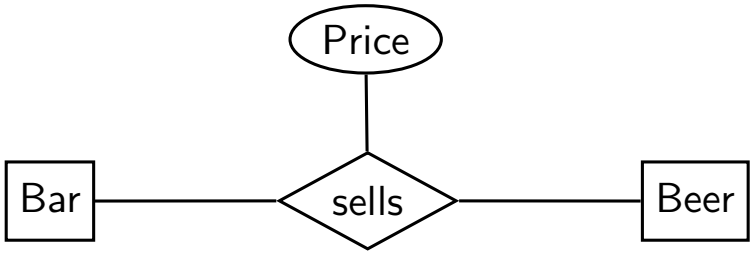
ER Definitions (3)

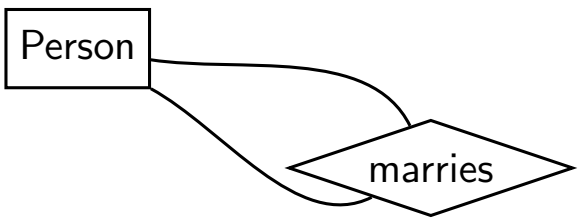
1. 

2. 

3. 

ER Definitions (4)

4. 

5. 

Keys and Key Attributes

- *Super-Key*: A set of attributes that uniquely identifies a row.
  - For the SP table this would be {S#,P#,QTY} or {S#,P#}
- *Candidate Key*: (Irreducible) combination of attributes which uniquely identifies each row.
  - For the SP table this is {S#, P#}
- *Primary Key*: One of the candidate keys.
- *Alternate Key*: One of the candidate keys not chosen as the primary key.
- *Foreign Key*: A (combination of) attribute(s) in one relation whose value(s) are required to be equal in the primary key of another relation.

S

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

SP

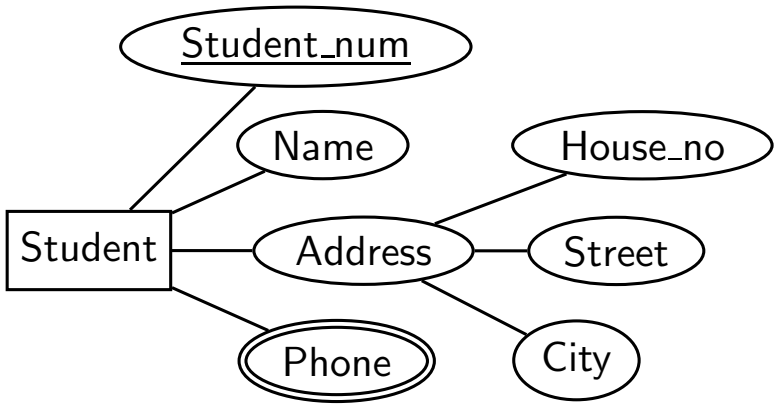
S#	P#	QTY
S1	P1	300
S1	P2	200
S1	P3	400
S2	P1	300
S2	P2	400
S3	P2	200

P

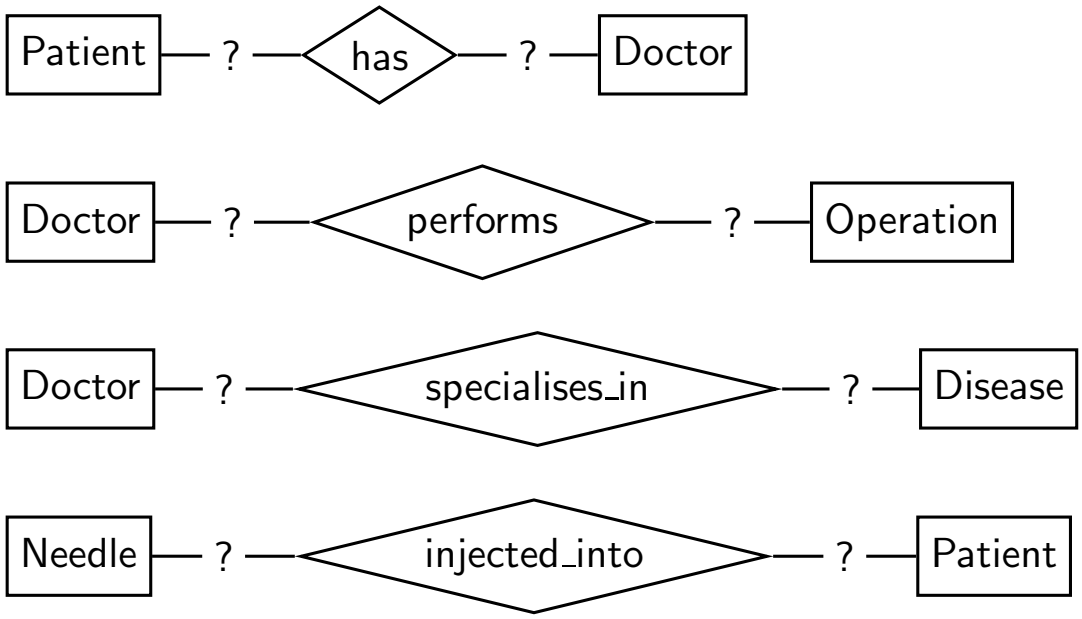
P#	PName	Colour	Weight	City
P1	Nut	Red	12	Dublin
P2	Bolt	Green	17	Paris
P3	Screw	Blue	27	Rome
P4	Screw	Red	14	Dublin

ER Example 1

A student has a student number (identifying), a name, an address (with house number, street and city) and several phone numbers.

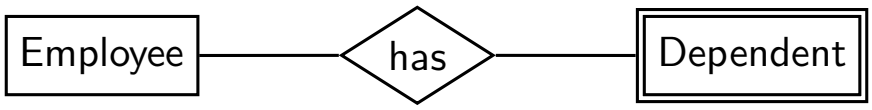


Cardinality Questions



More ER Definitions

- *Weak Entity*: An entity that cannot be identified by its attributes alone.



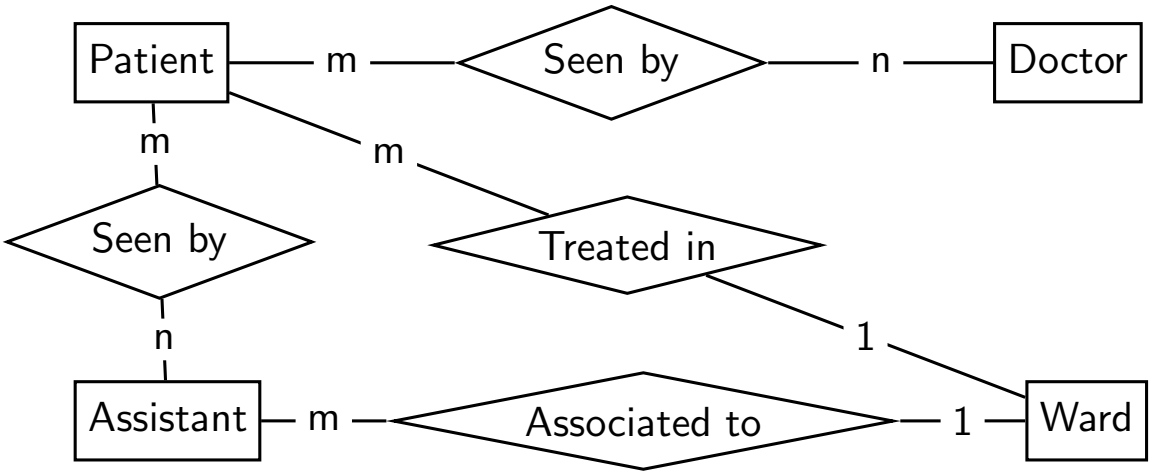
- *ID-Dependent Entity*: A special case of a weak entity that includes the entity ID it depends on.
  - An apartment in a building block
  - Block: Identifier `BldgName`, Apartment: Identifier {`BldgName`,`ApartNo`}
- *Derived Attribute*: An attribute whose values are generated from another attribute.
  - AccountBalance = TotalCredit - TotalDebit

More ER Definitions (2)

- *Total/Partial Participation*:
  - *Partial*: An entity's existence does not require the existence of the associated entity in the relationship.
    - Employee Entity doesn't require the existence of the Dependent entity.
  - *Total*: An entity's existence requires the existence of the associated entity.
  - Doesn't have to be a Weak Entity to require Total Participation.
    - Employee work on a Project is a total relation on both sides.

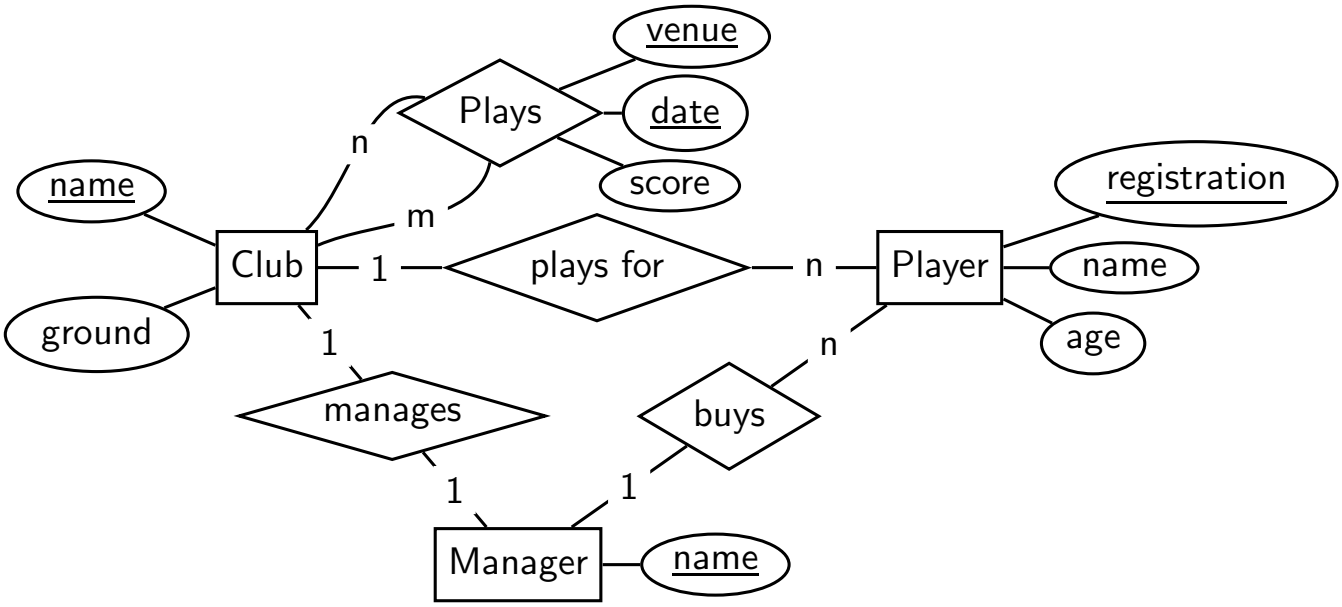
ER Example 2: A Hospital Case

Patients are treated in a single ward by doctors assigned to them. Usually each patient will be assigned to a single doctor, but in rare cases they will have two. Healthcare assistants also attend to the patients, a number of these are associated to each ward.



ER Example 3: Football Club

A football club has a name and a ground and is made up of players. A player can play for only one club and a manager, 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 4: Bus Company

A bus company owns a number of buses. Each bus is allocated to a particular route, although some routes may have several buses. Each route passes through a number of towns. One or more drivers are allocated to each stage of a route, which corresponds to a journey through some or all of the towns on a route. Some of the towns have a garage where buses are kept. Each of the buses is identified by a 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 carries per day for each route. Drivers have an employee number, name address, and sometimes a telephone number.

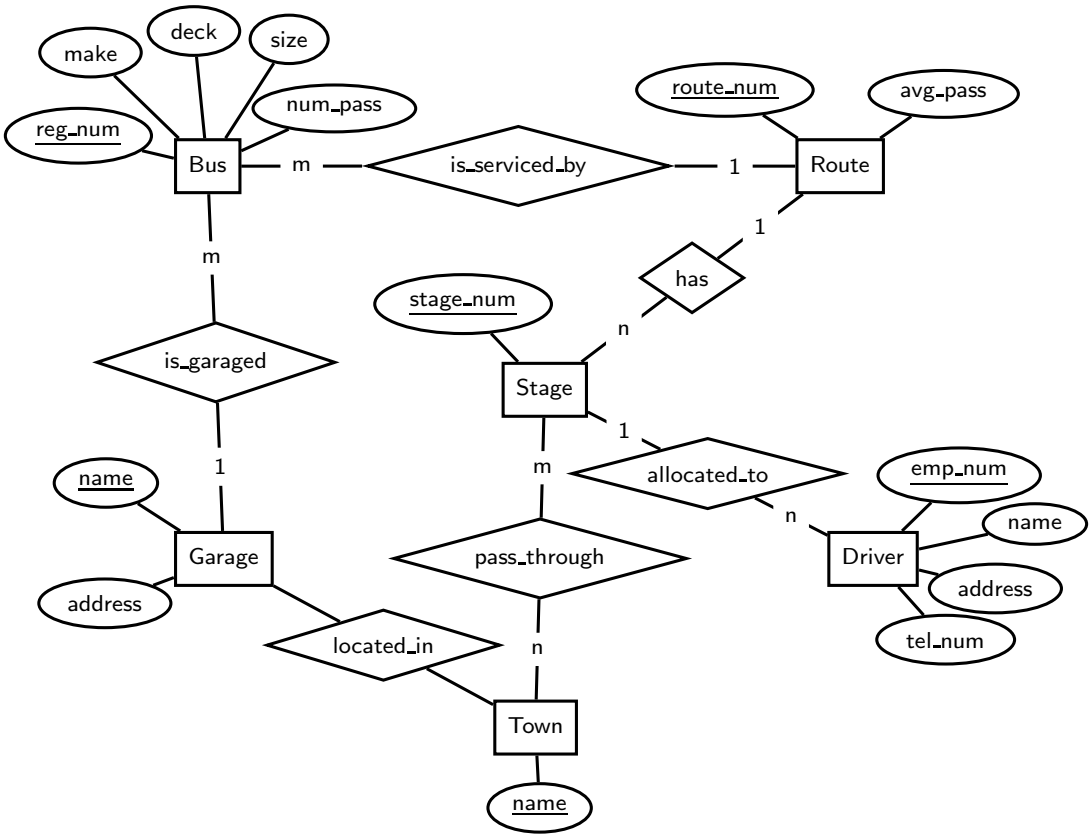
ER Example 4: Bus Company (2)

- **Entities** and the *Relationships* (including cardinality):
  - Each bus is allocated to a particular route, although some routes may have several buses.
    - **Bus** - **Route** (m:1) *is serviced by*
  - One or more drivers are allocated to each stage of a route, which corresponds to a journey through some or all of the towns on a route.
    - **Driver** - **Stage** (m:1) *is allocated*
    - **Route** - **Stage** (1:n) *comprises*
  - Each route passes through a number of towns.
    - **Stage** - **Towns** (m:n) *passes through*
    - **Route** - **Towns** (m:n) *passes through*
  - Some of the towns have a garage where buses are kept.
    - **Garage** - **Town** (1:1) *located in*
    - **Garage** - **Bus** (1:n) *is garaged*

ER Example 4: Bus Company (3)

- **Attributes** (key attributes)
  - **Bus** (reg_num, make, size, deck, num_pass)
  - **Route** (route_num,avg_pass)
  - **Driver** (emp_num, name, address, tel_num)
  - **Town** (name)
  - **Stage** (stage_num)
  - **Garage** (name, address)

ER Example 4: Bus Company (4)



ER Example 5: University Database

A lecturer, identified by his or her staff number, name and room number, is responsible for organising a number of course modules. Each module has a unique code and also a name. Each course module can involve a number of lecturers who deliver part of it. A module is composed of a series of lectuers 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. Students, identified by a name and a number, 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 act as a tutor for a number of students and each student only has one tutor.

ER Example 5: University Database (2)

- **Entities** and their Attributes (key)
  - **Lecturer** (staff_num, name, office)
  - **Student** (number, name)
  - **Module** (code, name)
  - **Lecture** (room, date, time)
- **Relationships** and their cardinalities
  - A lecturer is responsible for organising a number of course modules.
    - **Lecturer** - **Module** (1:n) *is responsible for*
  - Each course module can involve a number of lecturers who deliver part of it.
    - **Lecturer** - **Module** (m:n) *lectures*
  - A module is composed of a series of lectures and because of economic constraints and common sense, sometimes lectures on a given topic can be part of more than one module.
    - **Module** - **Lecture** (m:n) *is part of*

ER Example 5: University Database (3)

- **Relationships** and their cardinalities (continued)
  - 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** (m:n) *attend*
  - and a student must be registered for a number of modules.
    - **Student** - **Modules** (m:n) *registers* (Attribute: date)
  - a lecturer act as a tutor for a number of students and each student only has one tutor.
    - **Lecturer** - **Student** (1:n) *tutors*

ER Example 5: University Database (4)