COMP3311 19T3 | Database Systems

Exercises 02
Relational Model, ER-Relational Mapping, SQL DDL

1. Describe each of the following core components of the relational model:

   a. attribute

   Answer:

   An *attribute* is a single atomic data item that forms part of a relation. In the "table view" of relations, an attribute would be a column.

   b. domain

   Answer:

   A *domain* is a set of allowed values, typically associated with an attribute. Values are atomic and belong to a single data type (e.g. number, string, date). A given domain may have additional constraints defined on the data type (e.g. a person's age must be a positive integer and will be less than 150 ... although in this particular example, the upper bound is fuzzy).

   c. relation schema

   Answer:

   A relation schema gives a name for the relation, names and domains for each attribute in the relation, and constraints on individual attributes and on the relation as a whole. For simplicty, and especially when talking about the relational model in the abstract, we might omit the domains and constraints and asssume that they can be inferred from the attribute names.

   E.g. full relation schema (expressed in an invented notation):

   ```
   Student(id:integer/key, name:string, degree:string, year:integer>0)
   ```

   abstract relation schema

   ```
   Student(id, name, degree, year)
   ```

   Note that a common convention is to underline the key attributes.

   d. relational schema

   Answer:

   A relational schema is a collection of relation schemas, along with additional constraints that define properties involving multiple relations (e.g. all banks must have at least one employee). Foreign key constraints also fit into this category of constraints.

   e. tuple

   Answer:

   A tuple is a collection of attribute values. In the SQL version of the relational model, some of the attribute values may be NULL; in the pure relational model, every attribute is required to have a defined value. All non-NULL values must belong to the domain corresponding to that attribute. They must also satisfy any other constraints defined in the schema.

   f. relation

   Answer:

A relation is a set of tuples based on a relational schema, where all tuples in the set

- have the same structure as defined in the relational schema
- satisfy all of the constraints defined in the relational schema.

g. key

Answer:

A set of attributes (often just a single attribute) that contains a distinct value for every tuple in the relation. Common single attribute keys are identifiers such as StudentID, TaxFileNumber, SocialSecurityNumber, etc. which are invented specifically for the purpose of distinguishing tuples. A multi-attribute key might be the combination of student and course in an enrolment table (i.e. you can only be enrolled in a given course once at a particular point in time)

h. foreign key

Answer:

A set of attributes (often just a single attribute) in one relation that contains the value of key attribute(s) in another relation. This is the relational model's mechanism by which one table can reference another. We say that the foreign key in table T references the corresponding primary key in table R. For a given tuple in T, the values of foreign key attributes must correspond to a primary key value that exists in the table R or be all NULL; this property is called "referential integrity".

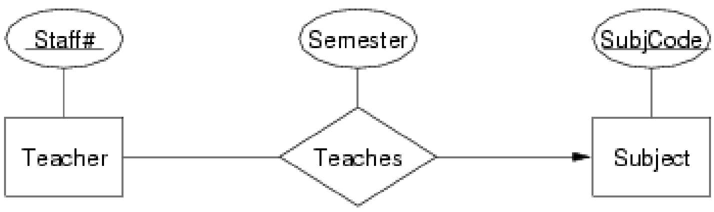
2. Why is it useful to first do an ER design and then convert this into a relational schema?

Answer:

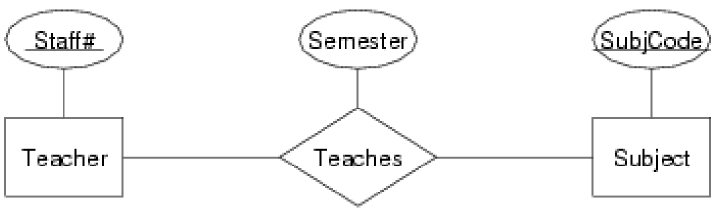
Because ...
- allows the designer to initially concentrate on abstract view of data
- allows the designer to initially concentrate on abstract view of relationships
- no need to initially worry about concrete represenation details
- no need to initially worry about fine-grained constraints
- the "structural" parts of the mapping are straightforward
- new information (concrete data types, constraints, FKs) must be added for the relational model, but this easier if other design work already done

3. Convert each of the following ER design fragments into a relational data model expressed as a box-and-arrow diagram:

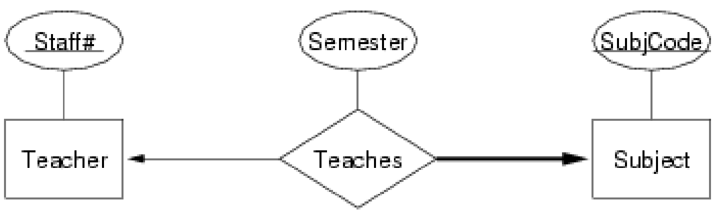
a.



b.



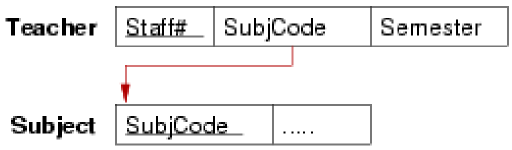
c.



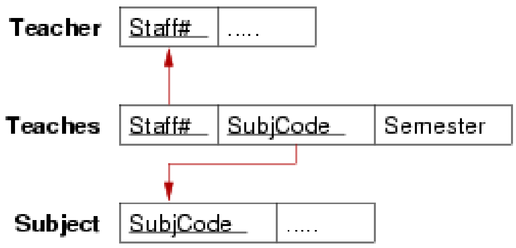
Answer:

Relational models for the three Teacher-Teaches-Subject scenarios:

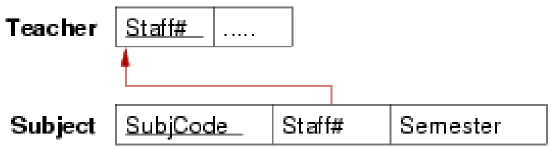
a.



b.

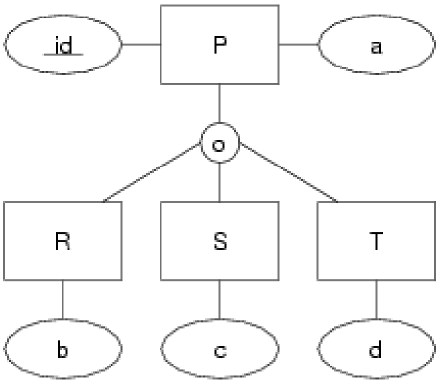


c.



In the third scenario, we place the foreign key in the relation that totally participates in the relationship, so as to minimise wasted space.

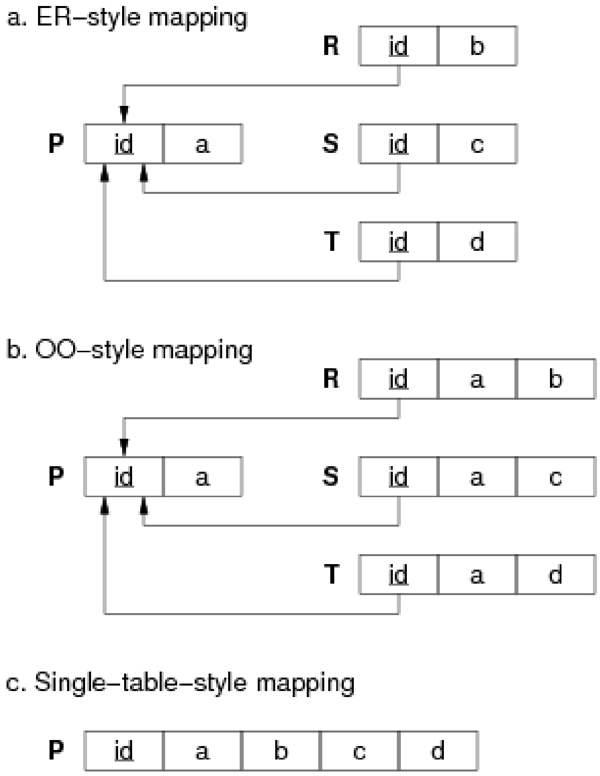
4. In the mapping from the ER model to the relational model, there are three different ways to map class hierarchies. Show each of them by giving the mapping for the following class hierarchy:



Use box-and-arrow diagrams for the relational models.

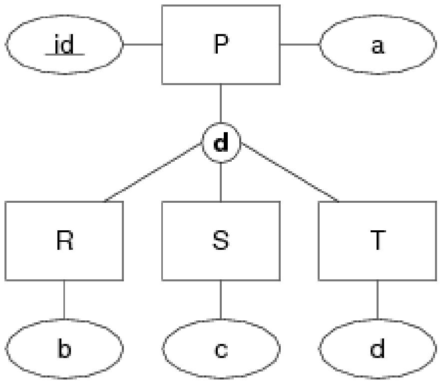
Answer:

Relational mappings for a class hierarchy:



Note: the arrows show how the foreign keys in the relations R, S, T reference the primary key `id` attribute in relation P.

5. Now consider a variation on the above class hierarchy where the sub-classes are disjoint. Show the three possible mappings for the class hierarchy and discuss how effectively they represent the semantics of the disjoint sub-classes:

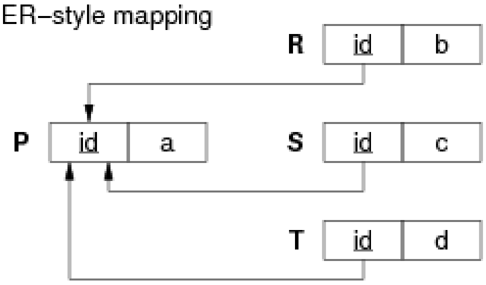


Use box-and-arrow diagrams for the relational models.

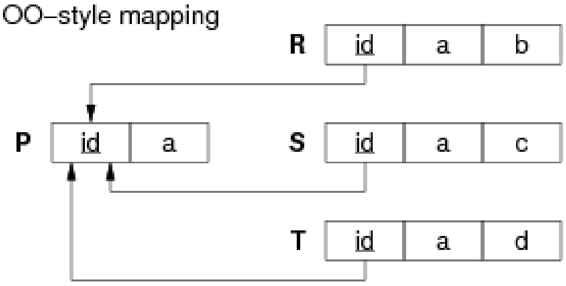
Answer:

Relational mappings for a class hierarchy:

a. ER–style mapping



b. OO–style mapping



c. Single–table–style mapping

Note: the ER and OO mappings cannot represent the disjoint constraint. There is nothing in the data model to prevent an object occurring in multiple sub-classes. In the single-table mapping, however, we can add an extra attribute which indicates which sub-class each tuple belongs to; this forces each tuple to belong to just a single sub-class. However, this still doesn't prevent a tuple from e.g. containing a value for attribute `b` when it also has a value of 'S' for the `subClass` attribute. In SQL, we can write table constraints to prevent such situations. Preventing sub-class overlap in the ER or OO models in SQL requires us to use global constraints, typically implemented as triggers.

6. Discuss suitable SQL representations for each of the following attributes, including additional domain constraints where relevant:

   a. people's names

      Answer:

      How to represent names, depends on how they're going to be used. If we need to sort people by family name, then we'd either need to store them as a single string in the format "*familyName*,*givenNames*" or stored as two separate attributes, one for each component of the name. If stored as a single string, `varchar(40)` would be ok to hold all but the longest human names. If stored as two separate strings, each individual component would probably need to hold up to 30 characters, e.g.

```
givenName    varchar(30),
familyNames  varchar(30),
```

      In some contexts, you might even want to store two versions of the name: the official one (perhaps as above), and another one which gives a single string to tell how the user would like their name to appear when displayed, e.g.

```
showname     varchar(50),
```

      (to avoid those horrible middle names that you don't want anybody to know about :-)

   b. addresses

      Answer:

      As for names, addresses could be broken into components such as street, town, state, country, postal-code, e.g.

```
street  varchar(30),
town    varchar(30),
state   varchar(30),
country varchar(30),
```

or simply done as a single string, but longer than a person's name.

```
address  varchar(80),
```

If `country` was available as a separate table (which may be plausible in some contexts), then a foreign key reference to a country identifier could be used.

```
street  varchar(30),
town    varchar(30),
state   varchar(30),
country integer references Country(id),
```

c. gender

Answer:

Since there are only two values, any data type that can store two values is ok. To make the data more readable direct from the database, using strings would be most appropriate (along with constraints to restrict the set of possible strings).Here are some possible representations:

```
gender  integer check (gender in (1,2)) -- 1=male, 2=female
gender  char(1) check (gender in ('m','f'))
gender  char(1) check (gender in ('M','F'))
gender  varchar(6) check (gender in ('male','female'))
gender  varchar(6) check (gender in ('Male','Female'))
```

(recall that SQL *is* case-sensitive inside strings)

d. ages

Answer:

It is probably better to use date-of-birth rather than age. Why? because age changes over time, while date-of-birth is fixed and there are typically operations available to compute age, given the date-of-birth. However, if anyone was to insist on having an age attribute, then it would be useful to use an integer value with additional common-sense constraints, e.g.

```
age  integer check (age > 0 and age < 150)
```

e. dollar values

Answer:

For monetary values, we typically need (for display, at least), an arbtrary number of total digits, with two digits after the decimal point. In SQL, this could be done as:

```
value  numeric(20,2),
```

Alternatively, it could simply be represented as a floating point number, e.g.

```
value  float,
```

Some database systems (e.g. PostgreSQL) have special (non-standard) types for handling monetary values, e.g.

```
value  money,
```

Values of this type are essentially floating point numbers with the additional property that they can be read and written using a format like `$1234.56`

If some application did not want to allow negative monetary values, it would need to add an additional constraint to enforce this:

```
value  money check (value >= 0.00)
```

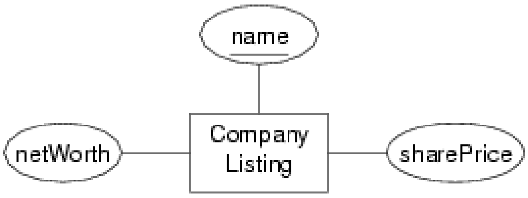
f. masses of material

Answer:

Generally, a floating point value would be the most suitable. Since you cannot have negative mass, it would be useful to add an additional constraint. It is also useful to document the units of measurement, although this can only be done as an SQL comment, e.g.

```
quantity  float check (quantity >= 0.0)  -- kilos
```

7. Convert the following entity into an SQL `CREATE TABLE` definition:



Give reasons for all choices of domain types.

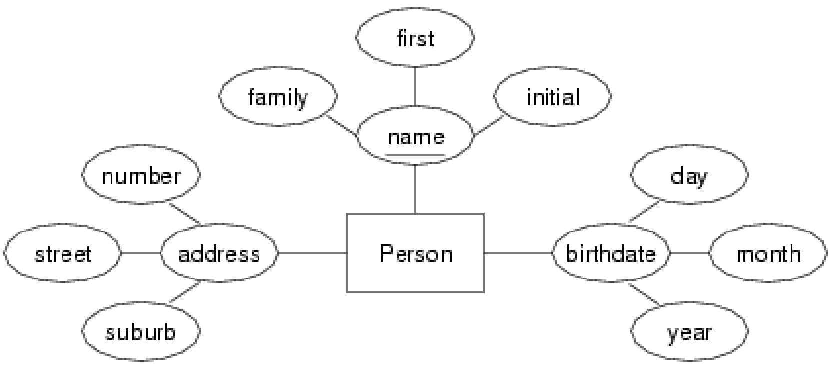
Answer:

Convert CompanyListing entity into an SQL `CREATE TABLE` definition:

```
CREATE TABLE CompanyListing
(
        name          char(4) PRIMARY KEY,
        sharePrice    numeric(6,2),
        netWorth      numeric(20,2)
);
```

Stock-market listings typically use 3-4 character abbreviations for company names, so a fixed-length character string is ok. Since share prices are money values, using numeric values with two decimal places (for cents) would be suitable. Individual share prices are rarely more than $1000.00, so we use a field with 6 digits, including 2 decimal places. The nett worth of a listed company is likely to be very large, so we allow for up to 20 digits. Note that both of these allow only integer values of cents. Since the stock market probably requires more precision, then a `float` value (or allowing more digits after the decimal point) might be more appropriate. PostgreSQL provides a `money` data type which uses floating point and has the added advantage of displaying the field in a format like `$999.99`

8. Convert the following entity into an SQL `CREATE TABLE` definition:



Give reasons for all choices of domain types.

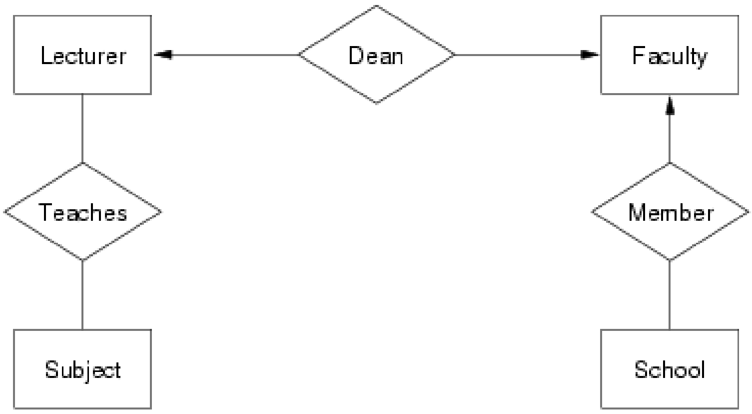
Answer:

Convert Person entity into SQL `CREATE TABLE` definition:

```
CREATE TABLE Person
(
        familyName      varchar(30),
        givenName       varchar(30),
        initial         char(1),
        streetNumber    integer,
        streetName      varchar(40),
        suburb          varchar(40),
        birthday        date,
        PRIMARY KEY     (familyName,givenName,initial)
);
```

The choice of a three-part name is tricky. The family-name and given-name parts are pretty much as described above. However, the initial creates a problem. It is part of the key, and so the above definition requires it to be provided, even though not everyone is going to have a middle initial. It ought to remain part of the key, however, so that we can distinguish between people called "John A. Smith" and "John B. Smith". Since no part of the key is allowed to be NULL, we need to adopt some convention for people with no initials; a plausible approach would to use a single space character (i.e. `' '`). If we need to deal with addresses like "1a Smith Street", then we'd need to change the `number` attribute to a string type. Since all DBMSs have a `date` type, along with functions for extracting the components, we may as well collapse the components of the `birthday` attribute into a single field of `date` type.

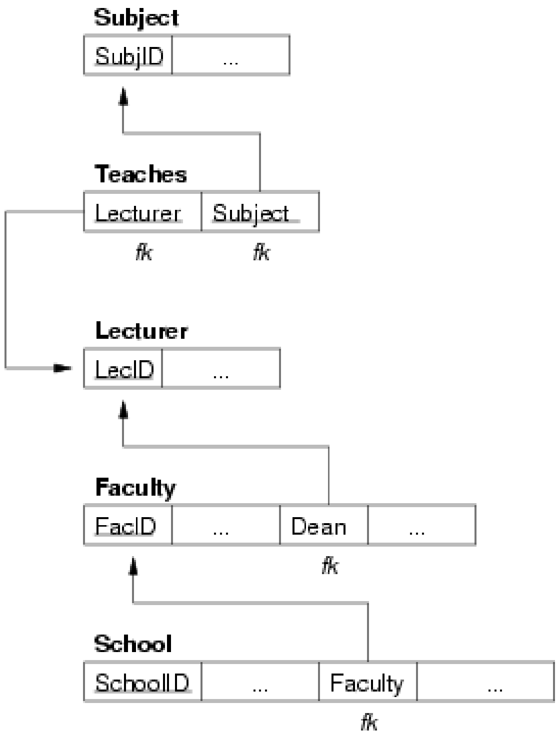
9. Convert the following ER design into a relational data model:



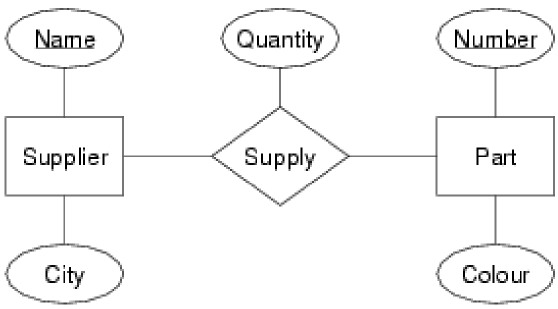
You can assume that each attributes contains (at least) a suitably-named attribute containing a unique identifying number (e.g. the `Lecturer` entity contains a `LecID` attribute).

Answer:

Relational models for very small University ER model:



10. Convert the following ER design into an SQL schema:



Which elements of the ER design do not appear in the relational version?

Answer:

Supplier/Parts ER design expressed as an SQL schema:

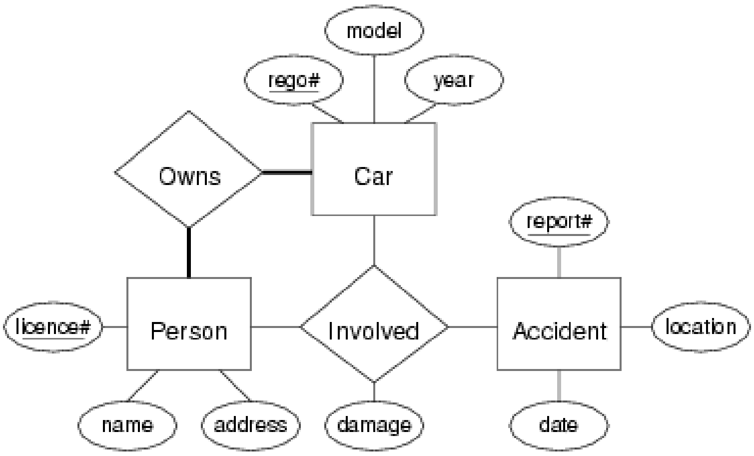
```
CREATE TABLE Supplier (
        name    varchar(50),
        city    varchar(50),
        PRIMARY KEY (name)
);
create TABLE Part (
        number  integer,
        colour  varchar(20),
        PRIMARY KEY (number)

);
CREATE TABLE Supply (
        supplier varchar(50),
        part     integer,
        quantity integer,
        PRIMARY KEY (supplier,part),
        FOREIGN KEY (supplier) REFERENCES Supplier(name),
        FOREIGN KEY (part) REFERENCES Part(number)
);
```

In this example, we write all constraints at the table level. In subsequent examples, we write constraints in a more compact form.

Which elements of the E/R design do not appear in the relational version?

All of the elements appear. The translation is a straightforward mapping because we have an N:M relationship. Each entity becomes a table; the relationship becomes a table. Attributes in the ER model become attributes in the relational model. The only information we need to add are specific domain definitions for the attributes; we've chosen "reasonable" domains.

11. Convert the following ER design into a relational data model expressed first as a box-and-arrow diagram and then as a sequence of statements in the SQL data definition language:

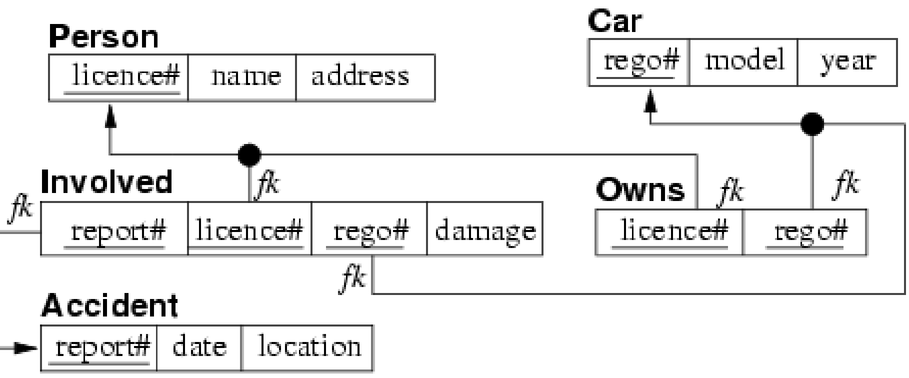


Which elements of the ER design do not appear in the relational version?

Answer:

Relational design for Person-Car-Accident

Box-and-arrow version:



SQL Schema:

```
CREATE TABLE Person
(
        licenceNo       integer PRIMARY KEY,
        name            varchar(40),
        address         varchar(60)
);
CREATE TABLE Car
(
        registrationNo  char(6) PRIMARY KEY, -- e.g. "ABC123"
        model           varchar(20),
        year            integer
);
CREATE TABLE Accident
```

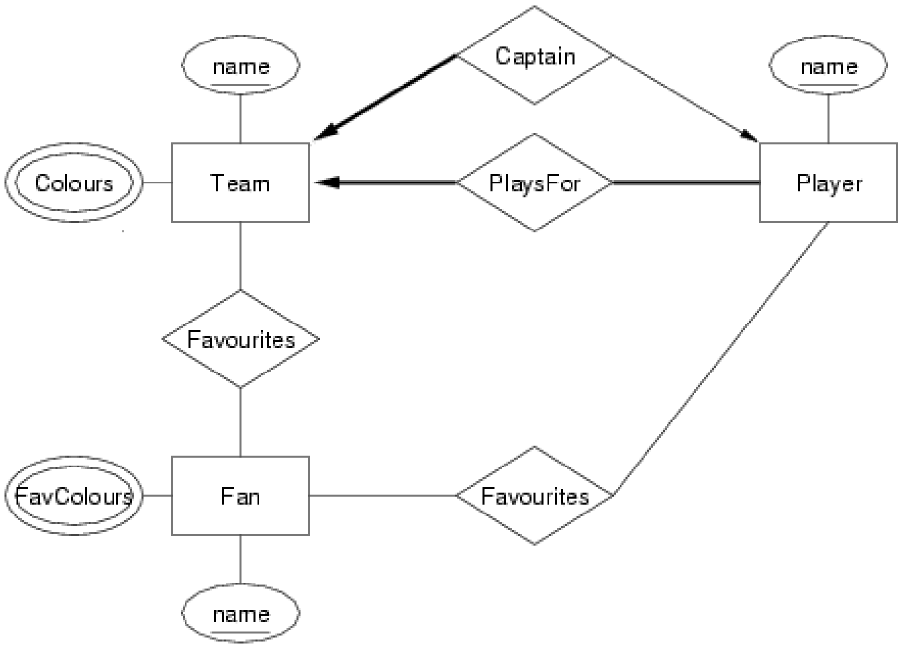
```
(
    reportNo        integer PRIMARY KEY,
        happenedAt      date,
        location        varchar(60)
);
CREATE TABLE Owns
        person          integer REFERENCES Person(licenceNo),
        car             char(6) REFERENCES Car(registrationNo),
        PRIMARY KEY     (person,car)
);
CREATE TABLE Involved
(
        accident        integer REFERENCES Accident(reportNo),
        person          integer REFERENCES Person(licenceNo),
        car             char(6) REFERENCES Car(registrationNo),
        damage          money,
        PRIMARY KEY     (accident,person,car)
);
```

Which elements of the E/R design do not appear in the relational version?

At a syntactic level, all of entities, relationships and attributes are explicitly represented in the relational schema. At a semantic level, the total participation constraints on `Person` and `Car` in the `Owns` relation are not represented, so that there could be people in the database who do not own a car, and cars that are not owned by anyone.

Note that it is not possible to express these constraints in standard SQL. They would need to be implemented by e.g. stored trigger procedures.

12. [Based on GUW 2.1.3] Convert the following ER design into a relational data model expressed first as a box-and-arrow diagram and then as a sequence of statements in the SQL data definition language:

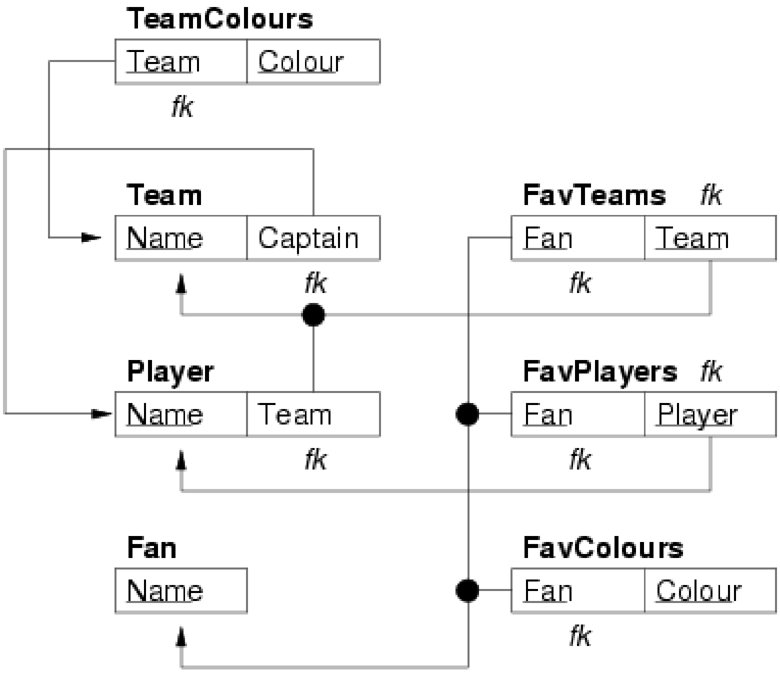


Which elements of the ER design do not appear in the relational version?

Answer:

[Based on GUW 2.1.3] Relational design for Teams-Players-Fans

Box-and-arrow version:



SQL schema:

```
CREATE TABLE Team
(
        name            varchar(50) PRIMARY KEY,
        captain         varchar(40) NOT NULL REFERENCES Player(name)
);
CREATE TABLE Player
(
        name            varchar(40) PRIMARY KEY,
        team            varchar(50) NOT NULL REFERENCES Team(name)
);
CREATE TABLE Fan
(
        name            varchar(40) PRIMARY KEY,
);
CREATE TABLE TeamColours
(
        team            varchar(50) REFERENCES Team(name),
        colour          varchar(30),
        PRIMARY KEY     (team,colour)
);
CREATE TABLE FavTeams
(
        fan             varchar(50) REFERENCES Fan(name),
        team            varchar(50) REFERENCES Team(name),
        PRIMARY KEY     (fan,team)
);
CREATE TABLE FavPlayers
(
        fan             varchar(50) REFERENCES Fan(name),
        player          varchar(50) REFERENCES Player(name),
        PRIMARY KEY     (fan,player)
);
CREATE TABLE FavColours
(
        fan             varchar(50) REFERENCES Fan(name),
        colour          varchar(30),
        PRIMARY KEY     (fan,colour)
);
```

Which elements of the E/R design do not appear in the relational version?

At a syntactic level, the multi-valued attributes from the E/R design do not appear directly in the relational model, but are replaced by tuples in the `TeamColours` and `FavColours` tables.

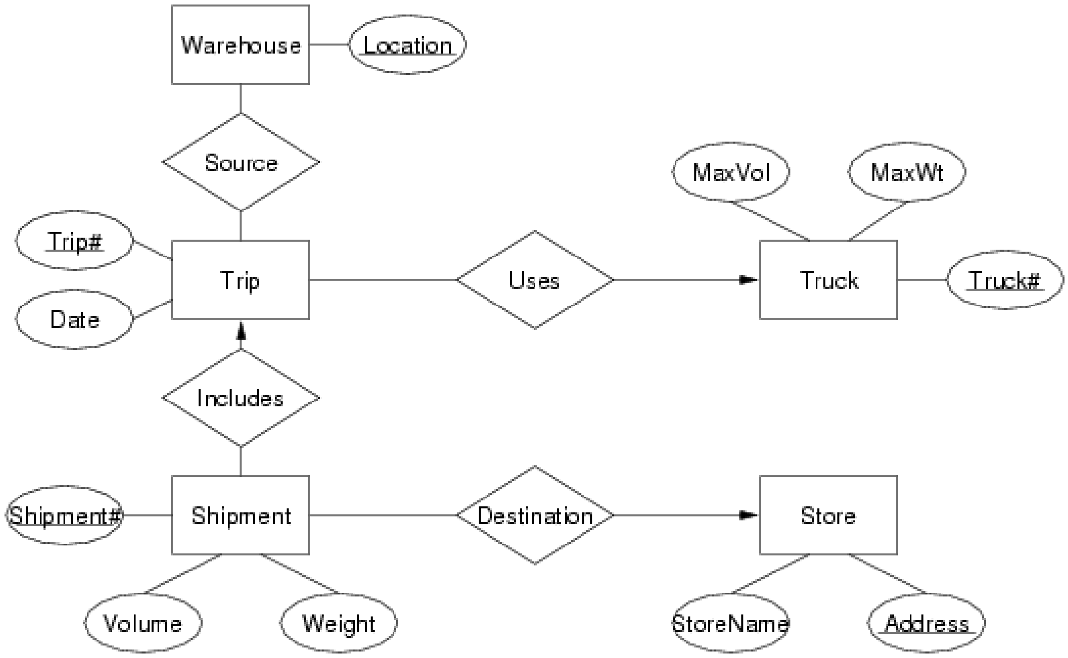
At a semantic level, it doesn't capture the total participation of the `Team` entity in the `PlaysFor` relationship. While all players have to play for a team, the diagram does not enforce that each team must have at least one player who plays for it (except indirectly via the fact that it has to have a captain).

It also doesn't require that a team has any colours or that a fan has any favourite colours. Of course, the E/R diagram doesn't imply this either (non-key attributes are not required to have a value), but if it did state this, the relational model as given could not capture it.

The above SQL schema is simple, but doesn't actually load because of the mutual interdependence of Player and Team. To fix this, you would need something like the following:

```
-- create Team without the foreign key and then add it once Player exists

CREATE TABLE Team
(
        name            varchar(50) PRIMARY KEY,
        captain         varchar(40) NOT NULL
);
CREATE TABLE Player
(
        name            varchar(40) PRIMARY KEY,
        team            varchar(50) NOT NULL REFERENCES Team(name)
);
ALTER TABLE Team ADD FOREIGN KEY (captain) REFERENCES Player(name);

-- alternatively, move the captain foreign key to the Player table
--   which is allowed because it's a 1:1 mapping
-- this isn't as efficient because players who are not captain will
--   have a null value for the captain foreign key

CREATE TABLE Team
(
        name            varchar(50) PRIMARY KEY
);
CREATE TABLE Player
(
        name            varchar(40) PRIMARY KEY,
        team            varchar(50) NOT NULL REFERENCES Team(name)
        captain         varchar(50) REFERENCES Team(name)
);
```

13. Convert the following ER design into a relational data model expressed first as a box-and-arrow diagram and then as a sequence of statements in the SQL data definition language:

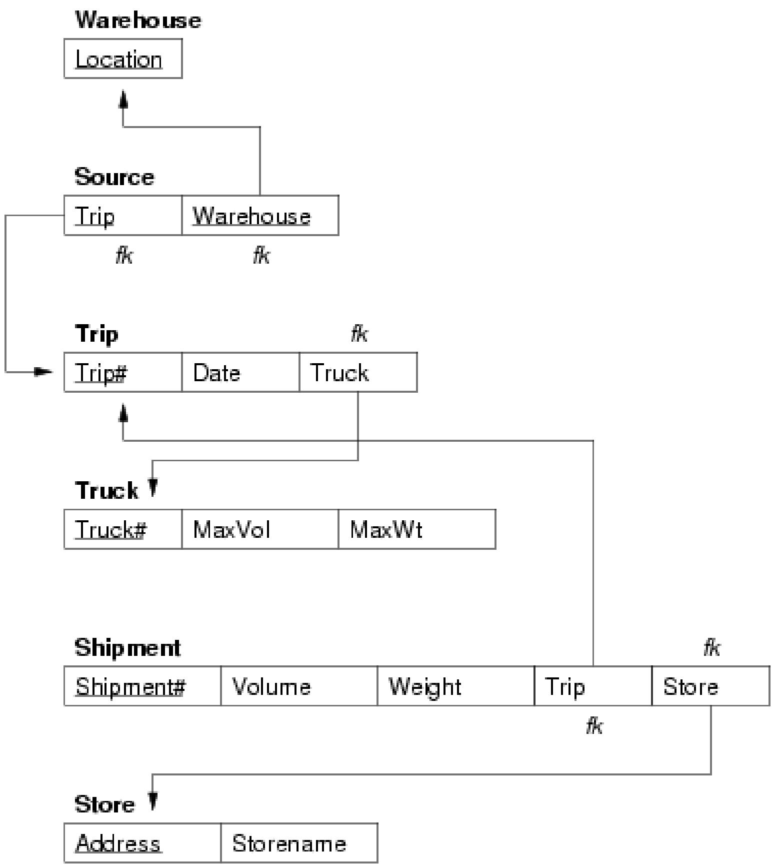


Which elements of the ER design do not appear in the relational version?

Answer:

Relational design for Trucking Company

Box-and-arrow version:



SQL schema:

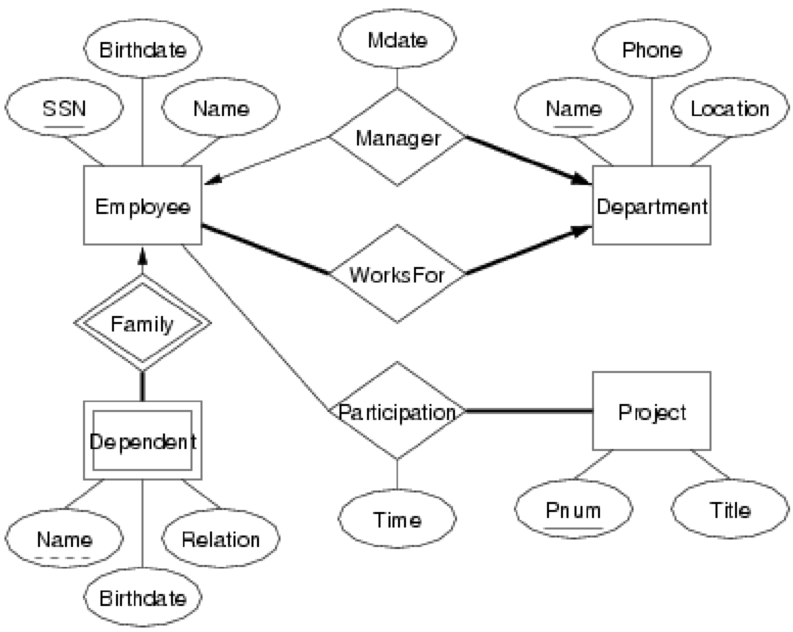
```
CREATE TABLE Truck
(
        truckNo         integer PRIMARY KEY,
        maxVolume       float,
        maxWeight       float
);
```

```
CREATE TABLE Trip
(
        tripNo          integer PRIMARY KEY,
        tripDate        date,
        truck           integer REFERENCES Truck(truckNo)
);
CREATE TABLE Store
(
        address         varchar(60) PRIMARY KEY,
        storeName       varchar(50)
);
CREATE TABLE Warehouse
(
        location        varchar(60) PRIMARY KEY
);
CREATE TABLE Shipment
(
        shipmentNo      integer PRIMARY KEY,
        volume          float,
        weight          float,
        trip            integer REFERENCES Trip(tripNo),
        store           varchar(60) REFERENCES Store(address)
);
CREATE TABLE Source
(
        trip            integer REFERENCES Trip(tripNo),
        warehouse       varchar(60) REFERENCES Warehouse(location),
        PRIMARY KEY     (trip,warehouse)
);
```

Which elements of the E/R design do not appear in the relational version?

At a syntactic level, the 1:n relationships (Includes, Uses, Destination) do not appear as tables in the relational model. They are implemented by foreign keys in the table which has only one associated entity.

14. Convert the following ER design to relational form:

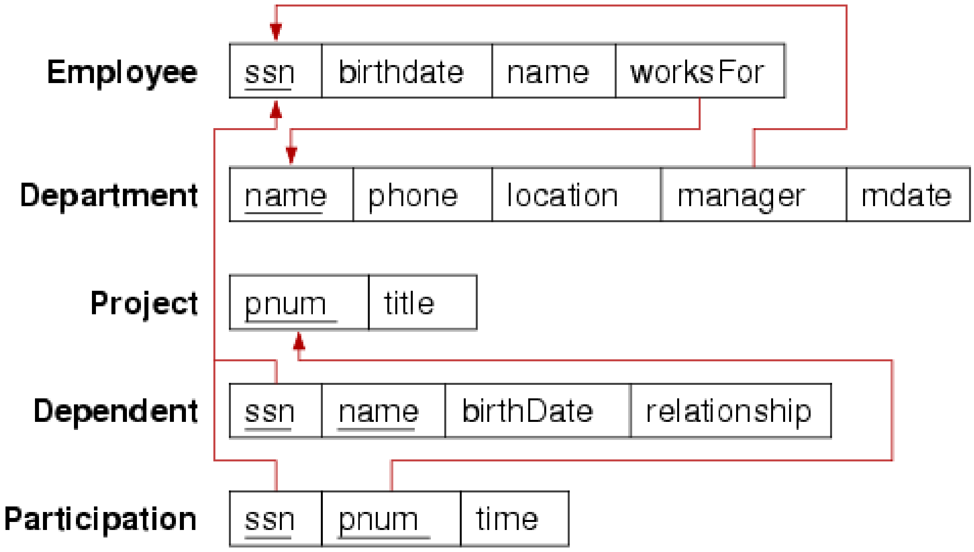


Which elements of the ER design do not appear in the relational version?

Answer:

Relational models for company ER model:

Box-and-arrows schema:



SQL schema:

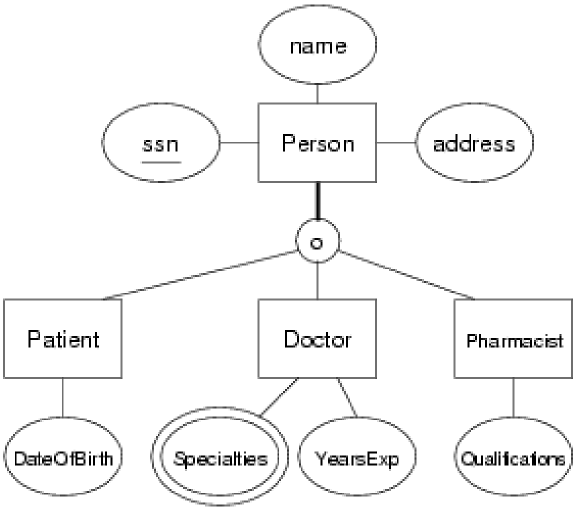
```
create table Employee (
        ssn         integer,
        birthdate   date,
        name        varchar(50),
        worksFor    varchar(50) not null,
        primary key (ssn)
--      foreign key (worksFor) is added later
);

create table Department (
        name        varchar(50),
        phone       varchar(20),
        location    varchar(30),
        manager     integer not null unique,
        mdate       date,
        primary key (name),
        foreign key (manager) references Employee(ssn)
);

alter table Employee add
        foreign key (worksFor)
        references Department(name);

create table Project (
        pnum        integer,
        title       varchar(100),
        primary key (pnum)
);

create table Dependent (
        ssn         integer not null,
        name        varchar(50),
        birthdate   date,
        relation    varchar(10) check
                      (relation in ('spouse','child')),
        primary key (ssn,name),
        foreign key (ssn) references Employee(ssn)
);
```

```
create table Participation (
        ssn          integer,
        pnum         integer,
        "time"       integer, -- number of hours on project
        primary key (ssn,pnum),
        foreign key (pnum) references Project(pnum),
        foreign key (ssn) references Employee(ssn)
);
```

The reason why the foreign key constraint is added later is because there is a mutually recursive pair of foreign key references between `Employee` and `Department`. We can't add the foreign key reference until the relevant table exists, so we need to create one table first, without the foreign key, add the other table (which refers to the first table), and then add the foreign key reference from the first table to the second table.

The `not null` constraints on `Department.manager`, `Employee.worksFor` and `Depdendent.ssn` implement the total participation requirements from the ER model.

15. Using this version of the Person class hierarchy, from the Medical scenario described previously, convert the ER design to relational form as an SQL schema:



Give mappings using both the ER style and single-table-with-nulls style.

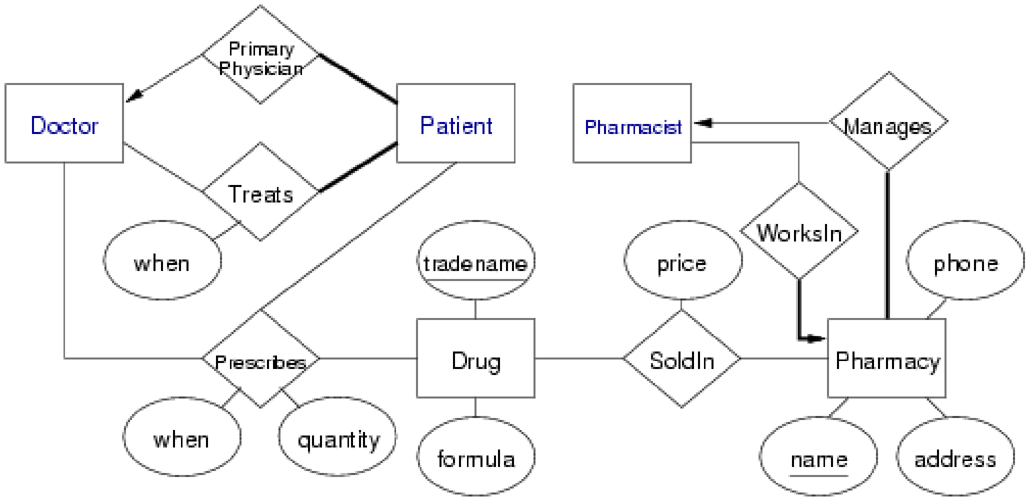
Answer:

SQL schemas for the `Person` class hierarchy in the medical scenario:

```
-- NOTE that these schemas include representations of
-- the relationships between various sub-classes of Person

-- Using ER-style mapping for subclasses of Person

create table Person (
        ssn          integer,
        name         varchar(50) not null,
        address      varchar(100),
        primary key (ssn)
);

-- subclasses are overlapping; a Person could thus be
-- in any combination of the Doctor, Patient or Pharmacist tables

create table Doctor (
        ssn          integer,
        yearsExp     integer,
        primary key (ssn),
```

```
        foreign key (ssn) references Person(ssn)
);

create table Specialties (
        doctor      integer,
        specialty   varchar(20) check
                      (specialty in ('Feet','Ears','Throat')),
        primary key (doctor),
        foreign key (doctor) references Doctor(ssn)
);

create table Patient (
        ssn         integer,
        birthdate   date,
        primaryPhys integer not null, -- total participation
        primary key (ssn),
        foreign key (ssn) references Person(ssn),
        foreign key (primaryPhys) references Doctor(ssn)
);

create table Pharmacist (
        ssn         integer,
        phName      varchar(30),
        phAddress   varchar(100),
        qual        varchar(30),
        primary key (ssn),
        foreign key (ssn) references Person(ssn)
--      foreign key (phName,phAddress) is added later
);


-- Using single-table-style mapping for subclasses of Person

create table Person (
        ssn         integer,
        name        varchar(50) not null,
        address     varchar(100),
        -- an Person can belong to any combination of subclasses
        isPatient   boolean,
        isDoctor    boolean,
        isPharmacist boolean,
        -- patient-specific attributes
        primaryPhys integer, -- total participation handled below
        birthdate   date,
        -- doctor-specific attributes
        -- ... none ... Specialities are in separate table
        -- pharmacist-specific attributes
        phName      varchar(30),
        phAddress   varchar(100),
        qual        varchar(30),
        primary key (ssn),
        foreign key (primaryPhys) references Person(ssn),
--      foreign key (phName,phAddress) is added later
--      constraint  ClassAttributeCheck ...
--      -- trying to write a boolean expression that determines
--      -- that there is an appropriate combination of subclass
--      -- flags (isX) and attribute values is extremely tedious,
--      -- so we don't even bother to try
);
```

16. Convert this ER design for the medical scenario into relational form:

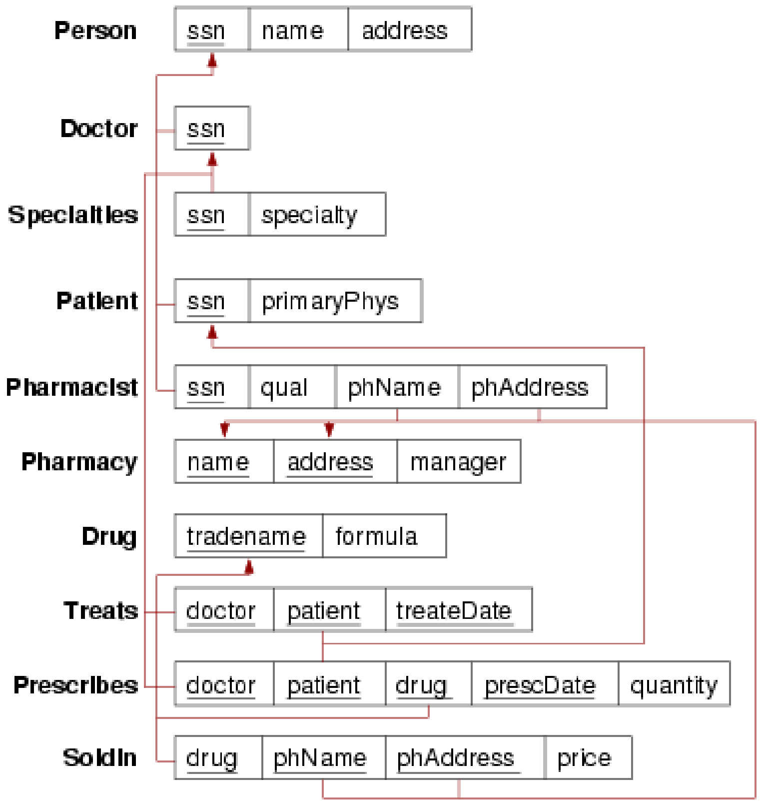


Assume that the Person classes are mapped using the ER-style mapping. Which elements of the ER design do not appear in the relational version?

Answer:

SQL schema for the rest of the medical scenario:

Box-and-arrow schema:



SQL Schema:

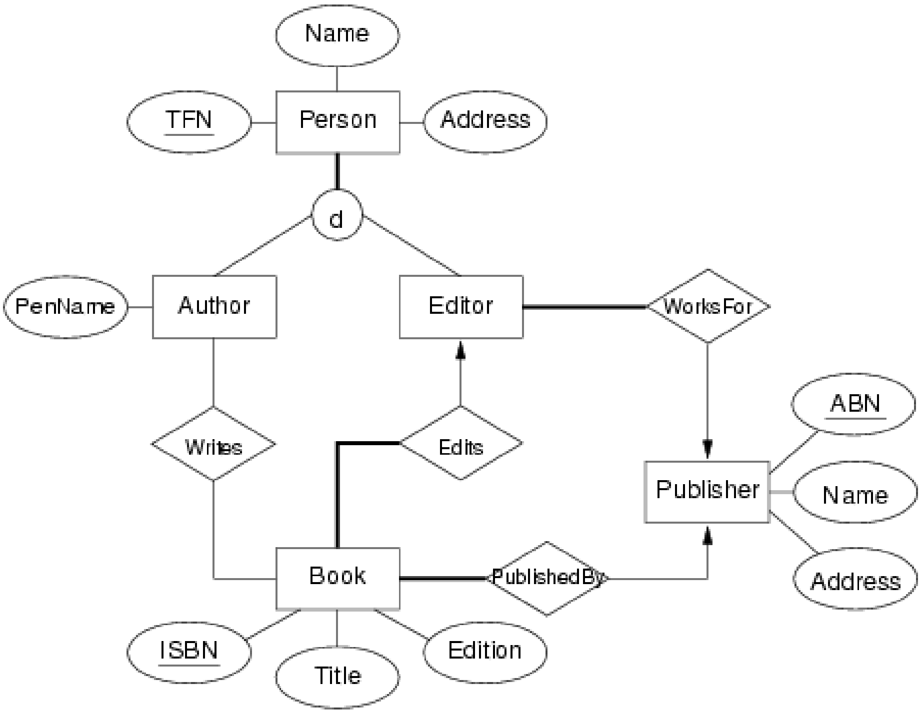
```
-- Assume the definitions of Person/Patient/Doctor/Pharmacist
-- as given above in the ER-style

create table Pharmacy (
        name        varchar(30),
        address     varchar(100),
        manager     integer not null,  -- total participation
        primary key (name,address),
        foreign key (manager) references Pharmacist(ssn)
);

alter table Pharmacist add
```

```
        foreign key (phName,phAddress)
        references Pharmacy(name,address);

create table Drug (
        tradename   varchar(40),
        formula     varchar(100),
        primary key (tradename)
);

-- if "treatDate" is date only, and is part of primary key,
-- then a doctor cannot treat a patient more than once/day.
-- if this is required, make "treatDate" as a timestamp
create table Treats (
        doctor      integer,
        patient     integer,
        treatDate   date,
        primary key (doctor,patient,treatDate),
        foreign key (doctor) references Doctor(ssn),
        foreign key (patient) references Patient(ssn)
);

-- if "prescDate" is date only, then cannot prescibe
-- the same drug more than once on the same day
create table Prescribes (
        doctor      integer,
        patient     integer,
        drug        varchar(40),
        prescDate   date,
        quantity    integer, -- float if mass/volume/...
        primary key (doctor,patient,drug,prescDate),
        foreign key (doctor) references Doctor(ssn),
        foreign key (patient) references Patient(ssn),
        foreign key (drug) references Drug(tradename)
);

create table SoldIn (
        drug        varchar(40),
        phName      varchar(30),
        phAddress   varchar(100),
        price       money,
        primary key (drug,phName,phAddress),
        foreign key (phName,phAddress)
                      references Pharmacy(name,address),
        foreign key (drug) references Drug(tradename)
);
```

Which elements of the ER design do not appear in the relational version?

The relational model cannot represent (in standard SQL), the total participation constraints for patients (i.e. every patient must be treated by at least one doctor). This would need to be enforced via e.g. a stored trigger procedure. It also cannot represent the total participation constraint on the relationship WorksFor between pharmacists and pharmacies (i.e. every pharmacy must have at least one pharmacist working in it).

17. Convert this ER design for the book publishing scenario into an SQL schema:



Give two versions, one using the ER-style mapping of subclasses, and the other using single-table-with-nulls mapping of subclasses.

Answer:

SQL schema for book publishing scenario:

SQL Schema: using ER-style mapping of subclasses

```
create domain TaxFileNum as char(11)
                check (value ~ '^[0-9]{3}-[0-9]{3}-[0-9]{3}$');
create domain ISBNumber as char(15)
                check (value ~ '^[A-Z][0-9]{3}-[0-9]{4}-[0-9]{5}$');
create domain ABNumber as integer check (value > 100000);

create table Publisher (
        abn         ABNumber,
        name        varchar(60),
        address     varchar(100),
        primary key (abn)
);

create table Person (
        tfn         TaxFileNum,
        name        varchar(50),
        address     varchar(100),
        primary key (tfn)
);

create table Author (
        person      TaxFileNum,
        penname     varchar(50),
        primary key (person),
        foreign key (person) references Person(tfn)
);

create table Editor (
        person      TaxFileNum,
        publisher   ABNumber not null,
        primary key (person),
        foreign key (person) references Person(tfn),
```

```
        foreign key (publisher) references Publisher(abn)
);

create table Book (
        isbn        ISBNumber,
        title       varchar(100),
        edition     integer check (edition > 0),
        editor      TaxFileNum not null,
        publisher   ABNumber not null,
        primary key (isbn),
        foreign key (editor) references Editor(person),
        foreign key (publisher) references Publisher(abn)
);

create table Writes (
        author      TaxFileNum,
        book        ISBNumber,
        primary key (author,book),
        foreign key (author) references Author(person),
        foreign key (book) references Book(isbn)
);
```

SQL Schema: using single-table-style mapping of subclasses

```
-- Uses single-table-style mapping for subclasses of Person

create domain TaxFileNum as char(11)
                check (value ~ '^[0-9]{3}-[0-9]{3}-[0-9]{3}$');
create domain ISBNumber as char(15)
                check (value ~ '^[A-Z][0-9]{3}-[0-9]{4}-[0-9]{5}$');
create domain ABNumber as integer check (value > 100000);

create table Publisher (
        abn         ABNumber,
        name        varchar(60),
        address     varchar(100),
        primary key (abn)
);

create table Person (
        tfn         TaxFileNum,
        name        varchar(50),
        address     varchar(100),
        kind        varchar(10) check (kind in ('author','editor')),
        -- attributes for Authors
        penname     varchar(50),
        -- attributes for Editors
        publisher   ABNumber not null,
        primary key (tfn),
        foreign key (publisher) references Publisher(abn),
        constraint  NoPenNameIfEditor check
                        ((kind = 'author' and publisher is null) or
                         (kind = 'editor' and penname is null))
);
-- Problem with the above:
-- * publisher attribute defined to be not null
-- * if author type, publisher is required to be null
-- * to resolve this, we have to lose one of the constraints
--    - either lose total participation of Editor with Publisher
--    - or lose check on null poublisher for authors

create table Book (
```

```
        isbn        ISBNumber,
        title       varchar(100),
        edition     integer check (edition > 0),
        editor      TaxFileNum not null,
        publisher   ABNumber not null,
        primary key (isbn),
        foreign key (editor) references Person(tfn),
        foreign key (publisher) references Publisher(abn)
);

create table Writes (
        author      TaxFileNum,
        book        ISBNumber,
        primary key (author,book),
        foreign key (author) references Person(tfn),
        foreign key (book) references Book(isbn)
);
```