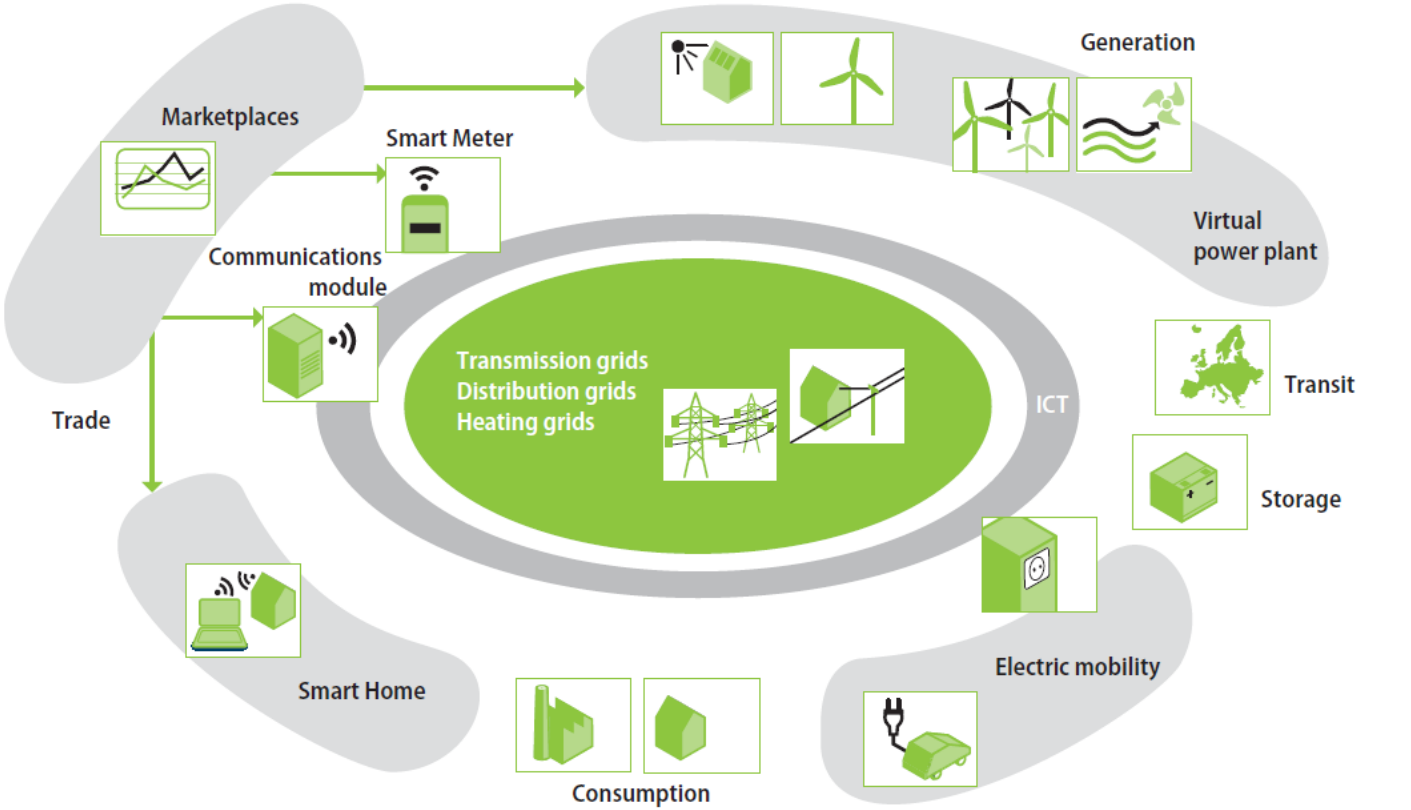
1. Motivation



Quelle: acatech, Future Energy Grid

Energy Management

- Synchronizing supply and demand
- Prognosis of supply and demand
- Load shifting
- Controlling power generating systems, managing storage devices
- Ancillary services for distributed resources: balancing power, reactive power,...
- Energy efficiency, user behavior

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- query and update data,
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To be able to forecast energy consumption we maintain a database to record the consumption of cities households.

To this end we need data about cities, their buildings, the corresponding households and their energy consumption values taken as readings with respect to periods. To make the data and the relationships between data explicit we develop a model.

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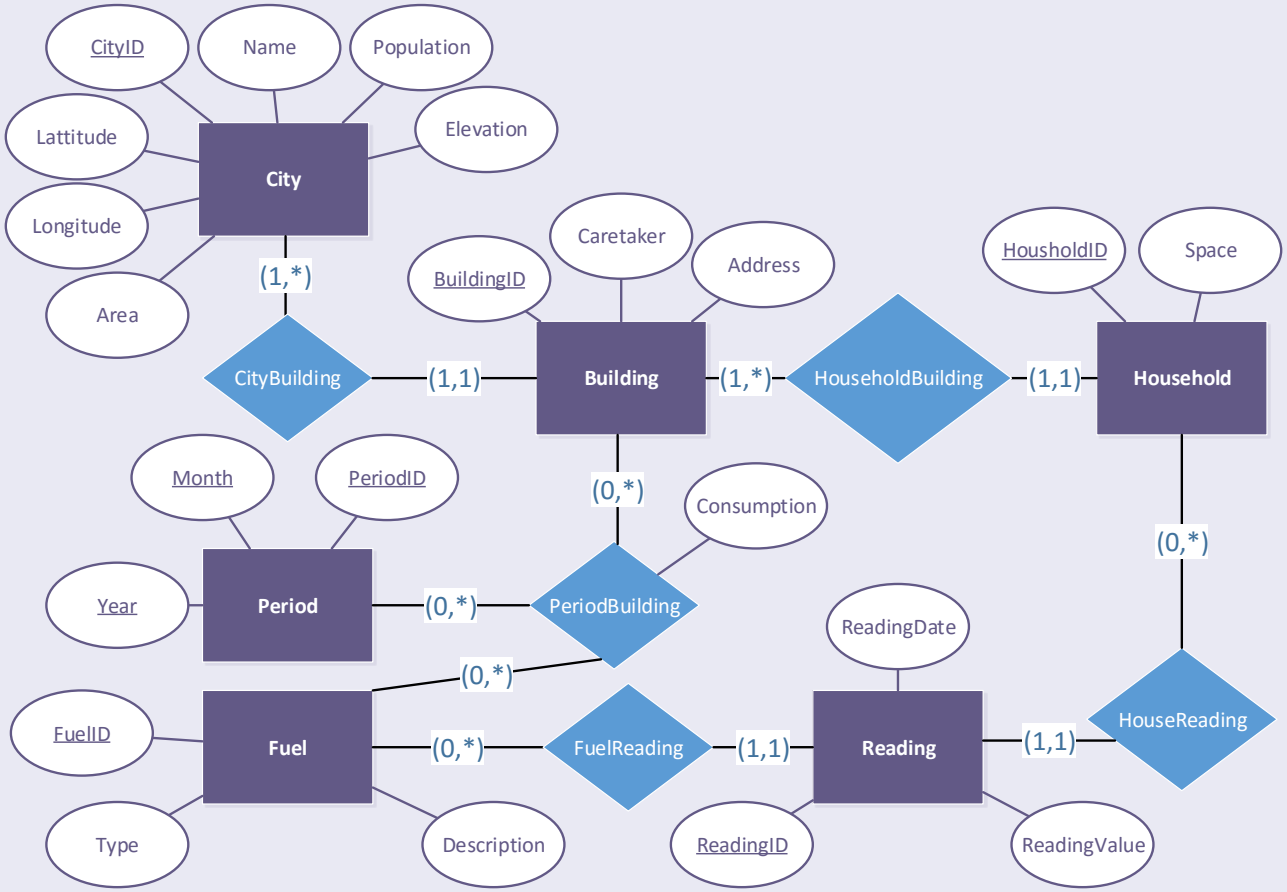
Entity-Relationship Diagram (ER-Diagram, ERD)



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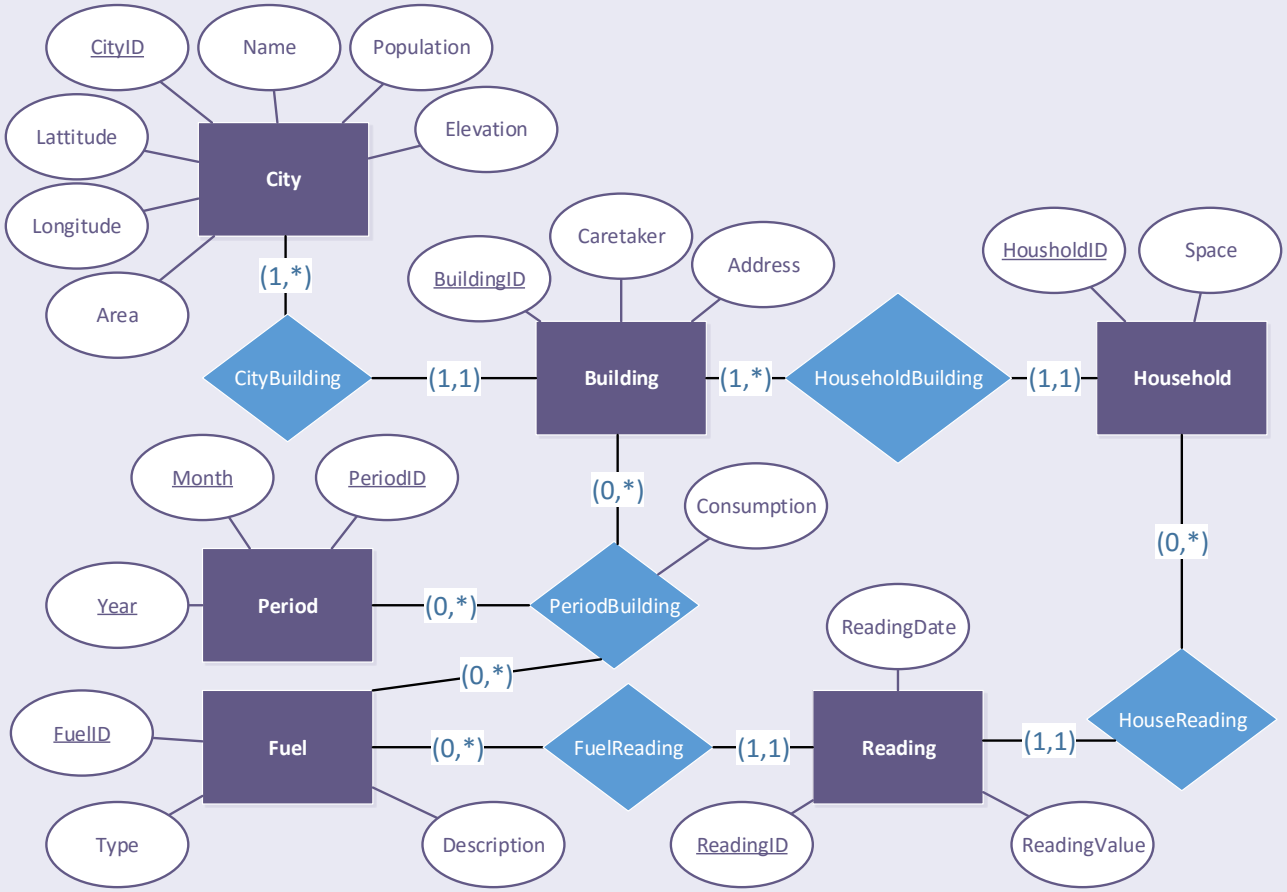

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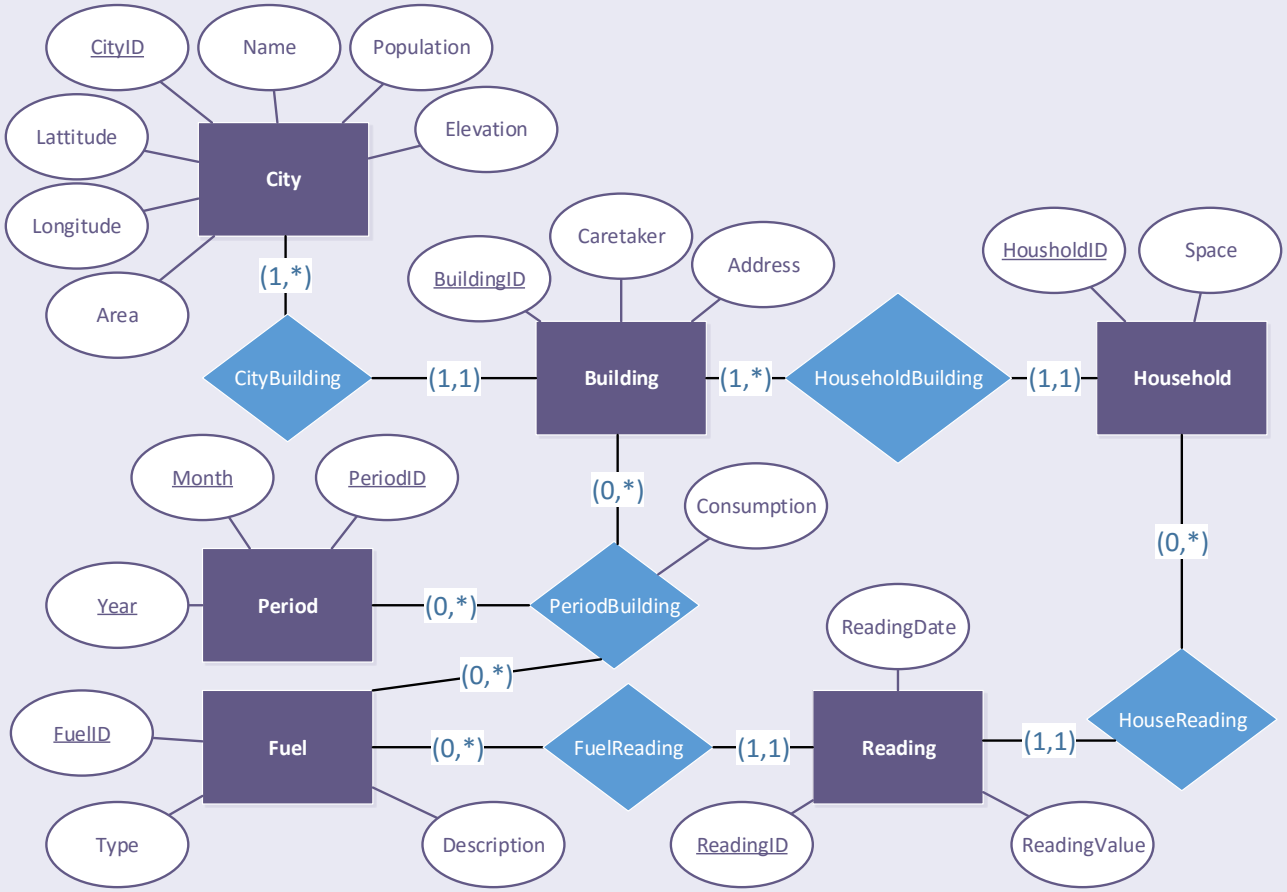

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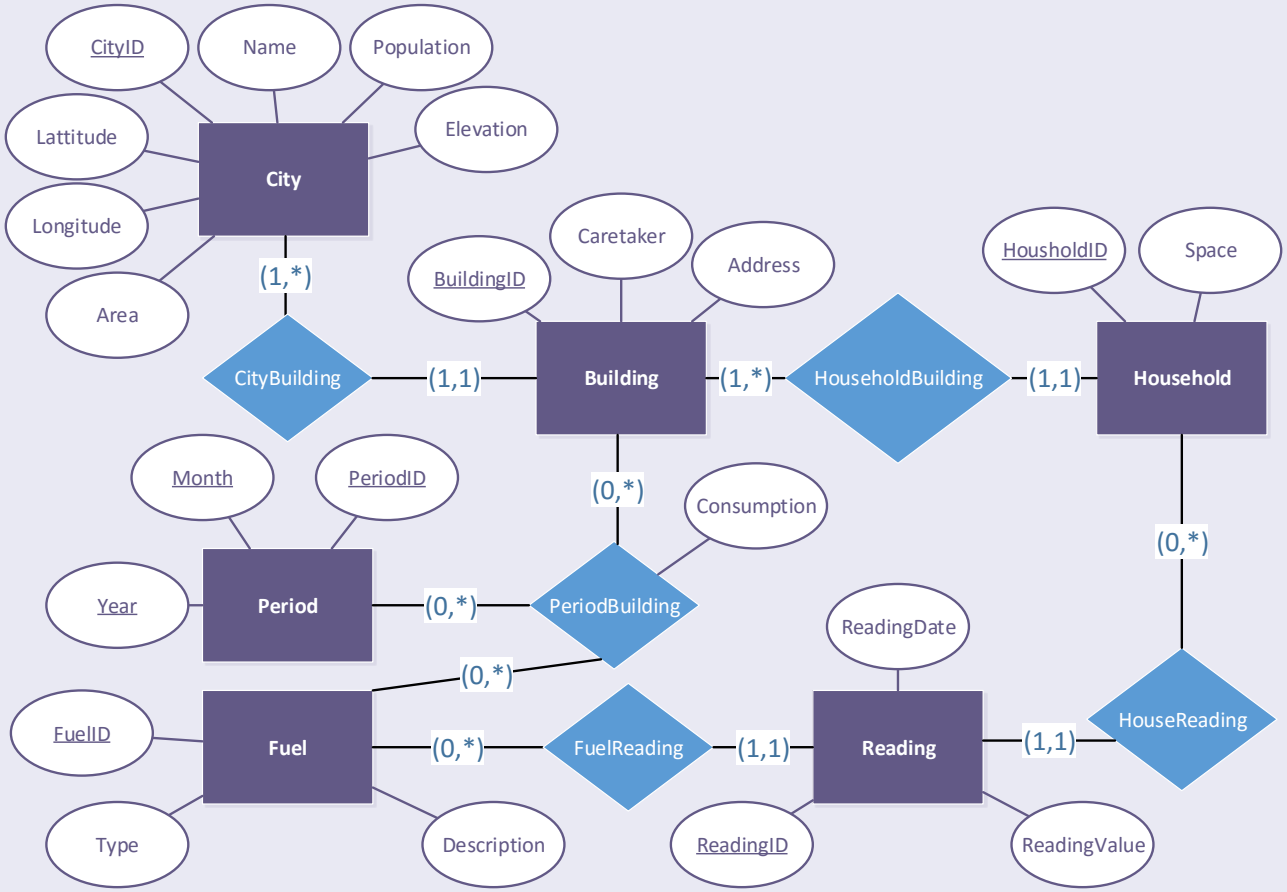

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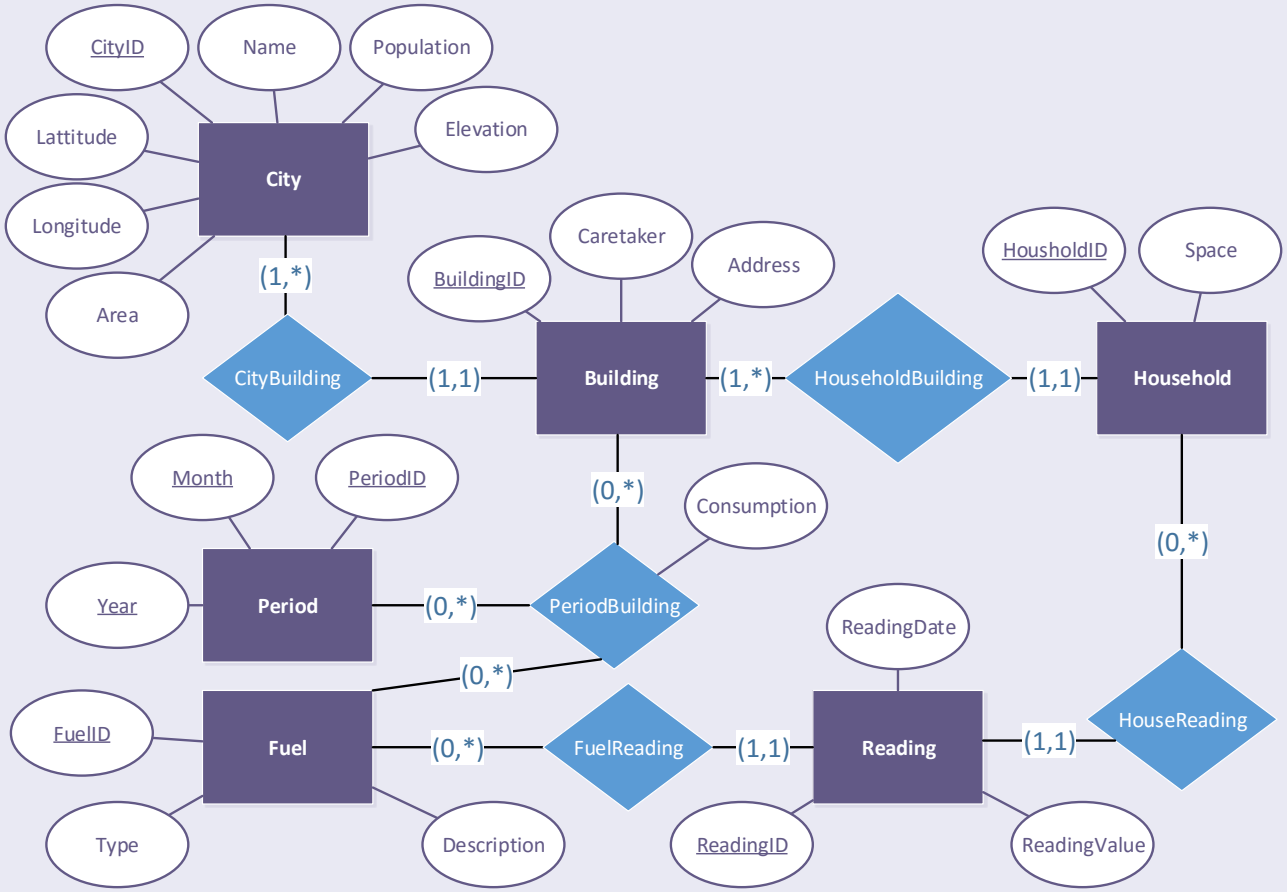

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a set of entities represented by a table

Building

BuildingID	Caretaker	Address
100	Miller	A-Street
200	Meier	B-Street
300	Schulze	C-Street
⋮	⋮	⋮

a set of relationships represented by a table

CityBuilding

CityID	BuildingID
C-1234	100
C-1234	200
C-4567	300
⋮	⋮

Keys, Entities, and Relationships

- *Entities* must be uniquely identifiable by a *key*, i.e. a selected number of attributes graphically indicates by underlining. Typically, an artificial attribute like cityID, buildingID, etc. acts as a *surrogate key*
  For example, to identify a building, the name of the city and the address would suffice, as well.

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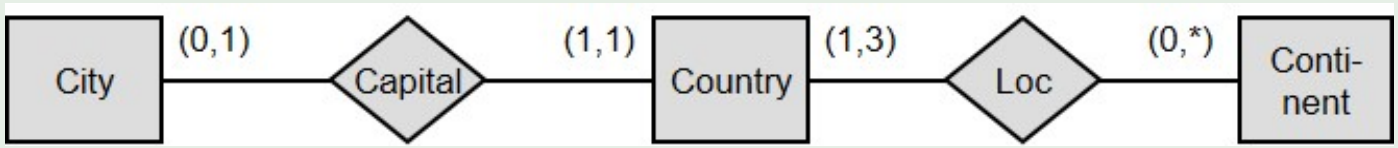

Cardinalities

- Let E —— R be an edge connecting entity-set E and relationship-set R which is labelled by (min, max), $min \leq max$.
- (min, max) is called *cardinality* of E with respect to R.
- A *cardinality* (min, max) of E with respect to R states that each entity $e \in E$ is involved in at least min and at most max relationships $r \in R$.
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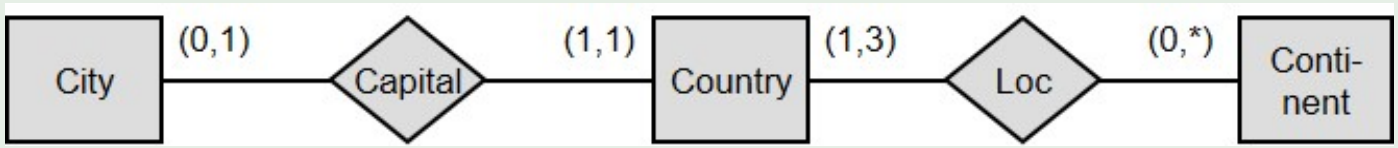

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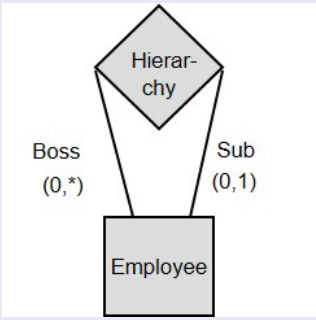

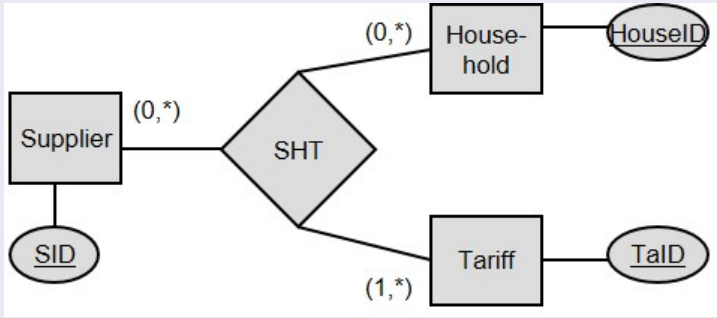

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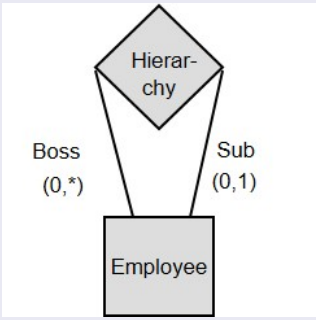

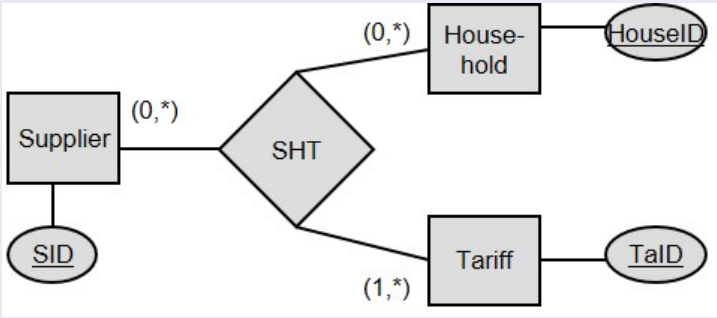

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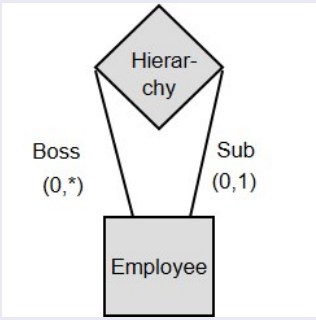

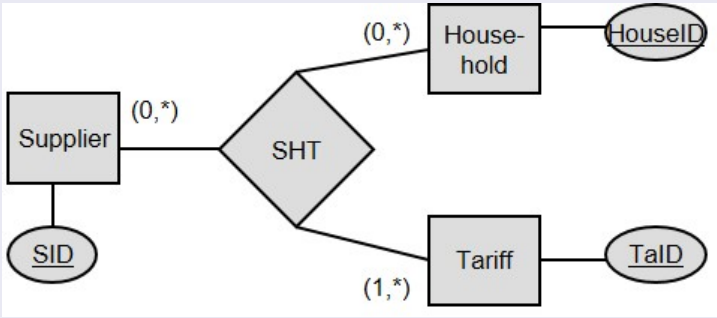

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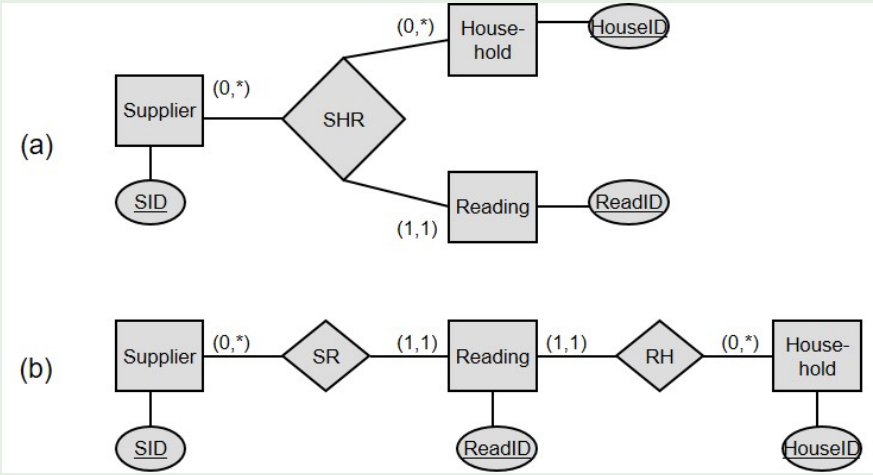

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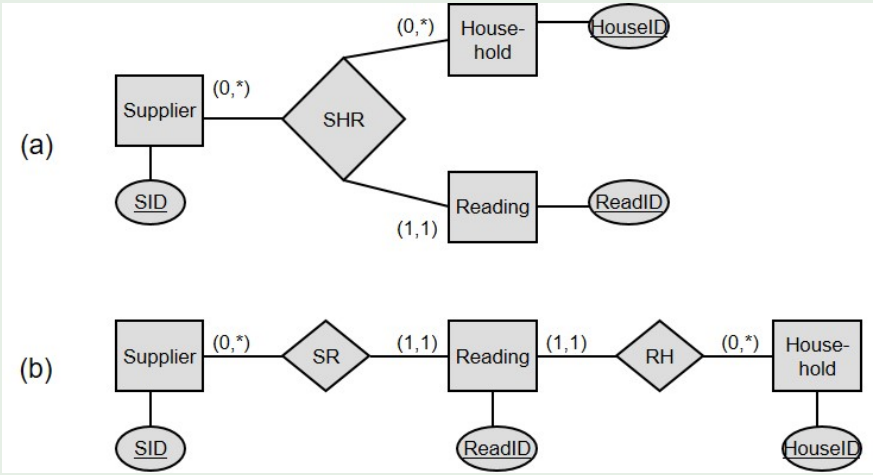

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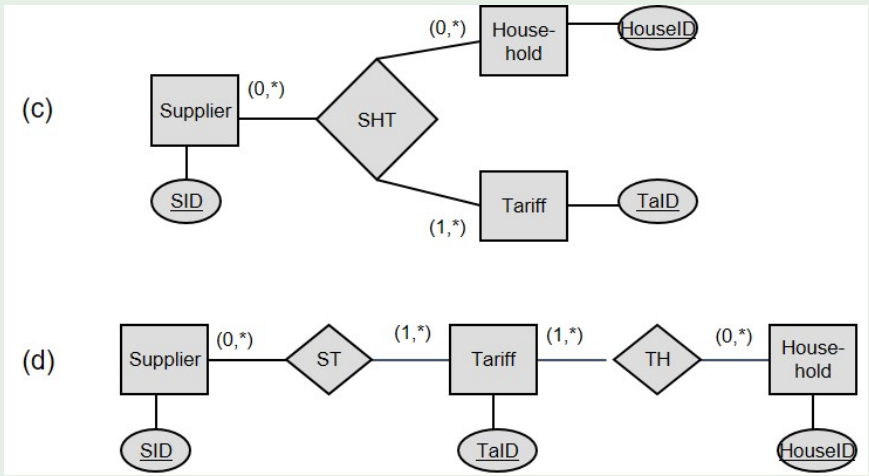

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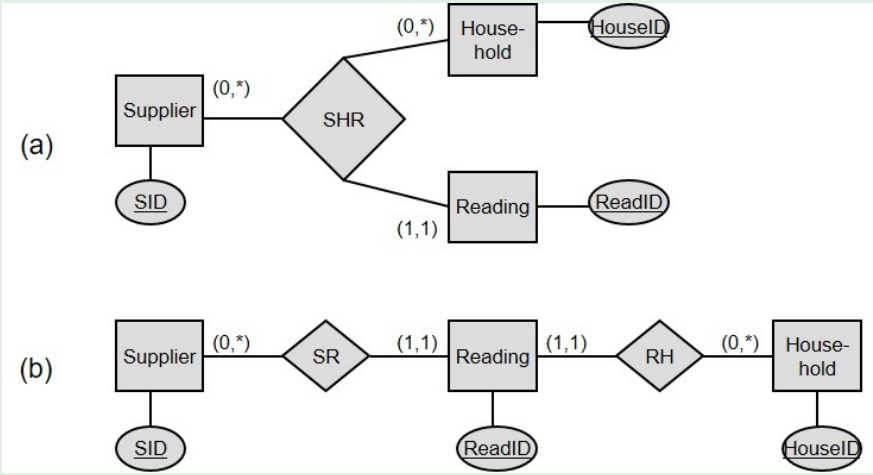

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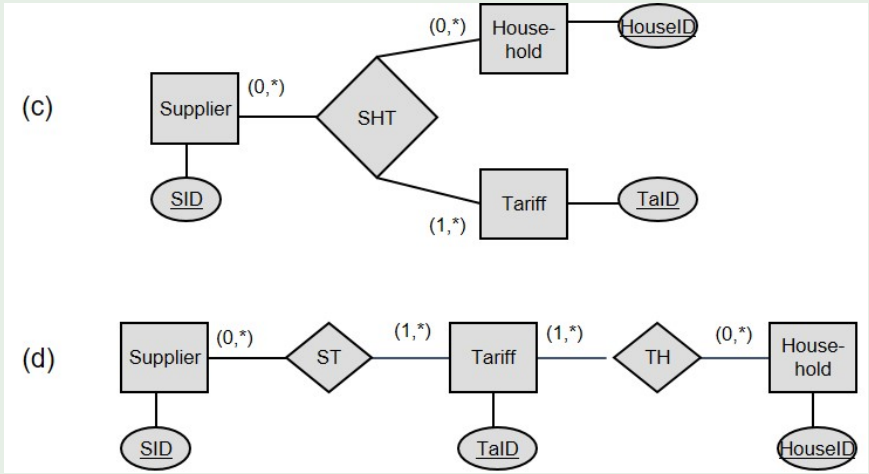

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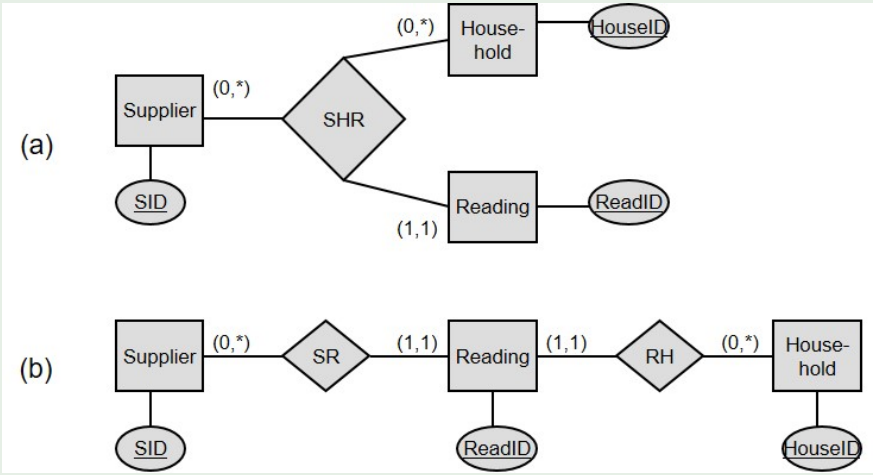

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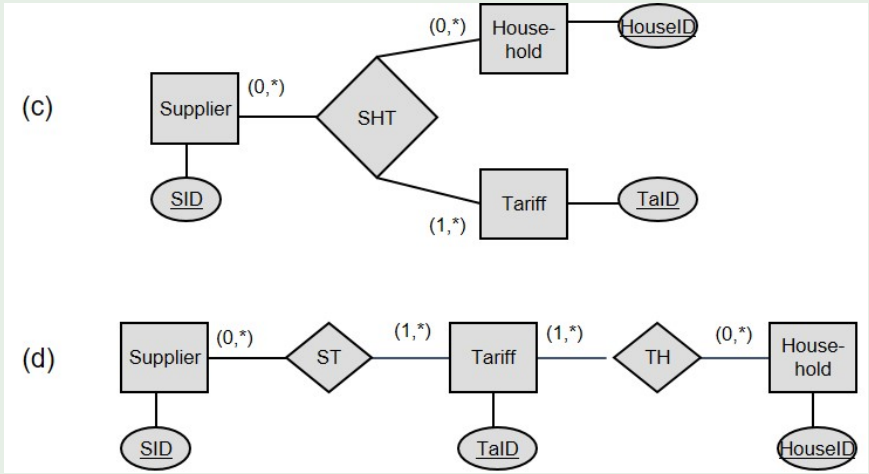

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Example: why decomposition is not (always) allowed!

SHT

Supplier	Household	Tariff
SID	HouseID	TaID
Energiedienst	1020	Eco
Badenova	1020	Maxi
Badenova	1030	Eco

SO

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TH

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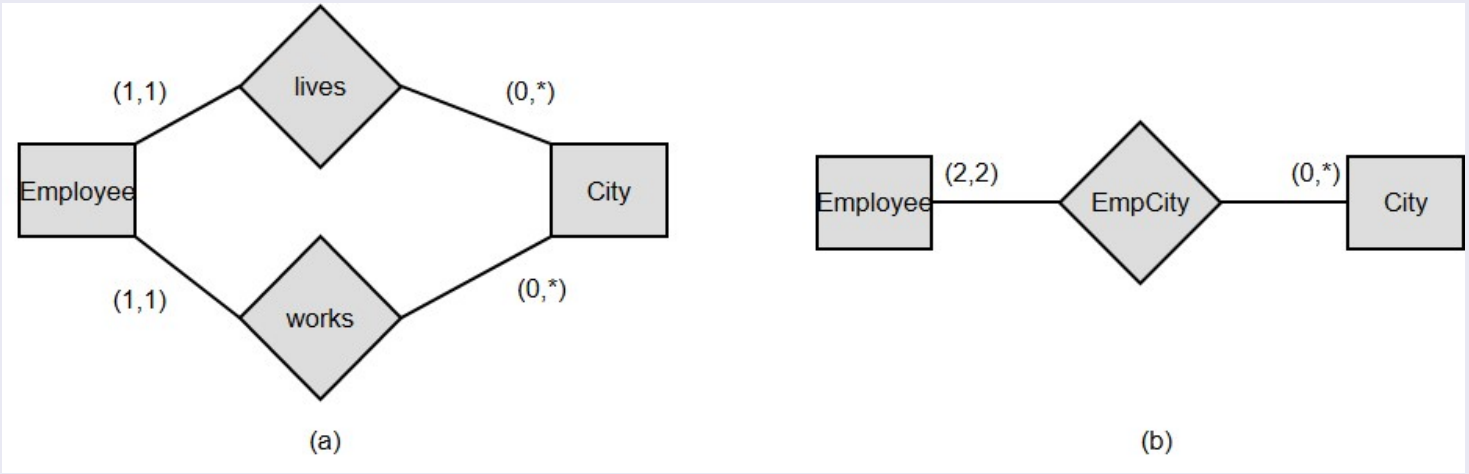

(a) and (b) describe different worlds - might have two living-addresses and no working address in (b).

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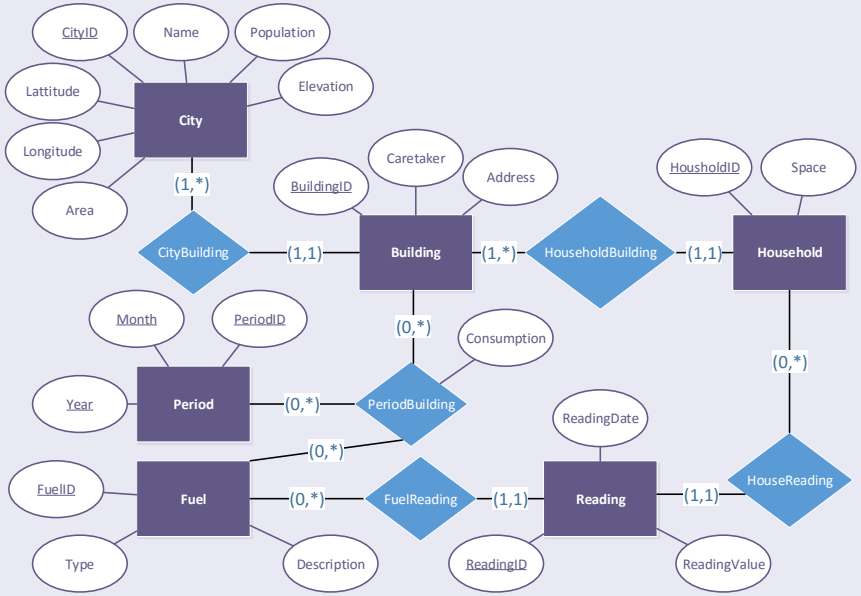
Example: Mapping ER-Diagrams to Tables (Relations)



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- `City`, with columns for `CityID`, `Name`, `Population`, ...,
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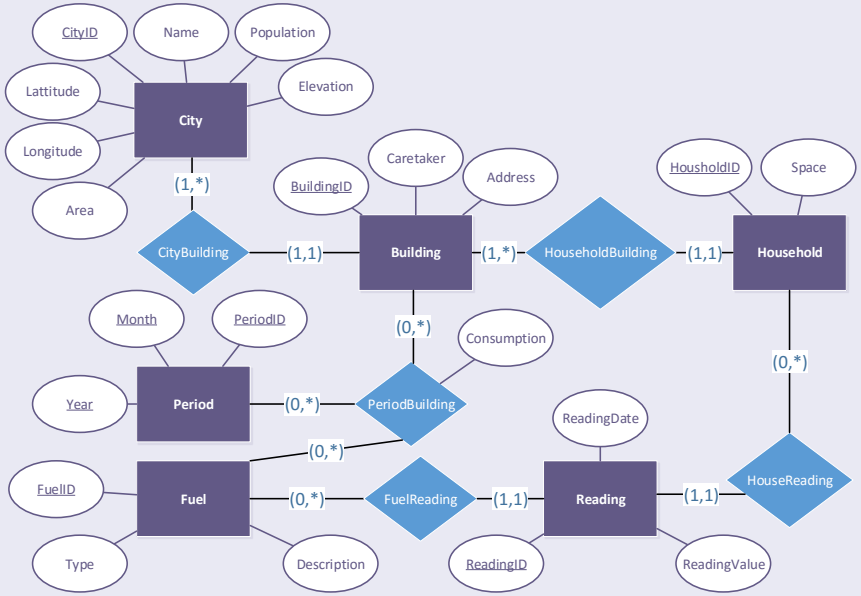

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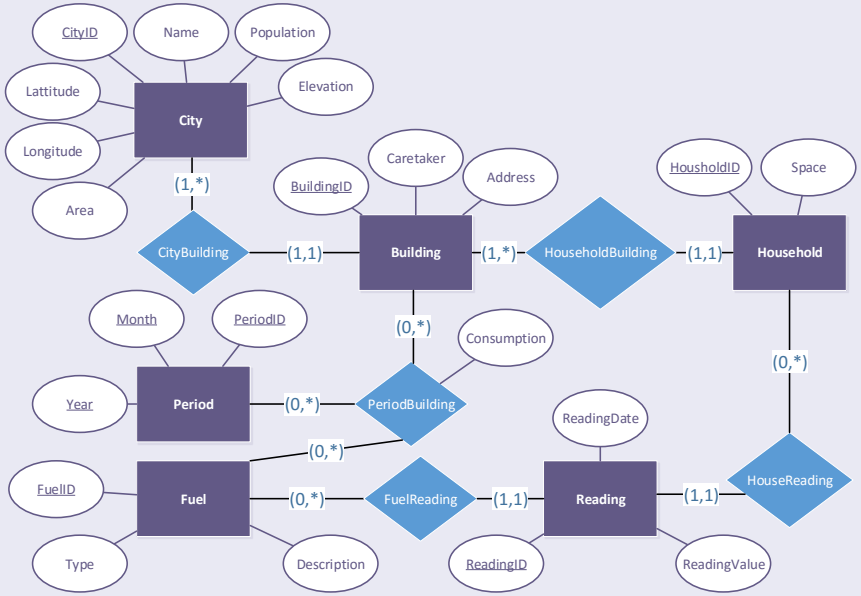

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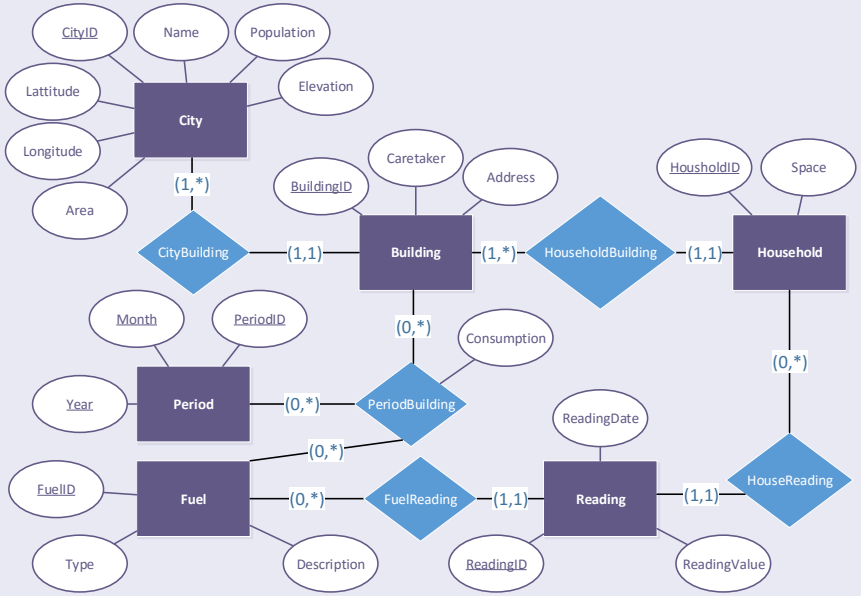

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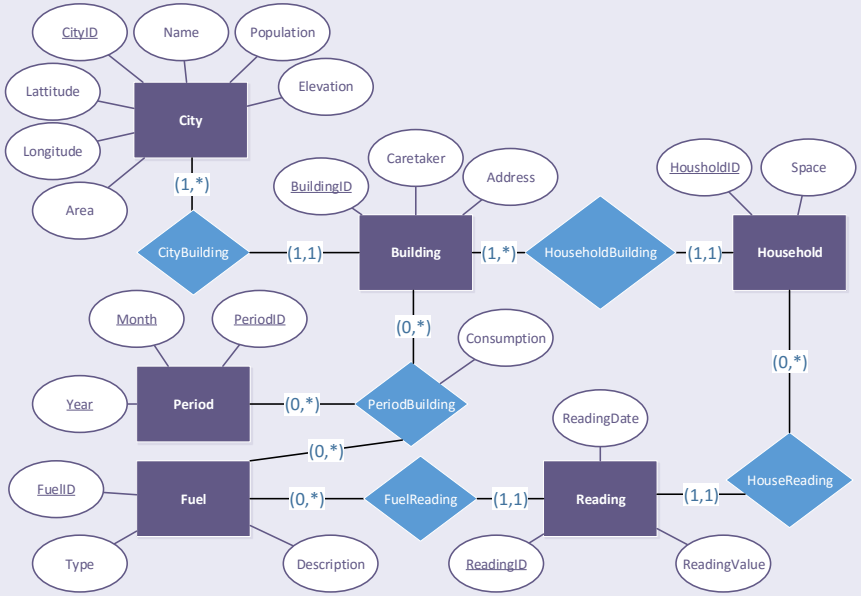

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Definition of tables representing the information content modelled by the ER-Diagram

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Household(HousID, BuildingID, Area)
Reading(ReadingID, HouseID, Date, Fuel, ReadinValus)
Fuel(FuelID, Type, Description)
Period(PeriodID, Year, Month)
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Household(HousID, BuildingID, Area)
Reading(ReadingID, HouseID, Date, Fuel, ReadinValus)
Fuel(FuelID, Type, Description)

Period(PeriodID, Year, Month)
PeriodBuilding(PeriodID, BuildingID, FuelID, Consumption)
```

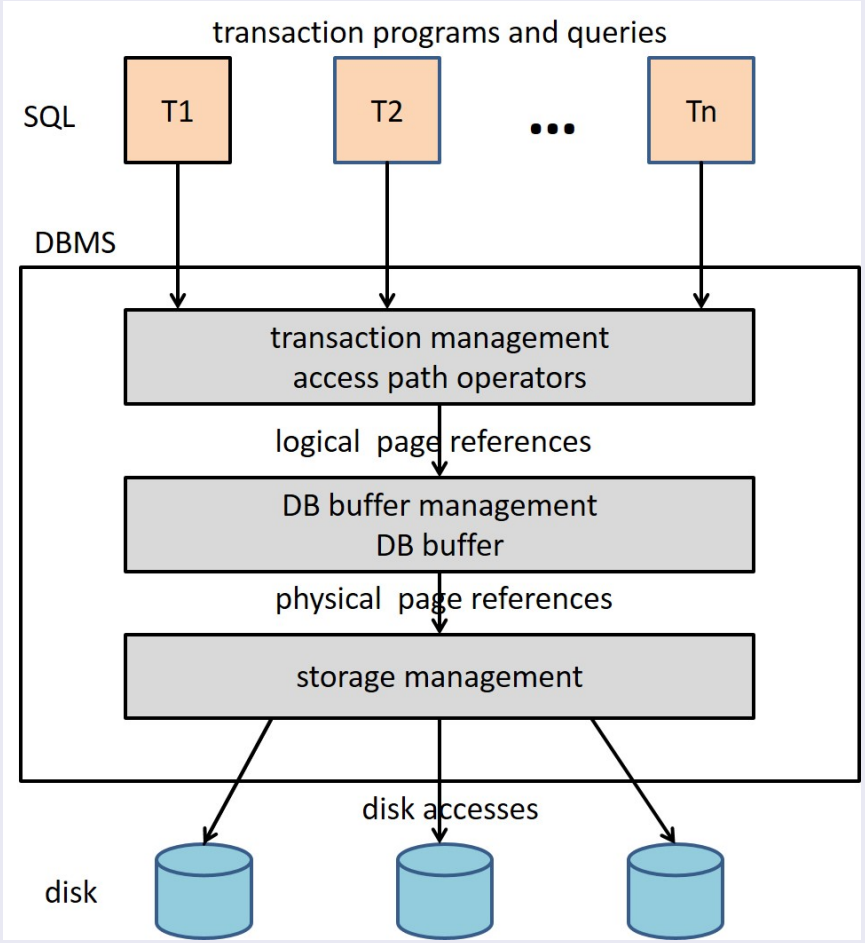
The rows of the tables contain the data - each column for each rows contains one value.

A system, which is able to process a set of tables, each containing a (very) large number of rows, is called *Relational Database System (DBS)*.

- To store, access and process the data managed by a DBS we need a language: SQL
- For scalability, a DBS is composed of layers: the user communicates with the layer called *Data Base Management Software (DBMS)*, which organizes the access to the data efficiently.
- The data typically is stored on disks.

We concentrate on SQL.

Basic Architcture of a DBMS



4. SQL

http://dbissql.informatik.uni-freiburg.de/dbis/energy/sql.php

There you can work with a database of size:

Name of City	Buildings	Households	Readings
Freiburg im Breisgau	10877	97061	2329464
Karlsruhe	14446	128028	3072672
Kehl	1715	14827	355848
Stuttgart	29383	262710	6305040
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How to create a table:

```
CREATE TABLE City {
    CityID          NUMBER,
    Name            VARCHAR(80),
    Population      NUMBER,
    Area            NUMBER,
    Elevation       NUMBER,
    Latitude        NUMBER,
    Longitude       NUMBER,
PRIMARY KEY (CityID) };
```

The primary key (a surrogate) is chosen to guarantee unique identification of every city.
Alternative: `PRIMARY KEY (Latitude, Longitude)`.

How to avoid dangling references between tables:

```
CREATE TABLE Building {
    BuildingID      NUMBER,
    CityID          NUMBER,
    Address         VARCHAR(40),
    Caretaker       VARCHAR(40),
PRIMARY KEY (BuildingID),
FOREIGN KEY (CityID) REFERENCES City (CityID) };
```

The references clause guarantees that there will be no tuples in relation `Building`, for which the referenced city does not exist in table `City`.
The *referential integrity* is guaranteed. Later: *referential actions* (e.g., what happens if the city is deleted).

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In each case, the result is also a table!

- Give me all rows of a table.

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SELECT * FROM City;
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- Give me a listing of building addresses with name of the city.

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SELECT D.HouseholdID, D.FuelID, D.ReadingValue
FROM City A, Building B, Household C, Reading D
WHERE A.Name = 'Kehl' AND A.CityID = B.CityID
AND B.BuildingID = C.BuildingID AND C.HouseholdID = D.HouseholdID
ORDER BY D.HouseholdIG ASC, D.FuelID ASC, D.ReadingValue DESC;
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