Aggregates and Grouping

Aggregats **avg, max, min, count, sum**

```
select avg (Semester)
   from Students ;

select Given_by, sum (WeeklyHours)
   from Lectures
   group by Given_by;
```

Aggregatfunktion und Gruppierung

```
select Given_by, Name, sum (WeeklyHours)
   from Lectures, Professors
   where Given_by = PersNr and Level = ´C4´
   group by Given_by, Name
        having avg (WeeklyHours) >= 3;
```

Characteristics of Aggregats

- SQL creates one result tuple per group
- all atributes of the **select**-clause – except the aggregated –have to be listed in the **group by**-clause
- Thus SQL can make sure that the attribute value does not change within a group
- NULL value is an own group

query with group by (Equi-Join, Selection Level=‚C4‘)

Lectures x Professors							
Lecture Nr	Title	Weekly Hours	Given_by	PersNr	Name	Level	Room
5001	Grundzüge	4	2137	2125	Sokrates	C4	226
5041	Ethik	4	2125	2125	Sokrates	C4	226
...	...	...	...	...	...	C3	...
4630	Die 3 Kritiken	4	2137	2137	Kant	C4	7

⇓ **where**-clause

Group by Given_by, Name

Lecture Nr	Title	Weekly Hours	Given_by	PersNr	Name	Level	Room
5001	Grundzüge	4	2137	2137	Kant	C4	7
5041	Ethik	4	2125	2125	Sokrates	C4	226
5043	Erkenntnistheorie	3	2126	2126	Russel	C4	232
5049	Mäeutik	2	2125	2125	Sokrates	C4	226
4052	Logik	4	2125	2125	Sokrates	C4	226
5052	Wissenschaftstheorie	3	2126	2126	Russel	C4	232
5216	Bioethik	2	2126	2126	Russel	C4	232
4630	Die 3 Kritiken	4	2137	2137	Kant	C4	7

⇓ Grouping

Professors

PersNr	Name	Level	Room
2125	Sokrates	C4	226
2126	Russel	C4	232
2127	Kopernikus	C3	310
2133	Popper	C3	52
2134	Augustinus	C3	309
2136	Curie	C4	36
2137	Kant	C4	7

Students

StudNr	Name	Semester
24002	Xenokrates	18
25403	Jonas	12
26120	Fichte	10
26830	Aristoxenos	8
27550	Schopenhauer	6
28106	Carnap	3
29120	Theophrastos	2
29555	Feuerbach	2

Lectures

Lecture Nr	Title	Weekly Hours	Given_by
5001	Grundzüge	4	2137
5041	Ethik	4	2125
5043	Erkenntnistheorie	3	2126
5049	Mäeutik	2	2125
4052	Logik	4	2125
5052	Wissenschaftstheorie	3	2126
5216	Bioethik	2	2126
5259	Der Wiener Kreis	2	2133
5022	Glaube und Wissen	2	2134
4630	Die 3 Kritiken	4	2137

attend

StudNr	LectureNr
26120	5001
27550	5001
27550	4052
28106	5041
28106	5052
28106	5216
28106	5259
29120	5001
29120	5041
29120	5049
25403	5022
29555	5022
29555	5001

require

Predecessor	Successor
5001	5041
5001	5043
5001	5049
5041	5216
5043	5052
5041	5052
5052	5259

Assistants

PersNr	Name	Area	Boss
3002	Platon	Ideenlehre	2125
3003	Aristoteles	Syllogistik	2125
3004	Wittgenstein	Sprachtheorie	2126
3005	Rhetikus	Planetenbewegung	2127
3006	Newton	Keplersche Gesetze	2127
3007	Spinoza	Gott und Natur	2126

test

StudNr	LectureNr	PersNr	Grade
28106	5001	2126	1
25403	5041	2125	2
27550	4630	2137	2

Only Groups with at least 3 WeeklyHours on average

Lecture Nr	Title	Weekly Hours	Given_by	PersNr	Name	Level	Room
5041	Ethik	4	2125	2125	Sokrates	C4	226
5049	Mäeutik	2	2125	2125	Sokrates	C4	226
4052	Logik	4	2125	2125	Sokrates	C4	226
5043	Erkenntnistheorie	3	2126	2126	Russel	C4	232
5052	Wissenschaftstheo.	3	2126	2126	Russel	C4	232
5216	Bioethik	2	2126	2126	Russel	C4	232
5001	Grundzüge	4	2137	2137	Kant	C4	7
4630	Die 3 Kritiken	4	2137	2137	Kant	C4	7

⇓ **having**-Bedingung

Summing up over WeeklyHours and Projection

Lecture Nr	Title	Weekly Hours	Given_by	PersNr	Name	Level	Room
5041	Ethik	4	2125	2125	Sokrates	C4	226
5049	Mäeutik	2	2125	2125	Sokrates	C4	226
4052	Logik	4	2125	2125	Sokrates	C4	226
5001	Grundzüge	4	2137	2137	Kant	C4	7
4630	Die 3 Kritiken	4	2137	2137	Kant	C4	7

⇓ Aggregation (**sum**) und Projektion

Result

Given_by	Name	**sum** (WeeklyHours)
2125	Sokrates	10
2137	Kant	8

Maximum / Minimum

Student with the highest StudNr

```
select  StudNr, Name
from Students
where StudNr =
   (select max(StudNr)
    from Student);
```

NOT

```
select Name, max(StudNr)
from Students;
```

Using the result set of a sub-query

```
select tmp.StudNr, tmp.Name, tmp. Number_of_Lectures
from (select s.StudNr, s.Name, count(*) as Number_of_Lectures
        from Students s, attend a
        where s.StudNr=a.StudNr
        group by s.StudNr, s.Name)  tmp
where tmp. Number_of_Lectures > 2;
```

StudNr	Name	Number_of_Lectures
28106	Carnap	4
29120	Theophrastos	3

… or alternativley

```
select tmp.StudNr, tmp.Name, tmp. Number_of_Lectures
 from (select s.StudNr, s.Name, count(*) as Number_of_Lectures
         from Students s, attend a
        where s.StudNr = a.StudNr
         group by s.StudNr, s.Name
         having count(*) > 2)  tmp;
```

Decision-Support-query with nested sub-queries

```
select  n.LectureNr, n.NumPerLect, t.TotalNum,
        n.NumPerLect /t.TotalNum as MarketShare
from    ( select LectureNr, count(*) as NumPerLect
          from attend
          group by LectureNr ) n,
        ( select count (*) as TotalNum
          from Students) t;
```

Result of the query ?!

LectureNr	NumPerLect	TotalNum	MarketShare
4052	1	8	0
5001	3	8	0
5022	2	8	0
...	...	...	...

Decision-Support-query with nested sub-queries

```
select  n.LectureNr, n.NumPerLect, t.TotalNum,
        cast(n.NumPerLect as decimal(6,2)) / t.TotalNum
        as MarketShare
from    ( select LectureNr, count(*) as NumPerLect
          from attend
          group by LectureNr ) n,
        ( select count (*) as TotalNum
          from Students) t;
```

Professors

PersNr	Name	Level	Room
2125	Sokrates	C4	226
2126	Russel	C4	232
2127	Kopernikus	C3	310
2133	Popper	C3	52
2134	Augustinus	C3	309
2136	Curie	C4	36
2137	Kant	C4	7

Students

StudNr	Name	Semester
24002	Xenokrates	18
25403	Jonas	12
26120	Fichte	10
26830	Aristoxenos	8
27550	Schopenhauer	6
28106	Carnap	3
29120	Theophrastos	2
29555	Feuerbach	2

Lectures

Lecture Nr	Title	Weekly Hours	Given_by
5001	Grundzüge	4	2137
5041	Ethik	4	2125
5043	Erkenntnistheorie	3	2126
5049	Mäeutik	2	2125
4052	Logik	4	2125
5052	Wissenschaftstheorie	3	2126
5216	Bioethik	2	2126
5259	Der Wiener Kreis	2	2133
5022	Glaube und Wissen	2	2134
4630	Die 3 Kritiken	4	2137

attend

StudNr	LectureNr
26120	5001
27550	5001
27550	4052
28106	5041
28106	5052
28106	5216
28106	5259
29120	5001
29120	5041
29120	5049
25403	5022
29555	5022
29555	5001

require

Predecessor	Successor
5001	5041
5001	5043
5001	5049
5041	5216
5043	5052
5041	5052
5052	5259

Assistants

PersNr	Name	Area	Boss
3002	Platon	Ideenlehre	2125
3003	Aristoteles	Syllogistik	2125
3004	Wittgenstein	Sprachtheorie	2126
3005	Rhetikus	Planetenbewegung	2127
3006	Newton	Keplersche Gesetze	2127
3007	Spinoza	Gott und Natur	2126

test

StudNr	LectureNr	PersNr	Grade
28106	5001	2126	1
25403	5041	2125	2
27550	4630	2137	2

Result of the query

LectureNr	NumPerLect	TotalNum	MarketShare
4052	1	8	.125
5001	3	8	.375
5022	2	8	.25
...	...	...	...

Further queries with sub-queries

```
select Name
from Professors
where PersNr not in ( select Given_by
                      from Lectures );

select Name
from Students
where Semester > = all ( select Semester
                         from Students );
```

case-construct (syntactic sugar)

```
select StudNr, ( case when Grade < 1.5 then ´very good´
                      when Grade < 2.5 then ´good´
                      when Grade < 3.5 then ´satisfactory´
                      when Grade < 4.0 then ´sufficient´
                      else ´failed´ end)
from test;
```

First qualifying **when**-clause is executed

Joins in SQL-92

- **cross join:** full cartesian product (not in all DBS!)
- **natural join:** equality test on all attributes with the same names, output of all attributes, those with the same names only once (not in all DBS!)
- **join** also called **inner join**: Theta Join, Theta is predicate on attributes, e.g. equi-join
- **left**, **right** or **full outer join**: keeps tuples with no join partner
- **semi-join**: no operator in SQL, expressed with **exists** or **in**

(Inner) Join

select *
from R_1, R_2
where $R_1.A = R_2.B$;

or alternatively

select *
from R_1 **join** R_2 **on** $R_1.A = R_2.B$;

Outer Joins (left)

```
select p.PersNr, p.Name, t.PersNr, t.Grade,
   t.StudNr, s.StudNr, s.Name
from Professors p left outer join
    (test t left outer join Students s
                on t.StudNr = s.StudNr)
                        on p.PersNr = t.PersNr;
```

Result

p.PersNr	p.Name	t.PersNr	t.Grade	t.StudNr	s.StudNr	s.Name
2126	Russel	2126	1	28106	28106	Carnap
2125	Sokrates	2125	2	25403	25403	Jonas
2137	Kant	2137	2	27550	27550	Schopen-hauer
2136	Curie	-	-	-	-	-
⋮	⋮	⋮	⋮	⋮	⋮	⋮

Outer Joins (right)

```
select p.PersNr, p.Name, t.PersNr, t.Grade,
   t.StudNr, s.StudNr, s.Name
from Professors p right outer join
    (test t right outer join Students s
                on t.StudNr = s.StudNr)
                        on p.PersNr = t.PersNr;
```

Result

p.PersNr	p.Name	t.PersNr	t.Grade	t.StudNr	s.StudNr	s.Name
2126	Russel	2126	1	28106	28106	Carnap
2125	Sokrates	2125	2	25403	25403	Jonas
2137	Kant	2137	2	27550	27550	Schopen-hauer
-	-	-	-	-	26120	Fichte
⋮	⋮	⋮	⋮	⋮	⋮	⋮

Outer Joins (full)

```
select p.PersNr, p.Name, t.PersNr, t.Grade,
   t.StudNr, s.StudNr, s.Name
from Professors p full outer join
    (test t full outer join Students s
                on t.StudNr = s.StudNr)
                        on p.PersNr = t.PersNr;
```

Changes in the database : Insert

Insert of tuples via a query

insert into attend

select StudNr, LectureNr

from Students, Lectures

where Title= `Logik´;

(Mandatory registration of all students for ‚Logik')

Insert of tuples by explicitely giving values

insert into Students (StudNr, Name)

values (28121, 'Archimedes'), (4711, 'Pythagoras');

Changes in the database : Insert

Insert of tuples from a file

Database system specific programs, e.g. DB2:

- **Import:**

```
IMPORT FROM studis.tbl OF DEL
INSERT INTO Students;
```

```
Analogously: EXPORT TO studis.tbl OF DEL
             SELECT * FROM Students;
```

- **Load:**

High-Performance alternative to import

Oracle: Load, Datapump, ...

Changes in the database : delete, update

delete from Students

where Semester > 13;

Note: **delete from** Students

deletes all tuples from the relation

update Students

set Semester= Semester + 1;

Changes in two phase

1. candidates for changes are determined and marked
2. Changes are performed at the marked tuples

Otherwise changes can depend on the order of the tuples, see following example:

```
delete from require
   where Predecessor in (select Successor
                         from require);
```

Example

require	
Predecessor	Successor
5001	5041
5001	5043
5001	5049
5041	5216
5043	5052
5041	5052
5052	5229

Execution in order of the example instance would (also) contain tuple (5052, 5229) erroneously as before all tuples with 5052 as *Successor* were deleted.

Changes to the schema

- **drop table** <Table name>
- **alter table** <Table name>
  drop| add column <Attribute name> <Data type>
  alter column <Attribute name> **set default** <default>
  …

Further commands vendor specific, e.g. Oracle:

- **alter table** <Table name>
  - **modify | add column** <Attribute name> <Data type>
  - **drop column** <Attribute name>
  - **add | drop | enable | disable** <constraint clause>

Views ...

- belong to DDL:
  create view <view name> **as** <select-statement>
- often used to design queries more clear
- are kind of a "virtual relation"
- show an excerpt of the database

Advantages

- simplify the access for certain user groups
- can be used to restrict the access to the data

Disadvantages

- not all (mostly none) views can be modified

Remember

```
select tmp.StudNr, tmp.Name, tmp. Number_of_Lectures
from (select s.StudNr, s.Name, count(*) as Number_of_Lectures
        from Students s, attend a
        where s.StudNr = a.StudNr
        group by s.StudNr, s.Name
        having count(*) > 2)  tmp;
```

… alternatively

```
with tmp (StudNr, Name, Number_of_Lectures) as
(select s.StudNr, s.Name, count(*)
        from Students s, attend a
        where s.StudNr=a.StudNr
        group by s.StudNr, s.Name)
select *
from tmp
where Number_of_Lectures > 2;
```

→ temporary table, only valid within the query

Simplyfying queries with views

Complex query: Names of all professors who give lectures with credits more than the average of credits and with more than three assistants

- not all at once → divide into smaller more concise parts

- these parts can be realized by using views or or named intermediate results

Simplification

1. All professors with weekly hours more than the average of weekly hours:

```
create view AboveAverageWeeklyHours as
   select Given_by
   from Lectures
   where WeeklyHours >
      (select avg (WeeklyHours)
       from Lectures);
```

Simplification

2. All professors with more than three assistants:

```
create view ManyAssistants as
   select Boss
   from Assistants
   group by Boss
   having count(*) > 3;
```

Simplification

- combine
- views can be used like common relations

```
select Name
from Professors
where PersNr in
   (select  Given_by
   from AboveAverageWeeklyHours) and
            PersNr in
   (select Boss
   from ManyAssistants);
```

Expanding when executed

```
select Name
from Professors
where PersNr in
   (select  Given_by
   from (select Given_by                    AboveAverageWeeklyHours
   from Lectures
   where WeeklyHours >
      (select avg (WeeklyHours)
       from Lectures))) and
          PersNr in
   (select Boss
   from (select Boss
   from Assistants                          ManyAssistants
   group by Boss
   having count(*) > 3));
```

Views ...

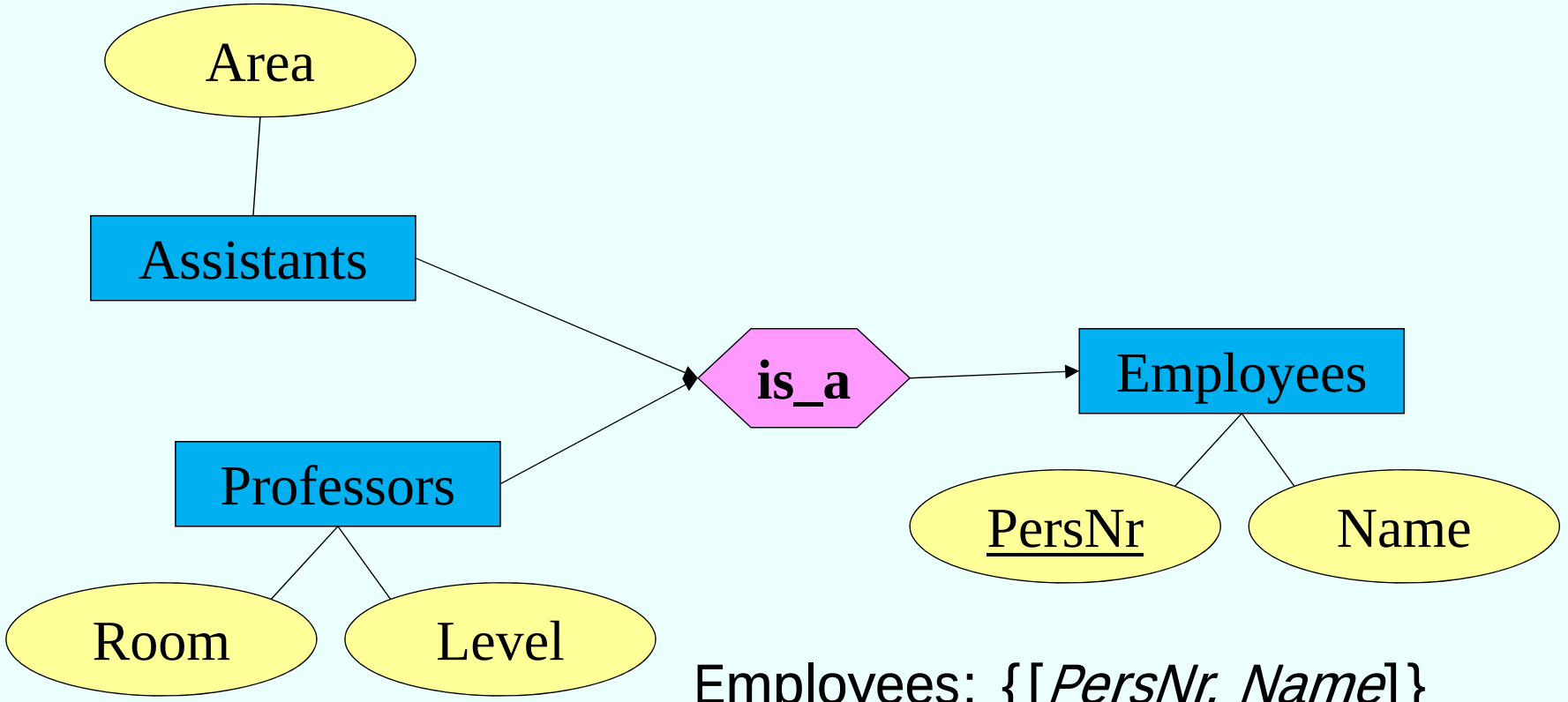
for data privacy

```
create view testView as
    select StudNr, LectureNr, PersNr
    from test
```

for statistics

```
create view TestQual(Name, QualLevel) as
      (select p.Name, avg(t.Grade)
       from Professors p join test t on
                    p.PersNr = t.PersNr
       group by p.Name, p.PersNr
       having count(*) > 50)
```

Relational Modelling of the Generalization



Employees: {[*PersNr, Name*]}

Professors: {[*PersNr, Level, Room*]}

Assistants: {[*PersNr, Area*]}

Table definition

```
create table Employees
        (PersNr    integer not null,
         Name      varchar (30) not null);
create table ProfData
        (PersNr    integer not null,
         Level     character(2),
         Room      integer);
create table AssData
        (PersNr          integer not null,
         Area            varchar(30) );
```

Views to model generalization

```
create view Professors as
        select *
        from employees e, ProfData p
        where e.PersNr=p.PersNr;

create view Assistants as
        select *
        from Employees e, AssData d
        where e.PersNr=a.PersNr;
```

➔ subtypes as view

Table definition

```
create table Professors
        (PersNr         integer not null,
        Name            varchar (30) not null,
        Level           character (2),
        Room            integer);

create table Assistants
        (PersNr         integer not null,
         Name           varchar (30) not null,
         Area           varchar (30) );

create table OtherEmployees
        (PersNr         integer not null,
         Name           varchar (30) not null);
```

Views to model generalization

```
create view Employees as
        (select PersNr, Name
        from Professors)
          union
        (select PersNr, Name
        from Assistants)
         union
        (select *
        from OtherEmployees);
```

➔ supertype as view

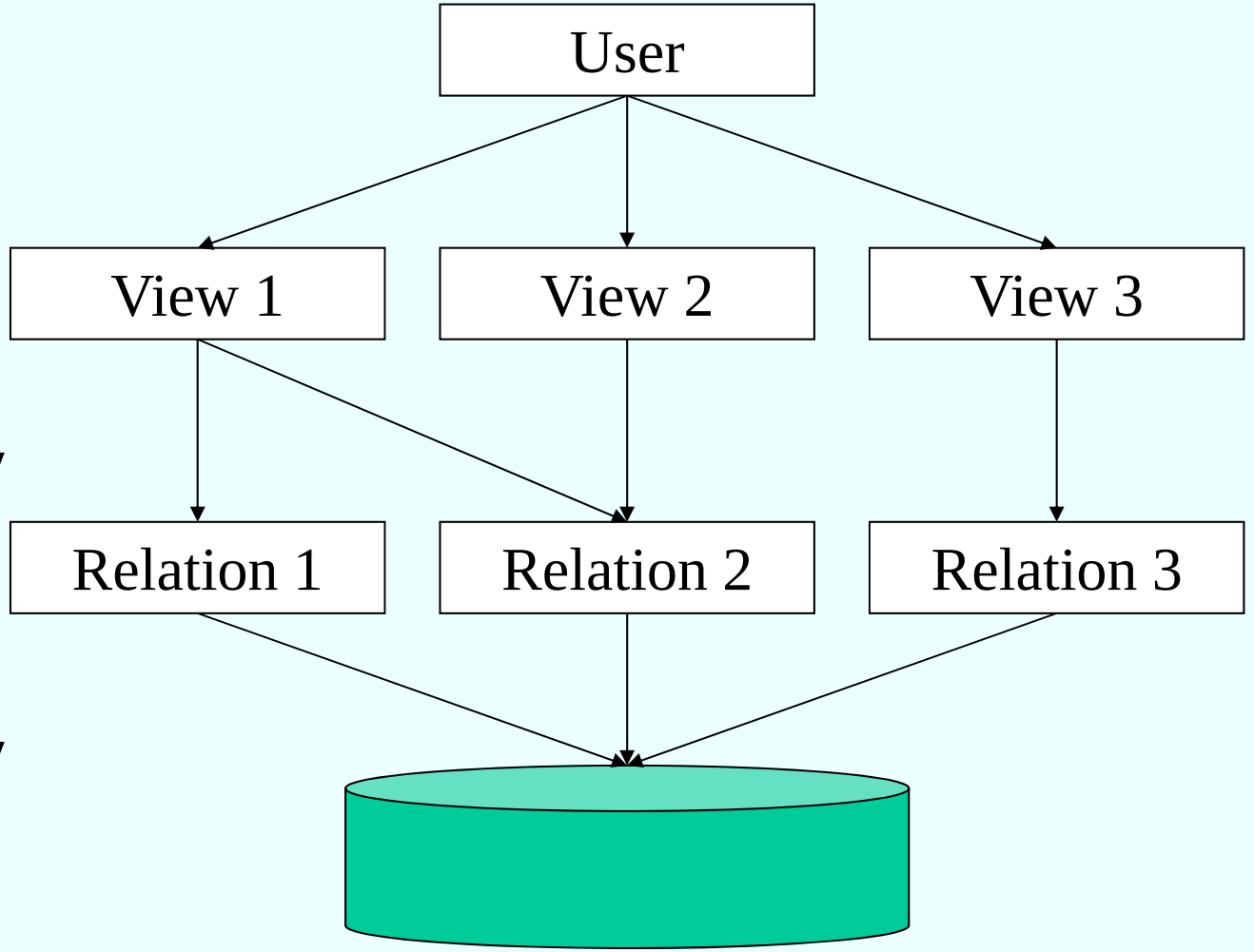
Views to guarantee data independency

logical

data independency

physical

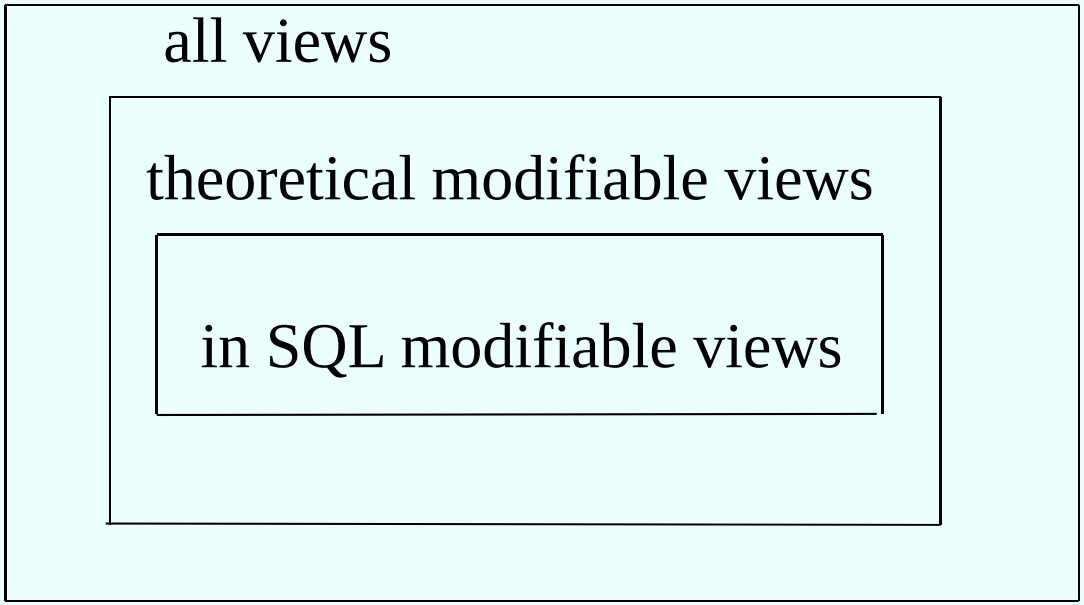
data independency



Modifyability of views

in SQL

- only one base relation
- key must be part of
- no aggregation, grouping, duplicate elimination



Views

- Life time, validity
  - Deletion: **`DROP VIEW` *`view-name`***
  - Invalid (inoperative) Views:
    - Base relation is deleted or
    - Loss of rights of view creator
    - View definition remains (marked invalid, can be reactivated)
  - Evaluation:
    - Substitute view by its definition (~ macro)
    - **no** storing (materialisation) of the evaluation of the view (result table)