Databases

3. Multi-table queries

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Fisheries Training Programme

6–9 Nov 2017

Outline

What is a database

purpose, design, data types

Create database

software, import data

Query

get data, join tables, SQL language

Interface

connect to database from other program

Goals

After this database course, you should:

1. **Understand** what a database is, and how it works
2. Be able to **create** a simple database
3. Be able to **get data** from any database

Database design

How do we design tables?

Design rules

1. **Long format**, not crosstab
2. **Normalization**, by splitting tables

Design rules

1. **Long format**, not crosstab
2. **Normalization**, by splitting tables

In a nutshell:

Make tables as narrow as possible

Long format

1. Long format, not crosstab

Long format

Data tables like this:

Species	Year	Catch
Anchovy	2001	...
Anchovy	2002	...
Anchovy	2003	...
Barnacle	2001	...
Barnacle	2002	...
Barnacle	2003	...
Catfish	2001	...
Catfish	2002	...
Catfish	2003	...
Dogfish	2001	...
Dogfish	2002	...
Dogfish	2003	...

Not like this:

Year	Anchovy	Barnacle	Catfish	Dogfish
2001	...	...	...	...
2002	...	...	...	...
2003	...	...	...	...

Design rules

1. **Long format**, not crosstab
2. **Normalization**, by splitting tables

In a nutshell:

Make tables as narrow as possible

Normalization

2. Normalization, by splitting tables

Normalization

Remember our first table:

Name	Country	Capital	Siblings	Cars	Movie
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

Normalization

Remember our first table:

Name	Country	Capital	Siblings	Cars	Movie
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

How does it scale, if the table contains 7 billion rows?

Normalization

Around 22 bytes per row:

Name	Country	Capital	Siblings	Cars	Movie
Short Text	Short Text	Short Text	Byte	Byte	Byte
∼6	∼7	∼6	1	1	1

Normalization

Around 22 bytes per row:

Name	Country	Capital	Siblings	Cars	Movie
Short Text	Short Text	Short Text	Byte	Byte	Byte
$\sim$6	$\sim$7	$\sim$6	1	1	1

Our table is then 7 billion $\times$ 22 $\approx$ 150 GB

The names of countries and capitals are taking up too much space

Normalization

Split data into People and Countries:

Name	CountryID	Siblings	Cars	Movie
Short Text	Byte	Byte	Byte	Byte
∼6	1	1	1	1

CountryID	Country	Capital
Byte	Short Text	Short Text
1	∼7	∼6

Normalization

Split data into People and Countries:

Name	CountryID	Siblings	Cars	Movie
Short Text	Byte	Byte	Byte	Byte
$\sim$6	1	1	1	1

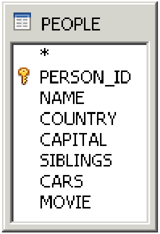
CountryID	Country	Capital
Byte	Short Text	Short Text
1	$\sim$7	$\sim$6

$$7 \text{ billion} \times 10 \approx 70 \text{ GB}$$

$$200 \times 14 = 0 \text{ GB}$$

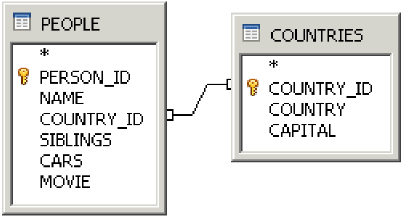
Normalization

One table



PEOPLE
*
PERSON_ID
NAME
COUNTRY
CAPITAL
SIBLINGS
CARS
MOVIE

Joined tables

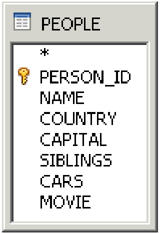


PEOPLE
*
PERSON_ID
NAME
COUNTRY_ID
SIBLINGS
CARS
MOVIE

COUNTRIES
*
COUNTRY_ID
COUNTRY
CAPITAL

Normalization

One table



redundant

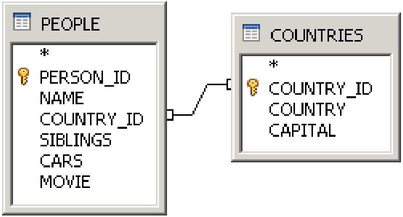
risk of inconsistent data/mistakes

more work to enter data and modify

waste of storage

but convenient for tiny datasets

Joined tables



efficient

enforces consistent rules

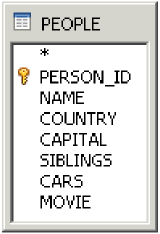
less work to enter data and modify

compact storage

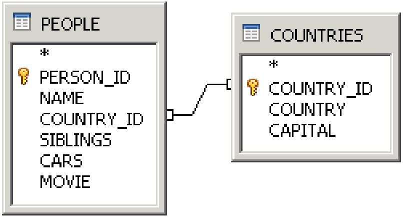
generally recommended

Normalization

One table



Joined tables



Splitting tables like this is called normalizing

. . .

An SQL query walks into a bar and sees two tables.

. . .

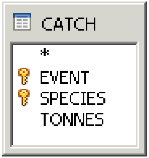
An SQL query walks into a bar and sees two tables.

He walks to them and says “Can I join you?”

Logbook data

Logbook data from Icelandic fisheries

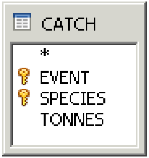
Logbook data



CATCH
*
EVENT
SPECIES
TONNES

Logbook data

```
SELECT sum(tonnes) AS total
  FROM catch
```



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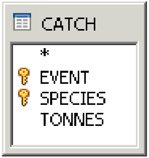
Logbook data

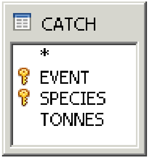


CATCH
*
EVENT
SPECIES
TONNES

```
SELECT sum(tonnes) AS total
  FROM catch
```

```
  SELECT species,
         sum(tonnes) AS total
    FROM catch
GROUP BY species
ORDER BY species
```

Logbook data


CATCH

*

EVENT

SPECIES

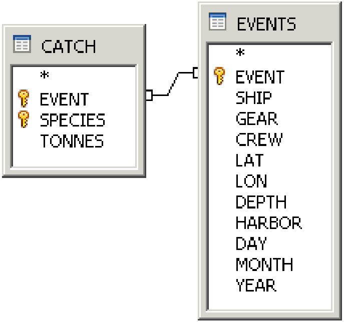
TONNES

```
  SELECT sum(tonnes) AS total
    FROM catch
```

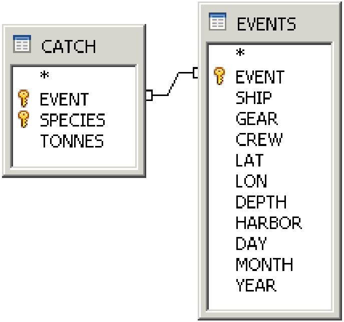
```
  SELECT species,
         sum(tonnes) AS total
    FROM catch
GROUP BY species
ORDER BY species
```

```
  SELECT species,
         max(tonnes) AS highscore
    FROM catch
GROUP BY species
ORDER BY species
```

Logbook data



Logbook data

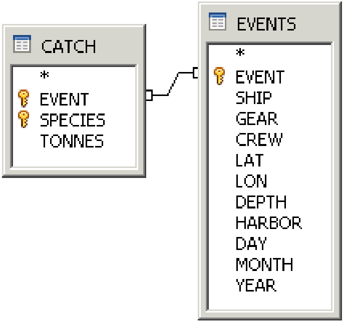


CATCH
*
EVENT
SPECIES
TONNES

EVENTS
*
EVENT
SHIP
GEAR
CREW
LAT
LON
DEPTH
HARBOR
DAY
MONTH
YEAR

```
  SELECT ship,
         sum(tonnes) AS total
    FROM catch c,
         events e
   WHERE c.event = e.event
GROUP BY ship
ORDER BY ship
```

Logbook data



CATCH
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SPECIES
TONNES

EVENTS
*
EVENT
SHIP
GEAR
CREW
LAT
LON
DEPTH
HARBOR
DAY
MONTH
YEAR

```
  SELECT ship,
         sum(tonnes) AS total
    FROM catch c,
         events e
   WHERE c.event = e.event
GROUP BY ship
ORDER BY ship
```

```
  SELECT gear,
         sum(tonnes) AS total
    FROM catch c,
         events e
   WHERE c.event = e.event
GROUP BY gear
ORDER BY gear
```

Multi-table queries

How do we query many tables?

Equijoin

The expression

WHERE table1.id = table2.id

is an equijoin, which is the simplest join type

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The expression

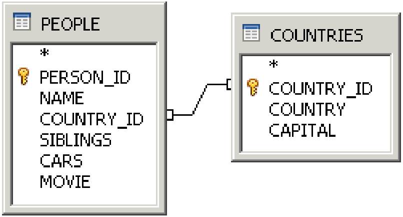
```
WHERE table1.id = table2.id
```

is an equijoin, which is the simplest join type

This is equivalent to

```
WHERE table2.id = table1.id
```

Table relationships



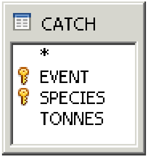
Most joins represent a

one-to-many table relationship

which is equivalent to many-to-one

This means that on one side of the join,
the column has only unique values

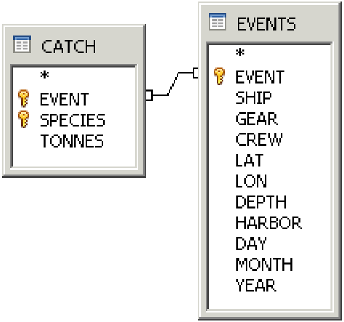
Table relationships



CATCH

*
EVENT
SPECIES
TONNES

Table relationships



CATCH
*
EVENT
SPECIES
TONNES

EVENTS
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EVENT
SHIP
GEAR
CREW
LAT
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DAY
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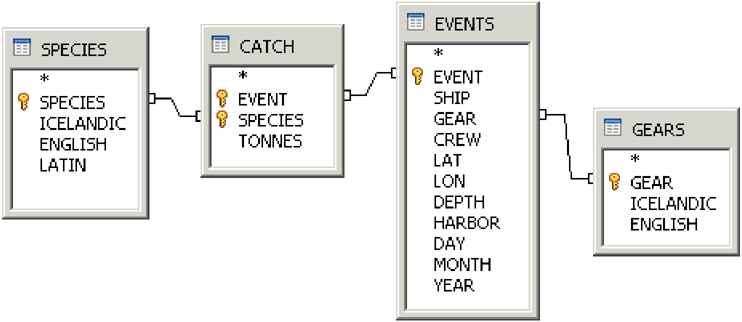
YEAR

Table relationships



SPECIES
- *
- SPECIES
- ICELANDIC
- ENGLISH
- LATIN

CATCH
- *
- EVENT
- SPECIES
- TONNES

EVENTS
- *
- EVENT
- SHIP
- GEAR
- CREW
- LAT
- LON
- DEPTH
- HARBOR
- DAY
- MONTH
- YEAR

GEARS
- *
- GEAR
- ICELANDIC
- ENGLISH

In what gear is saithe mainly caught?

```
SELECT
    g.english AS gearname,
    sum(tonnes) AS total

FROM
    catch c,
    events e,
    gears g,
    species s

WHERE
    c.species = s.species AND
    c.event = e.event AND
    e.gear = g.gear AND
    s.english = 'Saithe'

GROUP BY
    g.english
```

Table relationships

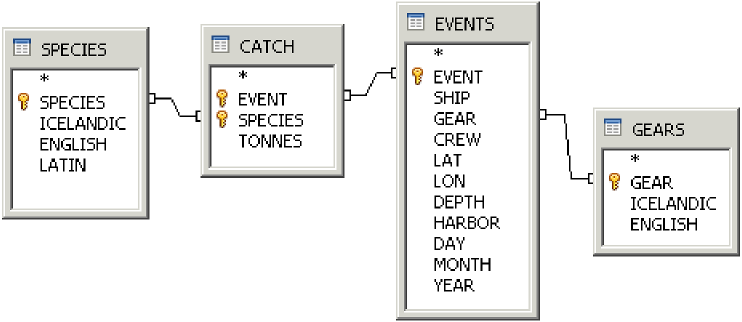
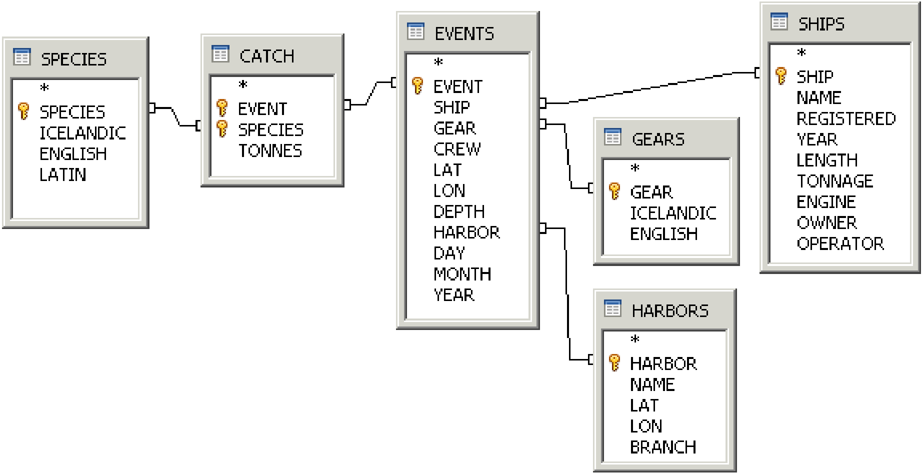


Table relationships



Postprocessing query results

What do we do with the query results?

Postprocessing query results

A query is just the first step

The next step is to analyze, create plots and summary tables
This is done outside the database, maybe in a spreadsheet or R

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It is often convenient to run a simple query and then do calculations afterwards in your preferred statistical software

Long format vs. crosstab

Data tables like this:

Species	Year	Catch
Anchovy	2001	...
Anchovy	2002	...
Anchovy	2003	...
Barnacle	2001	...
Barnacle	2002	...
Barnacle	2003	...
Catfish	2001	...
Catfish	2002	...
Catfish	2003	...
Dogfish	2001	...
Dogfish	2002	...
Dogfish	2003	...

Not like this:

Year	Anchovy	Barnacle	Catfish	Dogfish
2001	...	...	...	...
2002	...	...	...	...
2003	...	...	...	...

Crosstab

Year	Anchovy	Barnacle	Catfish	Dogfish
2001	...	...	...	...
2002	...	...	...	...
2003	...	...	...	...

Cross tabulation is great for viewing, but not for storing data

Crosstab

Year	Anchovy	Barnacle	Catfish	Dogfish
2001	...	...	...	...
2002	...	...	...	...
2003	...	...	...	...

Cross tabulation is great for viewing, but not for storing data

Not part of standard SQL, but query results can be crosstabbed afterwards:

- Pivot table in a spreadsheet
- xtabs in R

Avoid slow queries

A simple query can sometimes take a long time to compute

This should be avoided, especially on a multi-user database system

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A simple query can sometimes take a long time to compute

This should be avoided, especially on a multi-user database system

To make a query run fast, use

```
WHERE x = value AND
      y LIKE '%pattern%' AND
      z IN (value1,value2,value3)
```

to return only the subset that you're interested in