CSIT115 Data Management and Security

CSIT882 Data Management Systems

Database Design Quality

Subject coordinators: Dr Chen Chen, Dr Thanh Le Hoang

Slides created by Dr Janusz R. Getta, School of Computing and Information Technology - University of Wollongong

Database Design Quality

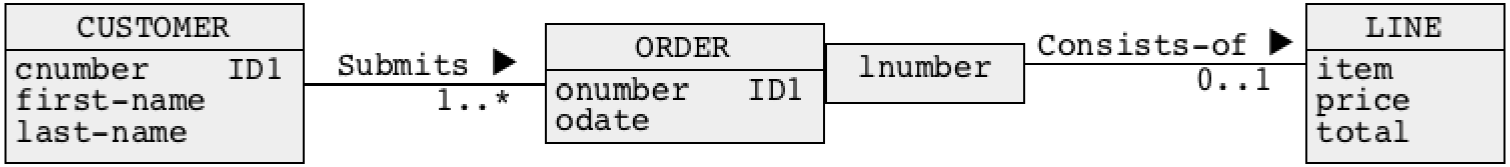
Outline

- Why not ONE BIG TABLE !?
- Where is a problem ?
- Insertion test
- Good design guidelines

Why not ONE BIG TABLE !?

Let us consider the following database domain:

- A customer is described by a unique customer number, first and last name
- Customers submit orders
- An order is described by a unique order number and order date
- Orders consist of lines
- A line contains information about a name of ordered item, price per single item and total number of ordered items



Why not ONE BIG TABLE !?

Logical design provides the following relational schemas:

Relational schema CUSTOMER

```
CUSTOMER(cnumber, first-name, last-name)
PRIMARY KEY = (cnumber)
```

Relational schema ORDERS

```
ORDERS(onumber, odate, cnumber) PRIMARY KEY = (onumber)
FOREIGN KEY = (cnumber) REFERENCES CUSTOMER(cnumber)
```

Relational schema LINE

```
LINE(onumber, lnumber, item, price total)
PRIMARY KEY = (onumber, lnumber)
FOREIGN KEY = (onumber) REFERENCES ORDERS(onumber)
```

Why not one relational schema ?

Big relational schema

```
CUSTOMER(cnumber, first-name, last-name, onumber, odate, cnumber,
         onumber, lnumber, item, price total)
PRIMARY KEY = (cnumber, onumber, lnumber)
```

Why not ONE BIG TABLE !?

Insertion of information about one customer who submitted 2 orders, such that each order consists several lines reveals a problem !

Big relational table

```
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
| cnumber | fname | lname | onumber | odate       | lnumber | item  | price | total |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
|    +----------------------+   +---------------+ |         |       |       |       |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       1 | bolt  | 23.04 |     5 |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       2 | screw | 29.01 |     3 |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       3 | nut   |  4.55 |     2 |
|    |    |       |       | |   +---------------+ |         |       |       |       |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       1 | bolt  | 23.04 |     1 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       2 | screw | 23.04 |     1 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       3 | nut   | 23.04 |     2 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       4 | lock  | 23.04 |     1 |
|    +----------------------+   +---------------+ |         |       |       |       |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
```

A number, first name and last name of a customer is repeated as many times as the total number of different items purchased in all orders and order number is repeated together with order date as many times as the total number of different items purchased in an order

Why not ONE BIG TABLE !?

A multitable design does not have such a problem:

Relational schema CUSTOMER

```
CUSTOMER(cnumber, first-name, last-name)
PRIMARY KEY = (cnumber)
```

Relational table CUSTOMER

```
+---------+-------+-------+
| cnumber | fname | lname |
+---------+-------+-------+
|       7 | James | Bond  |
+---------+-------+-------+
```

Relational schema ORDERS

```
ORDERS(onumber, odate, cnumber) PRIMARY KEY = (onumber)
FOREIGN KEY = (cnaumber) REFERENCES CUSTOMER(cnumber)
```

Relational table ORDERS

```
+---------+------------+---------+
| onumber | odate      | cnumber |
+---------+------------+---------+
|       7 | 2017-01-01 |       7 |
|       8 | 2018-01-01 |       7 |
+---------+------------+---------+
```

Why not ONE BIG TABLE !?

A multitable design does not have such a problem:

Relational schema LINE

```
LINE(onumber, lnumber, item, price total)
PRIMARY KEY = (onumber, lnumber)
FOREIGN KEY = (onumber) REFERENCES ORDERS(onumber)
```

Relational table LINE

```
+---------+---------+-------+-------+-------+
| onumber | lnumber | item  | price | total |
+---------+---------+-------+-------+-------+
|       7 |       1 | bolt  | 23.04 |     5 |
|       7 |       2 | screw | 29.01 |     3 |
|       7 |       3 | nut   |  4.55 |     2 |
|       8 |       1 | bolt  | 23.04 |     1 |
|       8 |       2 | screw | 23.04 |     1 |
|       8 |       3 | nut   | 23.04 |     2 |
|       8 |       4 | lock  | 23.04 |     1 |
+---------+---------+-------+-------+-------+
```

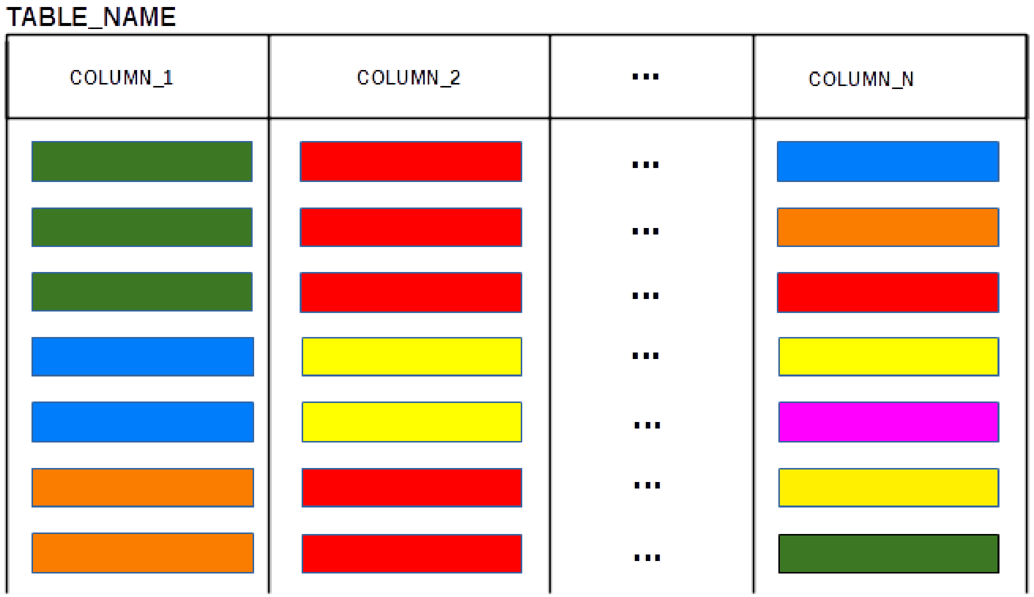
Database Design Quality

Outline

- Why not ONE BIG TABLE !?
- Where is a problem ?
- Insertion test
- Good design guidelines

Where is a problem ?

Why do we get redundancies in an incorrectly designed relational table ?



TABLE_NAME

COLUMN_1	COLUMN_2	...	COLUMN_N
🟩	🟥	...	🟦
🟩	🟥	...	🟧
🟩	🟥	...	🟥
🟦	🟨	...	🟨
🟦	🟨	...	🟪
🟧	🟥	...	🟨
🟧	🟥	...	🟩

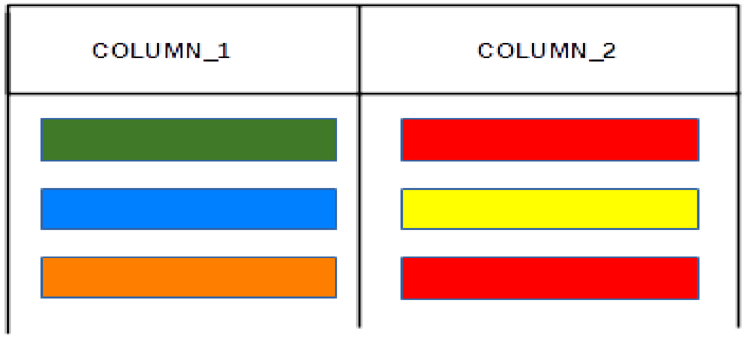
Data dependencies:

- If `COLUMN_1` is green then `COLUMN_2` is red
- If `COLUMN_1` is blue then `COLUMN_2` is yellow
- If `COLUMN_1` is orange then `COLUMN_2` is red
- For any colour x if `COLUMN_1` is x then `COLUMN_2 is` y

Where is a problem ?

Data dependencies can be represented as a separate relational table ...

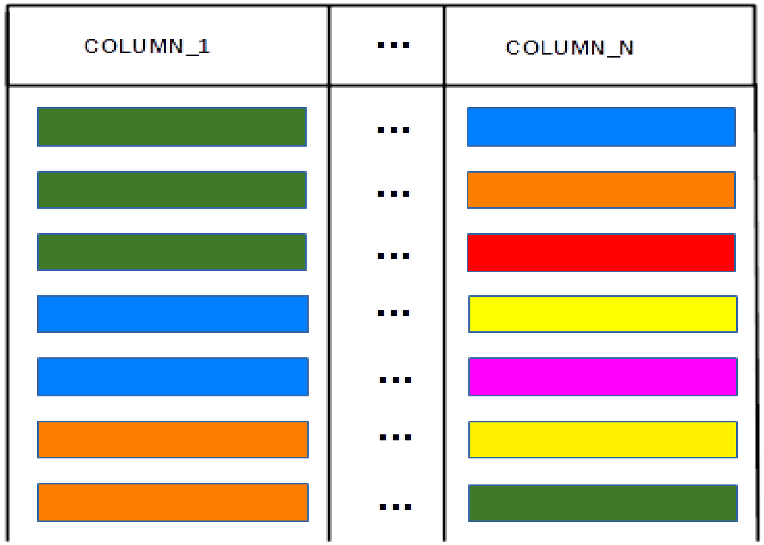
TABLE_1



COLUMN_1	COLUMN_2
🟩	🟥
🟦	🟨
🟧	🟥

... and `COLUMN_2` can be removed from the original table

TABLE_2



COLUMN_1	...	COLUMN_N
🟩	...	🟦
🟩	...	🟧
🟩	...	🟥
🟦	...	🟨
🟦	...	🟪
🟧	...	🟨
🟧	...	🟩

Where is a problem ?

Do data dependencies exist in BIG TABLE ?

Big relational table

```
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
| cnumber | fname | lname | onumber | odate       | lnumber | item  | price | total |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
|    +----------------------+   +---------------+ |         |       |       |       |
|    |  7 | James | Bond   | |   | 7 | 2017-01-01| |       1 | bolt  | 23.04 |     5 |
|    |  7 | James | Bond   | |   | 7 | 2017-01-01| |       2 | screw | 29.01 |     3 |
|    |  7 | James | Bond   | |   | 7 | 2017-01-01| |       3 | nut   |  4.55 |     2 |
|    |    |       |       | |   +---------------+ |         |       |       |       |
|    |  7 | James | Bond   | |   | 8 | 2018-01-01| |       1 | bolt  | 23.04 |     1 |
|    |  7 | James | Bond   | |   | 8 | 2018-01-01| |       2 | screw | 23.04 |     1 |
|    |  7 | James | Bond   | |   | 8 | 2018-01-01| |       3 | nut   | 23.04 |     2 |
|    |  7 | James | Bond   | |   | 8 | 2018-01-01| |       4 | lock  | 23.04 |     1 |
|    +----------------------+   +---------------+ |         |       |       |       |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
```

Data dependencies:

- If `cnumber` = 7 then `fname` = James
- If `cnumber` = 7 then `lname` = Bond
- For any customer number x if `cnumber` = x then `fname` = y and `lname` = z

Where is a problem ?

Do data dependencies exist in BIG TABLE ?

Big relational table

```
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
| cnumber | fname | lname | onumber | odate       | lnumber | item  | price | total |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
|    +----------------------+   +---------------+ |         |       |       |       |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       1 | bolt  | 23.04 |     5 |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       2 | screw | 29.01 |     3 |
|    |  7 | James | Bond  | |   | 7 | 2017-01-01| |       3 | nut   |  4.55 |     2 |
|    |    |       |       | |   +---------------+ |         |       |       |       |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       1 | bolt  | 23.04 |     1 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       2 | screw | 23.04 |     1 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       3 | nut   | 23.04 |     2 |
|    |  7 | James | Bond  | |   | 8 | 2018-01-01| |       4 | lock  | 23.04 |     1 |
|    +----------------------+   +---------------+ |         |       |       |       |
+---------+-------+-------+---------+-------------+---------+-------+-------+-------+
```

More data dependencies:

- If `onumber` = 7 then `odate` = 2017-01-01
- If `onumber` = 8 then `odate` = 2018-01-01
- For any order number x if `onumber` = x then `odate` = y

Database Design Quality

Outline

- Why not ONE BIG TABLE !?
- Where is a problem ?
- Insertion test
- Good design guidelines

Insertion test

How to verify if a relational schema is designed in a correct way ?

Simple ! We try to insert few rows to create the redundancies

For example, we insert few rows into a relational table ROOM

Relational schema ROOM

```
ROOM(bldgnum, name, roomnum, area)
PRIMARY KEY = (bldgnum, roomnum)
```

Relational table ROOM

```
+---------+----------+---------+------+
| bldgnum | bldgname | roomnum | area |
+---------+----------+---------+------+
|       3 | SCIT     |     210 |   20 |
+---------+----------+---------+------+
```

Relational table ROOM

```
+---------+----------+---------+------+
| bldgnum | bldgname | roomnum | area |
+---------+----------+---------+------+
|       3 | SCIT     |     210 |   20 |
|       3 | SCIT     |     211 |   22 |
+---------+----------+---------+------+
```

Relational table ROOM

```
+---------+----------+---------+------+
| bldgnum | bldgname | roomnum | area |
+---------+----------+---------+------+
|       3 | SCIT     |     210 |   20 |
|       3 | SCIT     |     211 |   22 |
|       3 | SCIT     |     213 |   20 |
+---------+----------+---------+------+
```

Insertion test

Relational table ROOM

```
+----------+-----------+----------+-------+
| bldgnum | bldgname | roomnum | area |
+----------+-----------+----------+-------+
|       3 | SCIT      |      210 |   20 |
|       3 | SCIT      |      211 |   22 |
|       3 | SCIT      |      213 |   20 |
+----------+-----------+----------+-------+
```

Problems:

- It is clearly visible that a building name is repeated as many times as many rooms are included in a building

Insertion test

In another example, we insert few rows into a relational table WAREHOUSE

A relational schema WAREHOUSE

```
WAREHOUSE(name, address, part, quantity)
PRIMARY KEY = (name, part)
```

A relational table WAREHOUSE

```
+--------------+-----------------+-------+----------+
| name         | address         | part  | quantity |
+--------------+-----------------+-------+----------+
| Golden Bolts | Northfields Ave | bolt  |      210 |
+--------------+-----------------+-------+----------+
```

A relational table WAREHOUSE

```
+--------------+-----------------+-------+----------+
| name         | address         | part  | quantity |
+--------------+-----------------+-------+----------+
| Golden Bolts | Northfields Ave | bolt  |      210 |
| Golden Bolts | Northfields Ave | lock  |       20 |
+--------------+-----------------+-------+----------+
```

A relational table WAREHOUSE

```
+--------------+-----------------+-------+----------+
| name         | address         | part  | quantity |
+--------------+-----------------+-------+----------+
| Golden Bolts | Northfields Ave | bolt  |      210 |
| Golden Bolts | Northfields Ave | lock  |       20 |
| Golden Bolts | Northfileds Ave | screw |      211 |
+--------------+-----------------+-------+----------+
```

Insertion test

A relational table WAREHOUSE

```
+--------------+-----------------+-------+----------+
| name         | address         | part  | quantity |
+--------------+-----------------+-------+----------+
| Golden Bolts | Northfields Ave | bolt  |      210 |
| Golden Bolts | Northfields Ave | lock  |       20 |
| Golden Bolts | Northfileds Ave | screw |      211 |
+--------------+-----------------+-------+----------+
```

Problems:

- An address of a warehouse is repeated as many times as many different parts are stored in the warehouse
- If at some point in time, there are no parts stored in a warehouse then there may be no rows to keep a warehouse address or the values of certain attributes must be set to `NULL`

Insertion test

In yet another example, we insert few rows into a relational table `EMPLOYEE`

A relational schema EMPLOYEE

```
EMPLOYEE(enum, skill, hobby)
PRIMARY KEY = (enum, skill, hobby)
```

A relational table EMPLOYEE

```
+------+-------------+----------+
| enum | skill       | hobby    |
+------+-------------+----------+
|    7 | cooking     | hiking   |
+------+-------------+----------+
```

A relational table EMPLOYEE

```
+------+-------------+----------+
| enum | skill       | hobby    |
+------+-------------+----------+
|    7 | cooking     | hiking   |
|    7 | cooking     | swimming |
+------+-------------+----------+
```

A relational table EMPLOYEE

```
+------+-------------+----------+
| enum | skill       | hobby    |
+------+-------------+----------+
|    7 | cooking     | hiking   |
|    7 | cooking     | swimming |
|    7 | programming | hiking   |
|    7 | programming | swimming |
+------+-------------+----------+
```

Insertion test

A relational table EMPLOYEE

```
+------+-------------+----------+
| enum | skill       | hobby    |
+------+-------------+----------+
|    7 | cooking     | hiking   |
|    7 | cooking     | swimming |
|    7 | programming | hiking   |
|    7 | programming | swimming |
+------+-------------+----------+
```

Problems:

- A skill name must be repeated with each hobby name
- A hobby name must be repeated with each skill name
- If at some point in time an employee has no hobbies (or skills) then a value of an attribute `hobby` (or `skill`) must be set to `NULL`, however, it is impossible due to `PRIMARY KEY = (enum, skill, hobby)` constraint

Database Design Quality

Outline

- Why not ONE BIG TABLE !?
- Where is a problem ?
- Insertion test
- Good design guidelines

Good design guidelines

Design a relational table such that it is easy to explain its meaning

Do not include the unrelated attributes into the same table

Design a relational table such that the insertion, deletion and update tests do not cause anomalies

Minimize the total number of attributes whose values can be missing (`NULL`)

Design the relational tables such that they can be joined over an equality conditions on the attributes that are either primary or foreign keys iin a proper way

And the first of all ...

ALWAYS START YOUR DESIGN FROM THE CONCEPTUAL MODELING !

References

T. Connoly, C. Begg, Database Systems, A Practical Approach to Design, Implementation and Management, Chapters 14.1 - 14.3 Introduction to normalization, Pearson Education Ltd, 2015