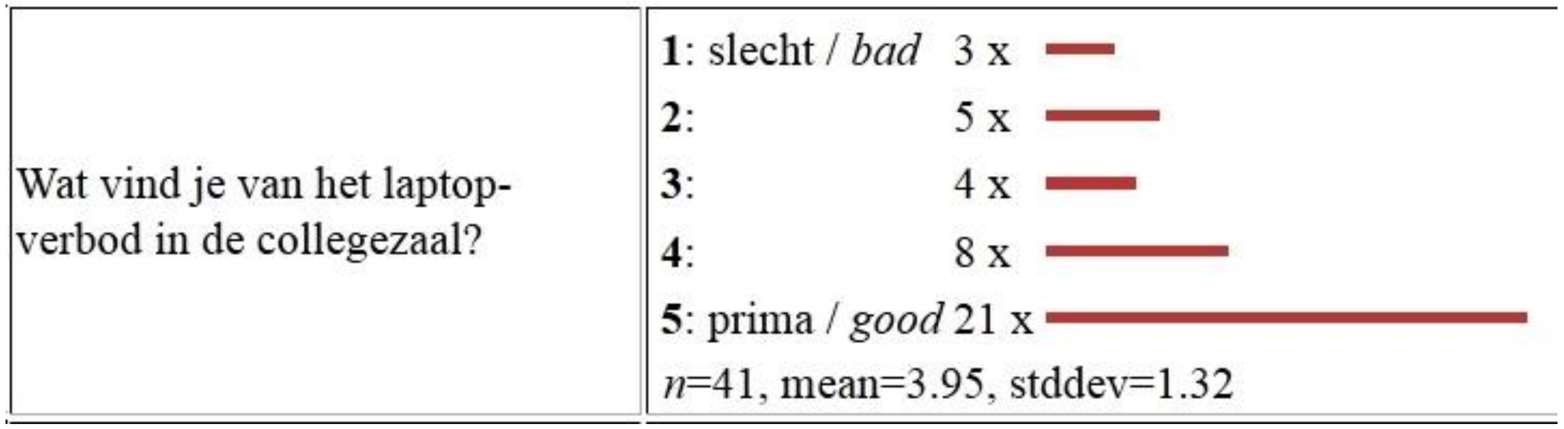
Databases 2019/2020

Introduction

The menu for today

- Organisational aspects
- Introduction to database technology
- The relational model

About using laptops in classes



Wat vind je van het laptop-verbod in de collegezaal?	**1**: slecht / *bad*	3 x
	2:	5 x
	3:	4 x
	4:	8 x
	5: prima / *good*	21 x
	n=41, mean=3.95, stddev=1.32	

Kun je niet zonder je laptop of smartphone?
Ga dan op één van de achterste acht rijen zitten.

Organisation

- Hoorcolleges
  - Dinsdag 9:00 – 10:45
  - Donderdag 15:15 – 17:00
- Werkcolleges
  - I.p.v. donderdag: online assignments via Blackboard
  - Dinsdag: regulier (met ingang van 12 februari)
- Practica (koppels)
  - Opgave 1: casusbeschrijving, modelleren, schema-ontwerp
  - Opgave 2: vulling van de database, SQL queries
- Huiswerkopdrachten (3x)

Introduction to database technology

- What are databases?
  - Relational data model
- Why should we look at databases?
- Some aspects of database technology
  - Query languages
  - Database applications: UI, constraints, reports
  - ER-modeling
  - Normalization
  - Transaction processing

What is a database?

- Example: library system
  - Books, readers, loans, reservations
  - Book loans, returning books, searching, making reservations, subscribing readers

Book

Bno	Author	Title
327	Gates	The road ahead
535	Baars	Fun-fishing
113	Carlsen	Chess for dummies

Reader

Rno	Name	Address
212	Rutte	Torentje 1, Den Haag
431	Karjakin	Plein 2, Wladiwostok
7	Bond	Downing Str. 7, London

Loan

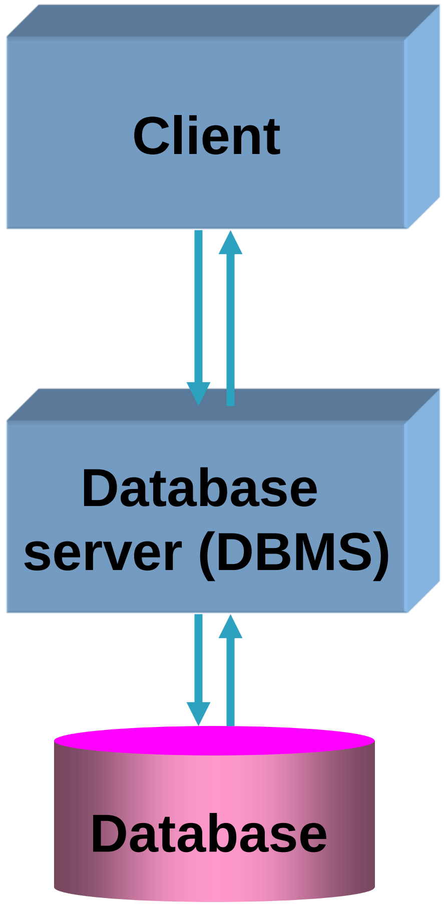
Bno	Rno	Loan date	Return date
113	431	14.10.2019	17.10.2019
327	212	21.10.2019	-
535	212	28.10.2019	-

What is a database?

- Manipulation of data using a query language
  - For example SQL
  - Integrated in an app/ web interface

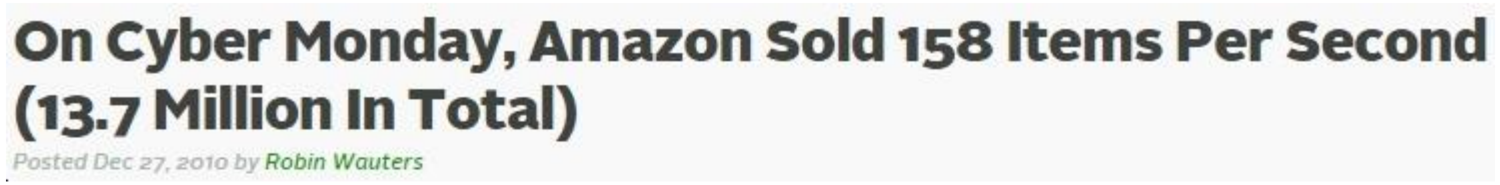
```
SELECT Title
FROM Book
WHERE Author = 'Rowling'
```

- Often client/server architecture
  - Application logic in the client



What is a database?

- Characteristics of a database environment
  - Stable structure of data
    - Compare to textual data (information retrieval)
  - Large volumes (external memory, persistency)
  - Good performance
  - More than one user at a time (concurrency)
  - Reliability and integrity of data



On Cyber Monday, Amazon Sold 158 Items Per Second (13.7 Million In Total)

Posted Dec 27, 2010 by Robin Wauters

Why look at databases?

- Databases are omnipresent
- Database technology is directly applicable
  - Software project
- Database technology is the backbone of most information systems
- Studying database technology provides insight in general principles of computer science
  - Layered software architecture
  - Application of predicate logic
  - Mathematical modeling

History of databases

- During the eighties, the relational data model (Codd, Turing Award 1981) received widespread commercial attention
  - In 1983, more than 100 **R**DBMSes existed
  - DB2, ORACLE, SYBASE, INFORMIX, INGRES
  - DBASE, PARADOX, MS-ACCESS
  - POSTGRES, MySQL, SQLite
  - *NoSQL*: MongoDB, MapReduce, GraphDBs
- SQL became a “standard” in 1986
- SQL92/SQL2, SQL3: ANSI standards

History of databases

- The first 4GL languages appeared during the eighties, supporting application development
- Object-oriented databases were introduced at the end of that decade, but disappeared
- Focus shifted to extending features and better performance
  - Multimedia databases, web databases, parallel processing
- Main memory databases for data analytics:
  - OLTP versus OLAP (data warehouse)
  - Mining in Databases: *Big Data*

Query languages

```
SELECT Name
FROM Book, Loan, Reader
WHERE Book.Title = ‘Fun-fishing’
  AND Book.Bno = Loan.Bno
  AND Loan.Rno = Reader.Rno
```

- From “how” to “what”
  - SQL is declarative

```
Book.Title := ‘Fun-fishing’;
FIND FIRST Book USING Title;
WHILE DB-Status = 0 DO
BEGIN
  FIND FIRST Loan WITHIN
     Book_Loan;
  WHILE DB-Status = 0 DO
  BEGIN
    FIND OWNER WITHIN
      Reader_Loan;
    GET Reader;
    PRINT(Reader.Name);
    FIND NEXT Loan WITHIN
      Book_Loan;
  END;
  FIND NEXT Book USING Title;
END
```

Database applications (fantasy language)

```
PROCEDURE Loan ();
{
  $today = system.call(‘current_date’);
  read($x);  // read Rno

  if (call(Rnocheck($x)) == 0)
  {
    message(“card invalid”);
    exit();
  };

  read($y);  # read Bno
  while ($y <> EndOfLoan)
  {
    call(Register_loan($today, $x, $y));
    read($y);
  }
}
```

```
int Rnocheck ($x);
{
  SELECT COUNT (*)
  FROM Reader
  WHERE Rno = $x;
}
```

```
void Register_loan
    ($d, $x, $y);
{
  INSERT INTO Loan
  VALUES ($y, $x, $d,  NULL);
}
```

Integrity constraints

```
CONSTRAINT constr1
  (SELECT COUNT (*)
   FROM Loan
   WHERE Return_date IS NULL
   GROUP BY Rno)
    <= 6
ON VIOLATION …
```

```
CONSTRAINT constr3
  (SELECT Bno
   FROM Loan)
  IS CONTAINED IN
  (SELECT Bno
   FROM Book)
ON VIOLATION …
```

```
CONSTRAINT constr2
  (SELECT COUNT (*)
   FROM Loan
   WHERE Return_date IS NULL
   GROUP BY Bno)
  <= 1
ON VIOLATION …
```

Database applications

- Report writing

```
SELECT Name, Address, …
FROM Loan, Reader, Book
WHERE Loan.Rno = Reader.Rno
  AND Loan_date < ‘01.12.2018’
  AND Return_date IS NULL
```

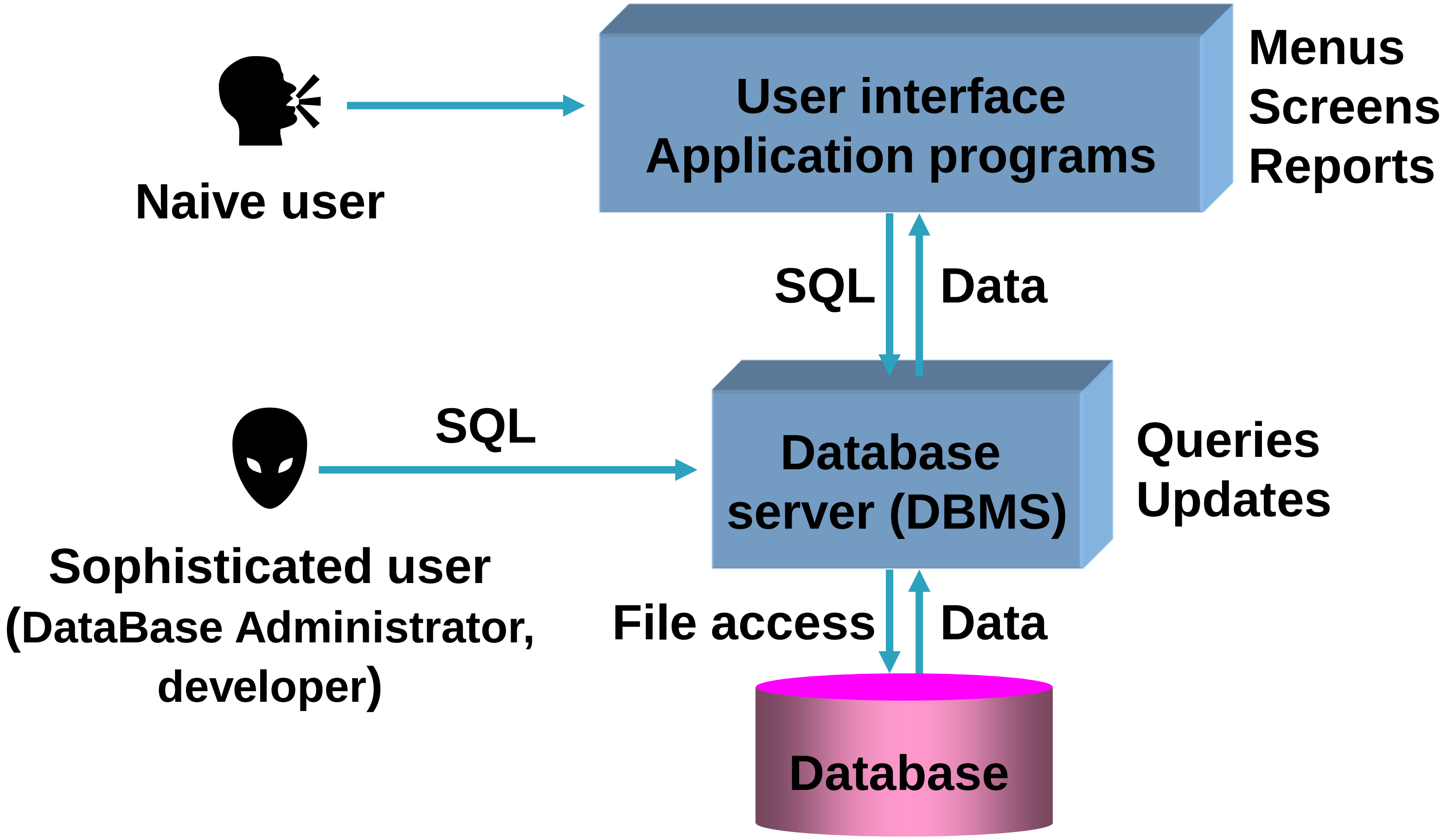
@name
@address

Dear mr/mrs @name,

On @loan_date you have borrowed the following book from our library:
@title by @author.

We kindly request you to return this book as soon as possible.

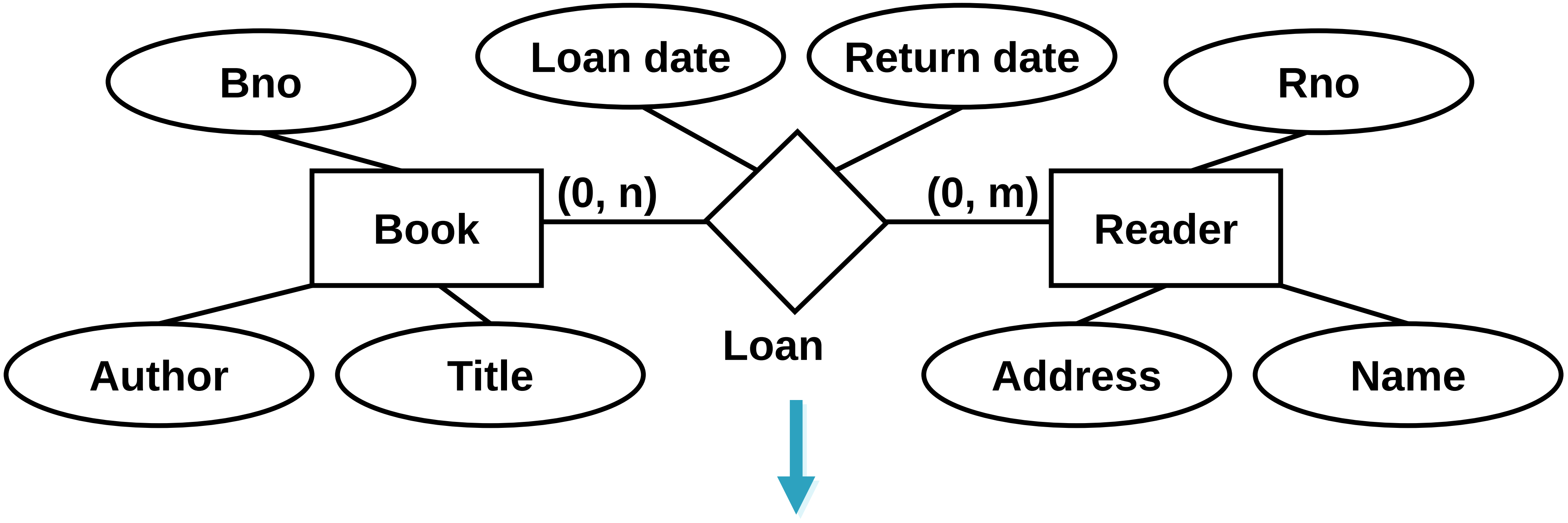
Database applications



Example application

- Database support for massive online gaming
- MSc project Vlad Alecu (now @ Electronic Arts)
- Two level approach:
  - Classical persistent DB support for essential player info with transactional integrity
  - Main-memory DB support for player status data, meeting critical respons time requirements
  - Optimizing physical proximity of players

DB design: ER modeling



Book(Bno, Author, Title)

Reader(Rno, Name, Address)

Loan(Bno, Rno, Loan_date, Return_date)

Normalization

- Why don't we put everything in one table?
  - Manageability
  - To prevent redundancy and inconsistency
  - Adequate representation (without NULLs)

Rno	Name	Address	Bno	Author	Title
212	Rutte	Torentje 1, Den Haag	327	Gates	The road ahead
212	Rutte	Torentje 2, Den Haag	535	Baars	Fun-fishing
431	Karjakin	Plein 2, Wladiwostok	113	Carlsen	Chess for dummies
7	Bond	Downing Str. 7, London	NULL	NULL	NULL

Normalization

Rno	Name	Address	Bno	Author	Title
212	Rutte	Torentje 1, Den Haag	327	Gates	The road ahead
212	Rutte	Torentje 1, Den Haag	535	Baars	Fun-fishing
431	Kramnik	Plein 2, Wladiwostok	113	Kasparov	Chess for dummies
7	Bond	Downing Str. 7, London	NULL	NULL	NULL

Rno	Name	Address
212	Rutte	Torentje 1, Den Haag
431	Kramnik	Plein 2, Wladiwostok
7	Bond	Downing Str. 7, London

Bno	Author	Title
327	Gates	The road ahead
535	Baars	Fun-fishing
113	Kasparov	Chess for dummies

Bno	Rno	Loan_date	Return_date
113	431	14.10.2015	17.11.2015
327	212	21.10.2015	NULL
535	212	28.10.2015	NULL

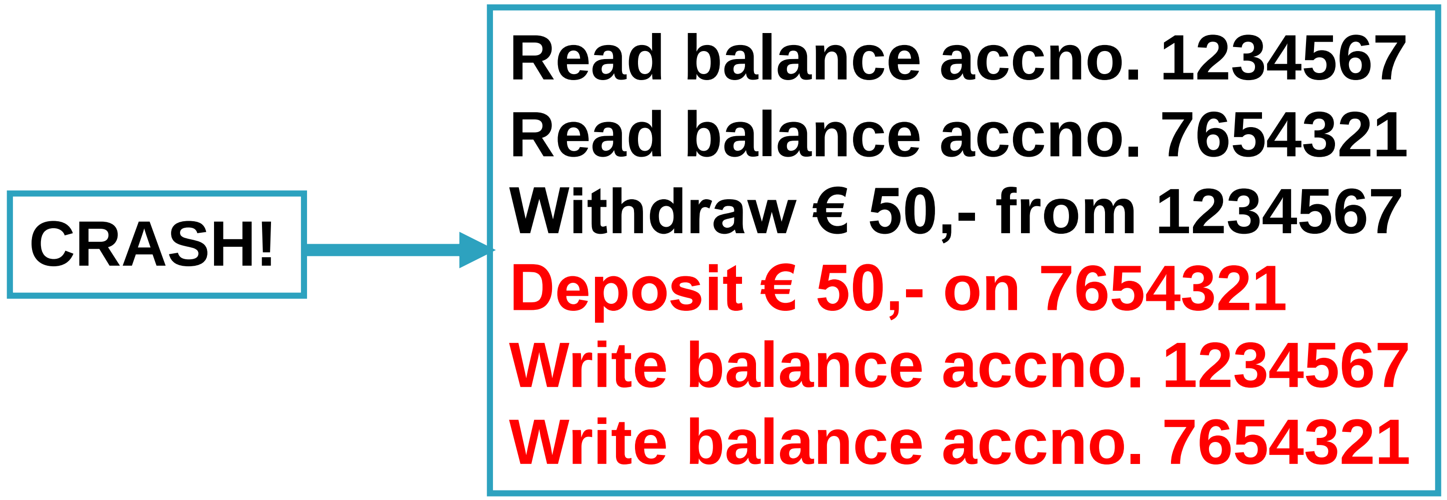
Transaction processing

- Transactions are important in case of crashes and simultaneous use of the database by multiple users
  - In case of a crash, no partial results of a transaction should be visible: *all or nothing*

Read balance accno. 1234567
Read balance accno. 7654321
Withdraw € 50,- from 1234567
Deposit € 50,- on 7654321
Write balance accno. 1234567
Write balance accno. 7654321

Transaction processing

- Transactions are important in case of crashes and simultaneous use of the database by multiple users
  - In case of a crash, no partial results of a transaction should be visible: *all or nothing*



CRASH!

Read balance accno. 1234567
Read balance accno. 7654321
Withdraw € 50,- from 1234567
Deposit € 50,- on 7654321
Write balance accno. 1234567
Write balance accno. 7654321

Transaction processing

```
1. Read balance accno. 1234567
          2. Read balance accno. 1234567
1. Withdraw € 500,- from balance
          2. Withdraw € 500,- from balance
1. Write balance accno. 1234567
          2. Write balance accno. 1234567
```

- Concurrency problem
- Solved by locking based techniques

Why relational databases?

- Software Engineering
  - High level data specification and manipulation
- Philosophy with regard to data oriented system development
  - Start with rigorous design of tables
    - Stable; detailed assessment is possible
  - Development of operations is secondary
    - Difficult to analyze, rapid prototyping, continuous adaptation
- Successful application of computer science
  - Set theory, predicate logic, optimization, design theory