

Databases 2024/2025

Introduction

The menu for today

- ▶ Organizational aspects
- ▶ Introduction to database technology
- ▶ The relational model

Organisatie

▶ Hoorcolleges

- Dinsdag 9:00 – 10:45
- Donderdag 13:15 – 15:00
- Wooclap quizzes: links verschijnen in Teams

▶ Werkcolleges (verplicht)

- Dinsdag: 11:00 – 12:45, start volgende week
- Donderdag 15:15 – 17:00
- Uitwerkingen verschijnen met een vertraging van één tot anderhalve week in Teams

Organisatie

- ▶ Practica (koppels)
 - Opgave 1: casusbeschrijving, modelleren, schema-ontwerp
 - Opgave 2: vulling van de database, SQL queries
 - Op zoek naar een partner? Channel *koffieautomaat* op Teams. Aanwijzingen voor registratie volgen nog.
- ▶ Huiswerkopdrachten (3x): verplicht
 - Typerend voor vragen eindtoets
 - Consequenties voor deelname herkansing

Introduction to database technology

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

What is a database?

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

Book

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

Reader

<i>Rno</i>	<i>Name</i>	<i>Address</i>
212	Schoof	Torentje 1, Den Haag
431	Karjakin	Plein 2, Wladiwostok
7	Bond	Downing Str. 7, London

Loan

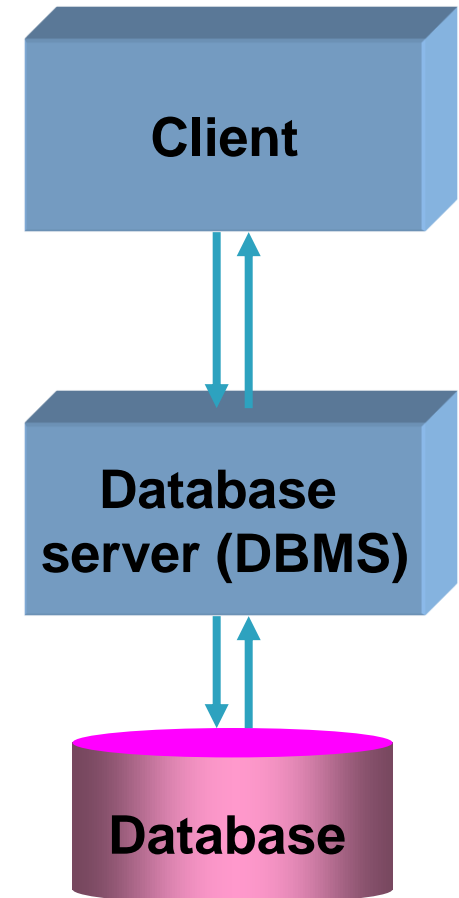
<i>Bno</i>	<i>Rno</i>	<i>Loan date</i>	<i>Return date</i>
113	431	14.10.2024	17.10.2024
327	212	21.10.2024	-
535	212	28.10.2024	-

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
 - Also called: front-end / back-end



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
 - Example: Amazon sells more than 400 items per second

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
 - Mathematical modeling
 - Application of predicate logic

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

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(Rncheck($x)) == 0)
  {
    message("card invalid");
    exit();
  };

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

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

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

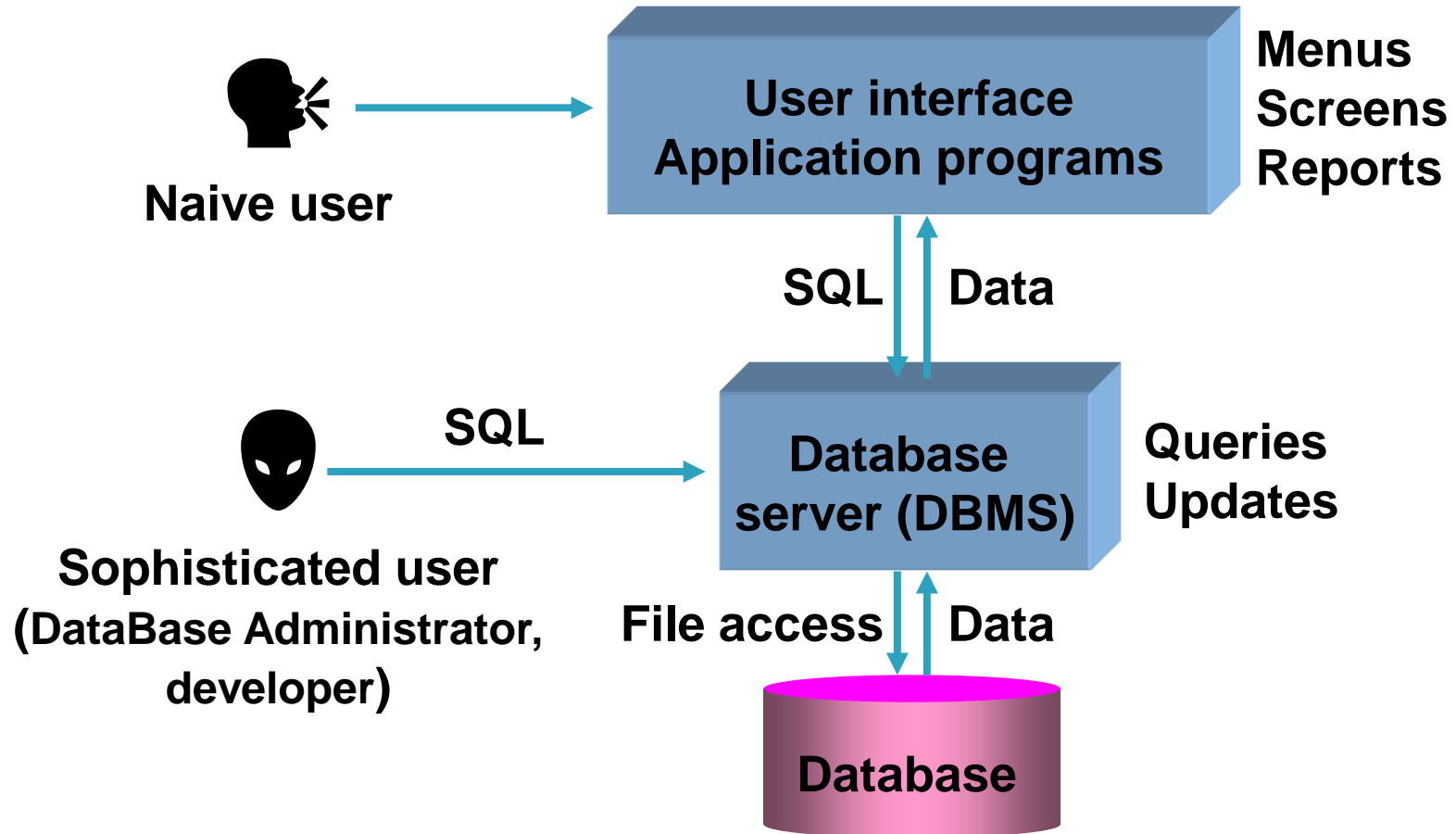
Integrity constraints

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

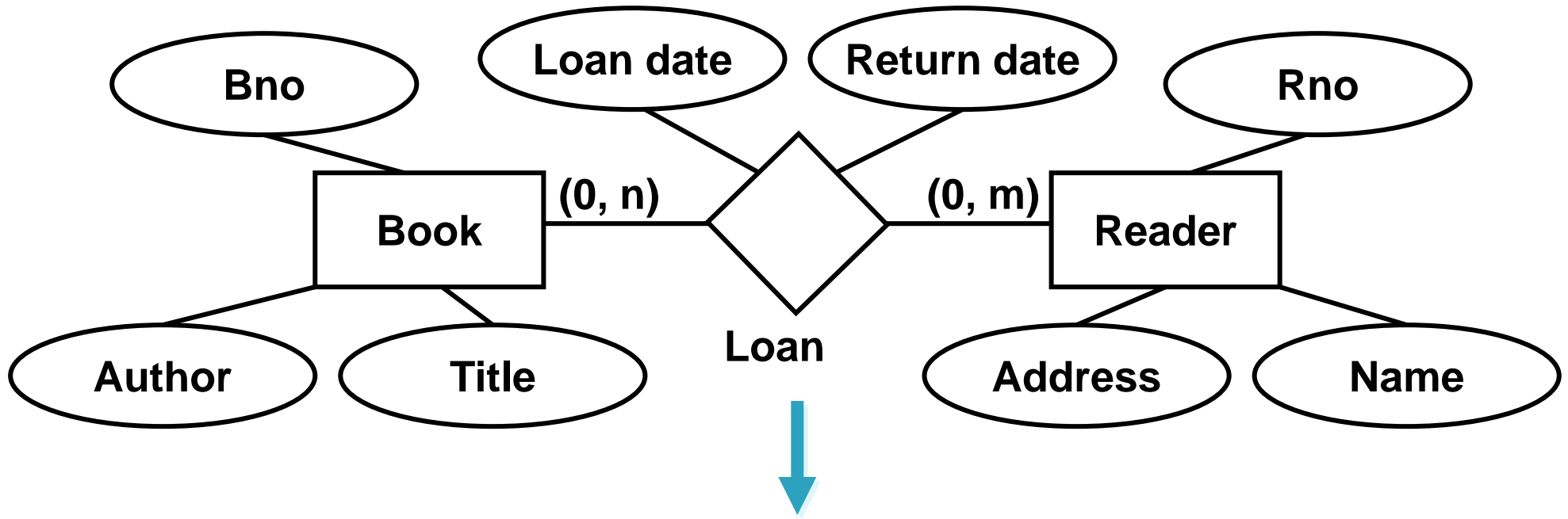
```
-- CONSTRAINT constr3
(SELECT Bno
 FROM Loan)
IS CONTAINED IN
(SELECT Bno
 FROM Book)
-- ON VIOLATION ...
```

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

Database applications



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 (avoiding NULLs)


<i>Rno</i>	<i>Name</i>	<i>Address</i>	<i>Bno</i>	<i>Author</i>	<i>Title</i>
212	Schoof	Torentje 1, Den Haag	327	Gates	The road ahead
212	Schoof	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

<i>Rno</i>	<i>Name</i>	<i>Address</i>	<i>Bno</i>	<i>Author</i>	<i>Title</i>
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



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



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



<i>Bno</i>	<i>Rno</i>	<i>Loan_date</i>	<i>Return_date</i>
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

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 - 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