Universität
Konstanz

Database System Architecture and Implementation

Module 0
Introduction and Overview
October 22, 2018
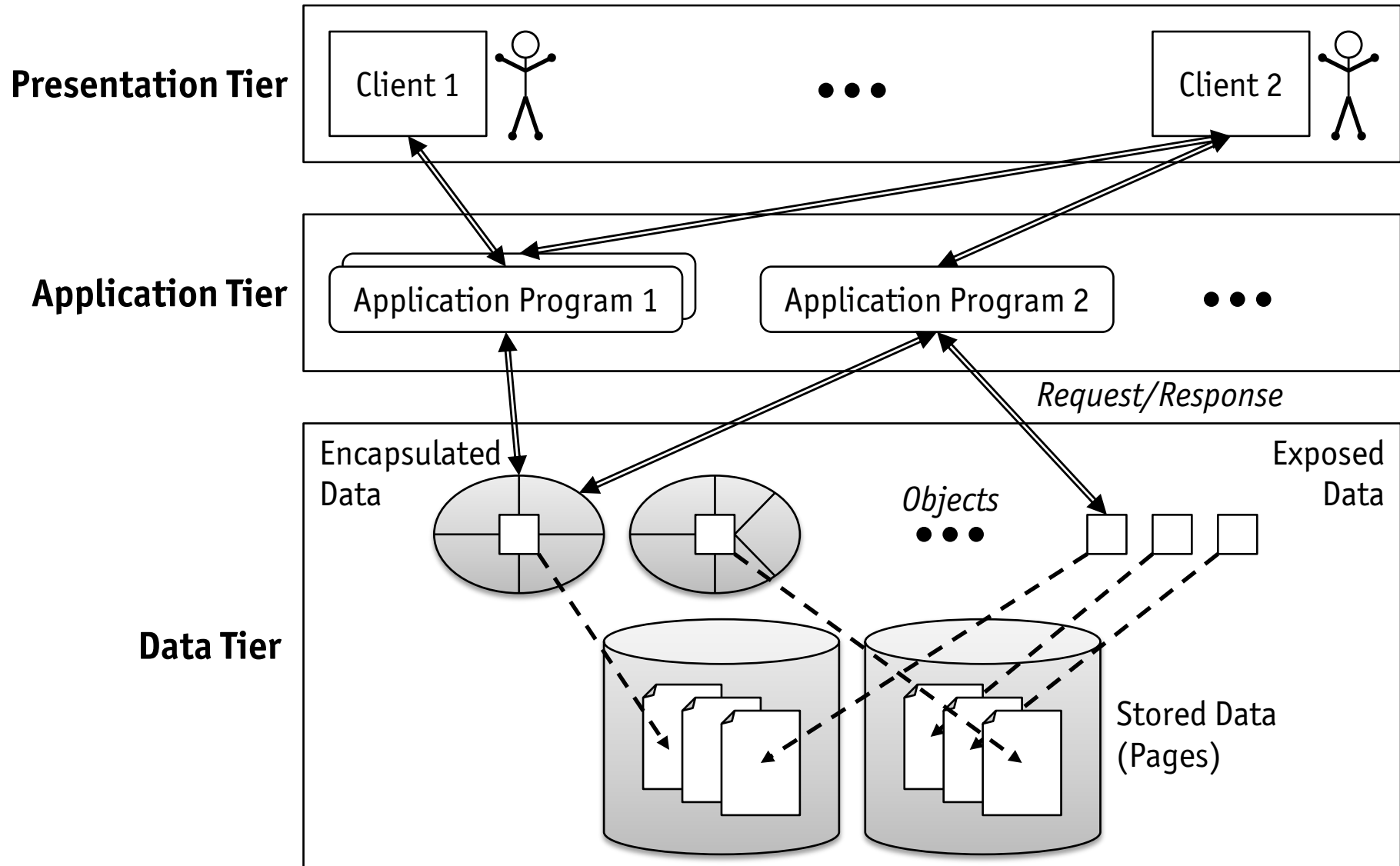
Module Overview

1. Course contents
   1. Goals of this course
   2. DBMS architecture overview
   3. Layers of DBMS architecture
2. Course organization
   1. Planned schedule
   2. Personnel
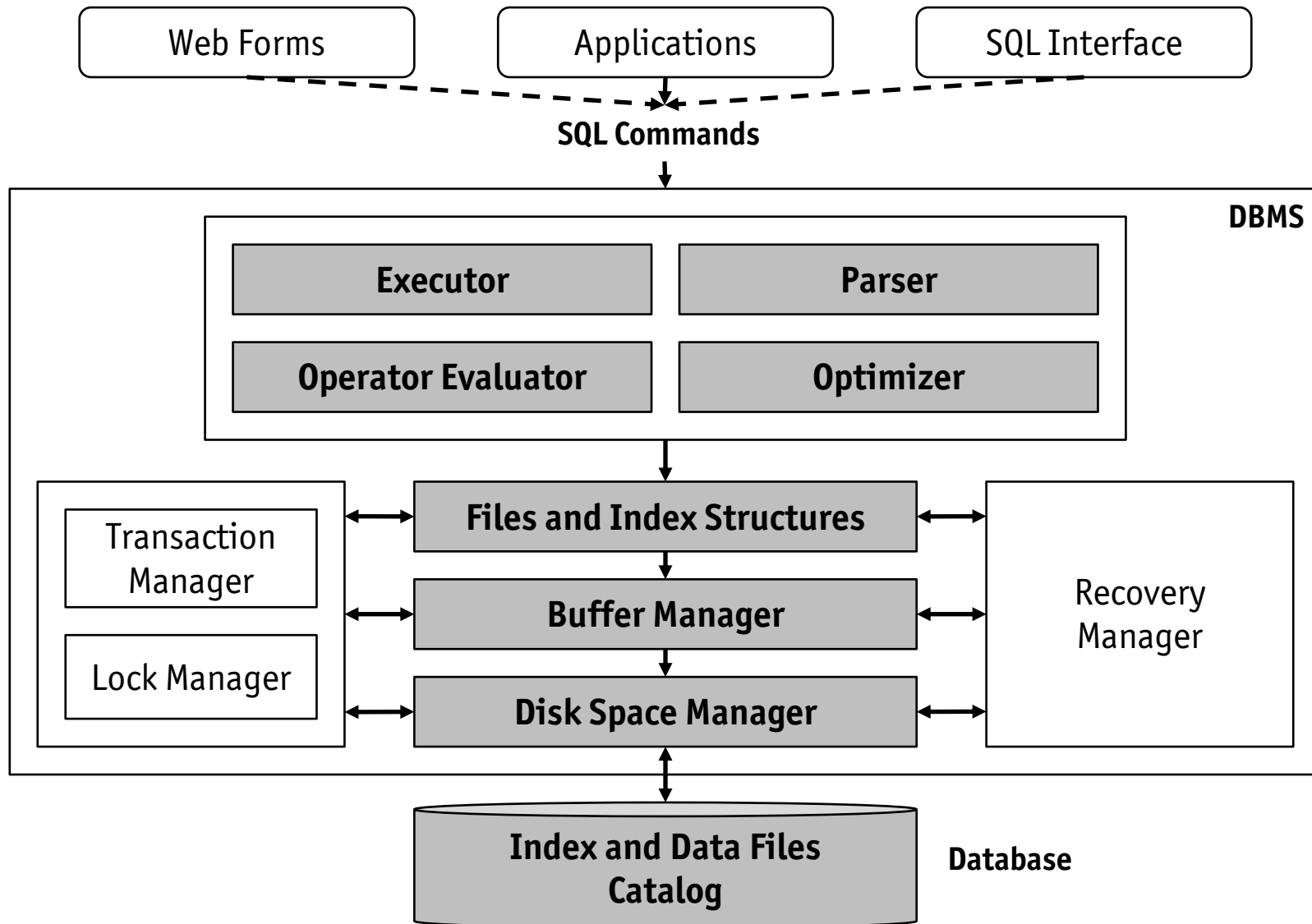   3. Course resources
   4. Exercises
   5. Exam

The Big Picture

Presentation Tier

Client 1 • • • Client 2

Application Tier

Application Program 1   Application Program 2 • • •

Request/Response

Data Tier

Encapsulated Data

Objects • • •

Exposed Data

Stored Data (Pages)

Course Contents and Goals

- Builds on introductory database course with focus on internals at system-level, rather than functionality at interface-level

- Learn how a DBMS can...
  - **organize and access files** on hard disks to minimize costly I/O traffic
  - **translate SQL statements** into efficient query execution plans
  - **sort/combine/filter data volumes** that exceed main memory size by far
  - be **tuned** for performance-critical applications
  - be evaluated by using **benchmarks**

DBMS Architecture

Web Forms	Applications	SQL Interface

SQL Commands

DBMS

Executor	Parser
Operator Evaluator	Optimizer

Transaction Manager		Files and Index Structures		Recovery Manager
Lock Manager		Buffer Manager		
		Disk Space Manager		

Index and Data Files Catalog

Database

Layered DBMS Architecture

- DBMS implements its functionality in a layered architecture
  - **incrementally** add more abstractions with each layer
  - from **low-level** block I/O devices to **high-level** declarative user interface
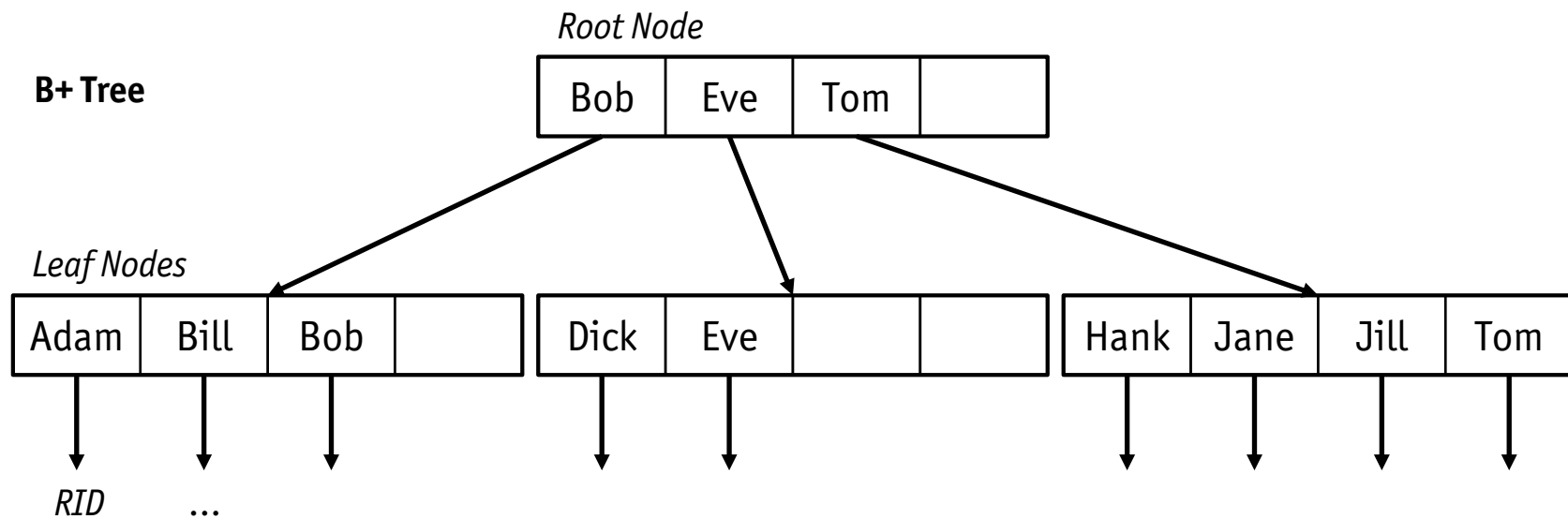

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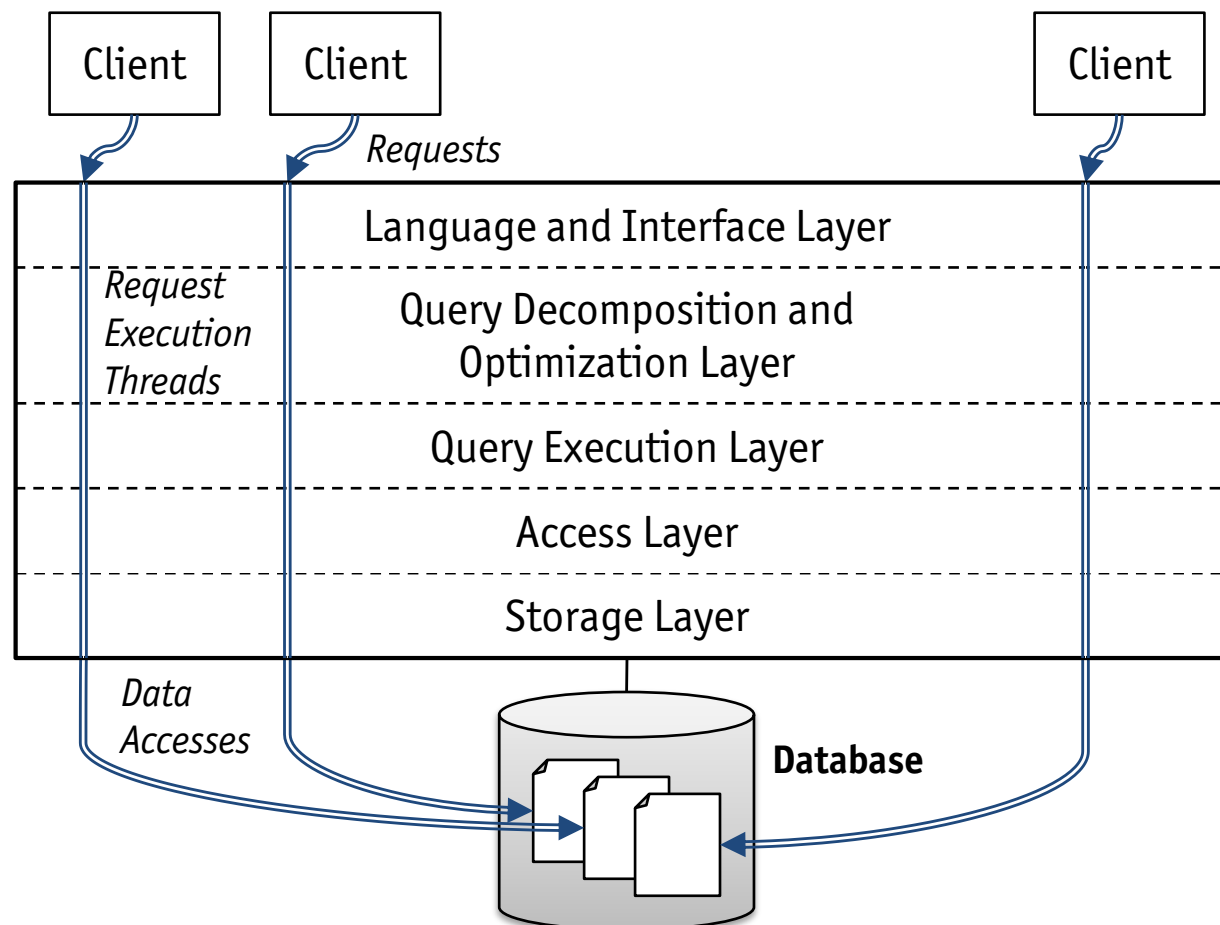
Storage Structures

- DBMS data structures are mapped to fixed-length blocks
  - basic I/O **unit of transfer** between main and secondary memory
  - true for **all** types of DBMS, i.e., relational, object-relational, etc.
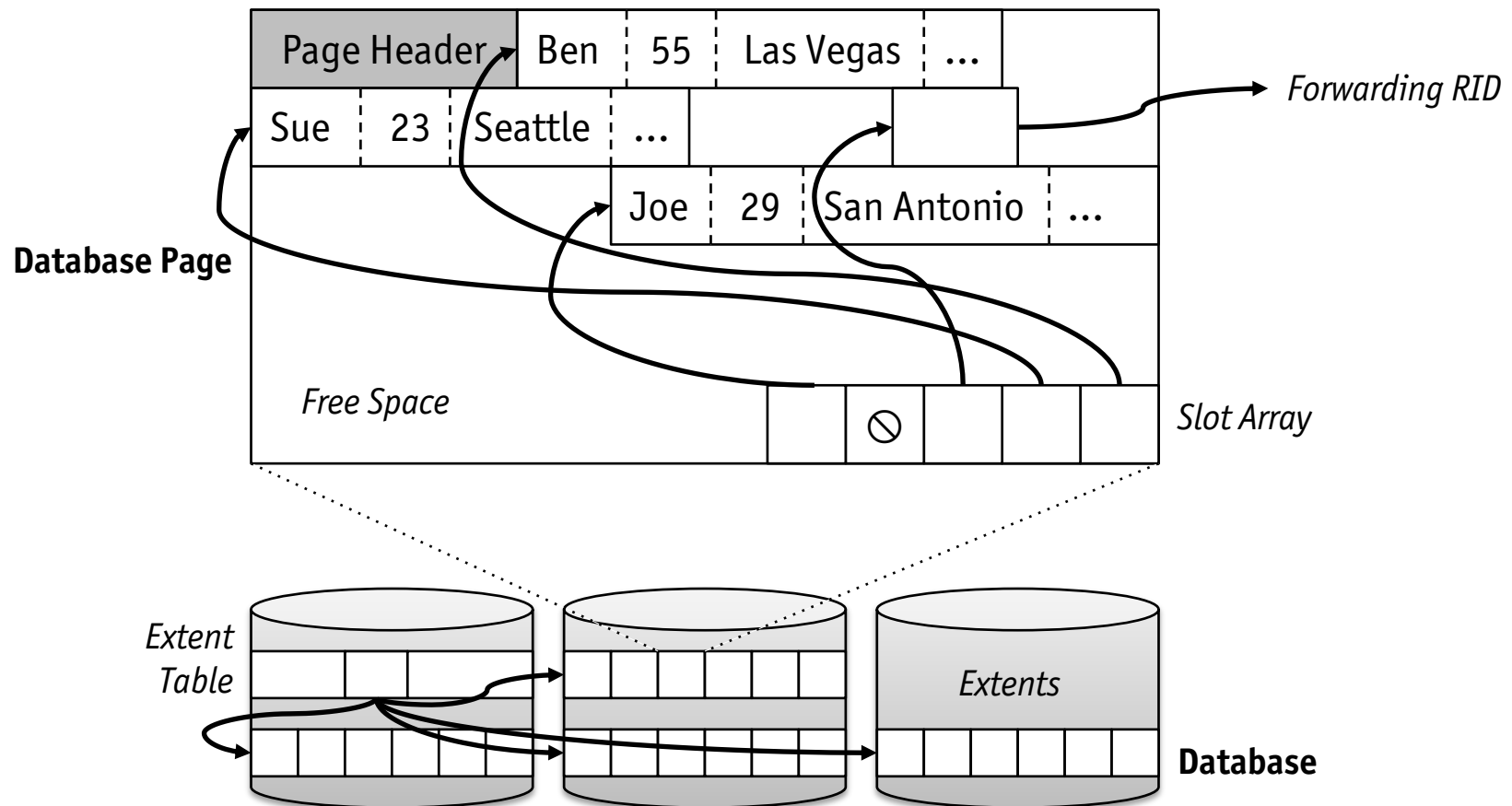
Access Paths

- DBMS indexing techniques enable fast content-based access
    - **tree-structured** and **hash-based** methods
    - **application-specific** methods

Root Node

B+ Tree

| Bob | Eve | Tom | |

Leaf Nodes

| Adam | Bill | Bob | |

| Dick | Eve | | |

| Hank | Jane | Jill | Tom |

RID   ...

Query Processing

- DBMS processes queries and returns results
  - **declarative query specification**, e.g., expressed in SQL, is optimized and transformed into efficient **query execution plan** (QEP)
  - QEP is a **sequential** or **parallel** program that computes the query results
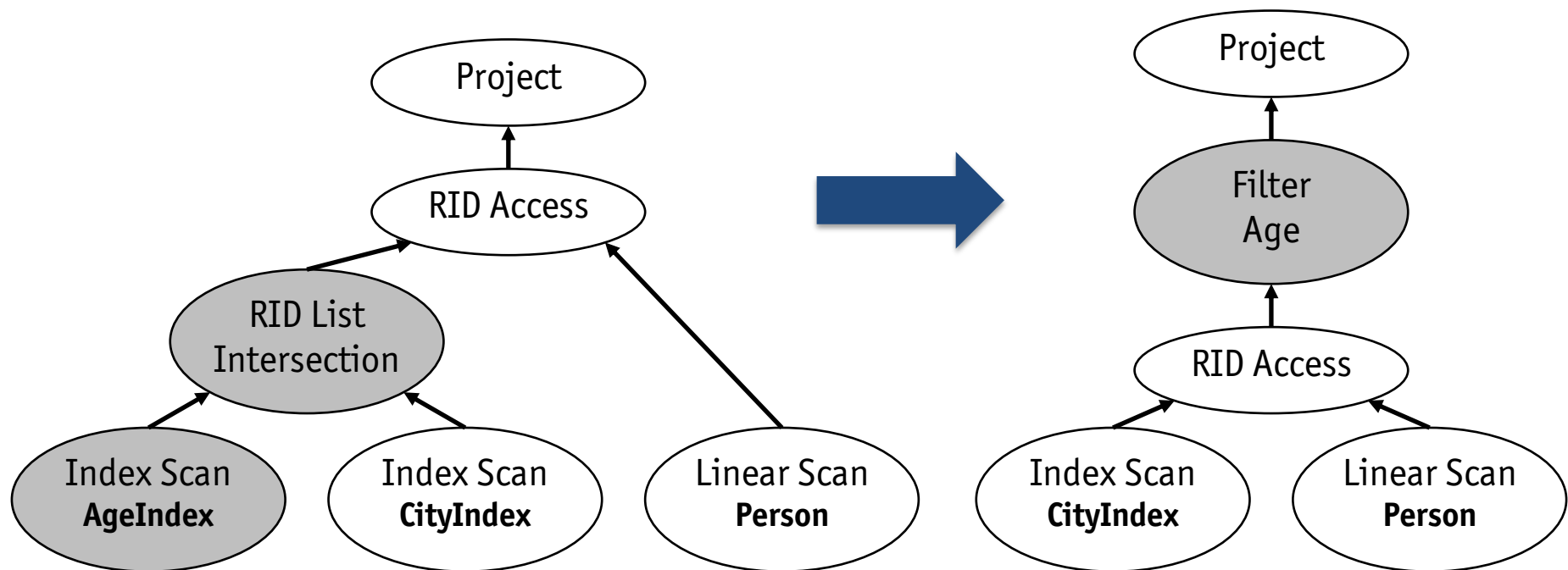
Planned Course Schedule

Week	Date	Topic	Exercise	Due
1	22.10.2018	**Introduction**	Disk Storage	30.10.2018
2	29.10.2018	**Disk and Buffer Management**	Disk Management	06.11.2018
3	05.11.2018	**File Management**	Buffer Management	20.11.2018
4	12.11.2018	**Tree-structured Indexing (I)**		
5	19.11.2018	**Tree-structured Indexing (II)**	B+ Trees	27.11.2018
6	26.11.2018	**Hash-based Indexing**	Disk-based Hash Indexes	11.12.2018
7	03.12.2018	**Query Evaluation and Optimization**		
8	10.12.2018	**External Sorting**	External Sorting	08.01.2019
9	17.12.2018	**Evaluating Relational Operators (I)**		
		Christmas Break		
10	07.01.2019	**Evaluating Relational Operators (II)**	Relational Operators	22.01.2019
11	14.01.2019	**Relational Algebra Equivalences**		
12	21.01.2019	**Histograms**	Cost and Estimation	29.01.2019
13	28.01.2019	**Nested Queries**	Query Optimization	12.02.2019
14	04.02.2019	**Optimizer Architectures**		
15	11.02.2019	**Physical Database Design and Tuning**	Flashback	

Personnel

- Prof. Dr. Michael Grossniklaus
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  - E-mail   michael.grossniklaus@uni-konstanz.de

- Leonard Wörteler
  - Office   PZ 813
  - E-mail   leonard.woerteler@uni-konstanz.de

Curriculum Vitae

- **1996-2008**: ETH Zurich
  - Dipl. Inf.-Ing. (MSc) in Computer Science
  - Dr. sc. techn. (PhD) in Moira Norrie's group
- **2008-2010**: Politecnico di Milano
  - Post-doc in Stefano Ceri's group
- **2010-2012**: Portland State University
  - Post-doc in David Maier's group
- **2012-2013**: Vienna University of Technology
  - Post-doc in Gerti Kappel's group
- **since 2013**: University of Konstanz
 - Professor for *Databases and Information Systems*

Course Resources

- Registration
  - **ZEuS** for course-related e-mail
  - **Ilias/ecoach** for participation in the exercises
  - **StudIS** for admittance to the exam

- Literature
  - lectures slides can be downloaded from the course website
  - textbook (see next slide)
  - further readings will be published on the course website

Textbook

- *Raghu Ramakrishnan* and *Johannes Gehrke*
  Database Management Systems (3rd Edition)
  McGraw-Hill, 2002
  - course will focus on chapters 8 to 15 and 20
- Ten copies of the **2nd edition** of the book
  are available at the university library
  - not much difference for the scope of this course
  - course will focus on chapters 7 to 14 and 16
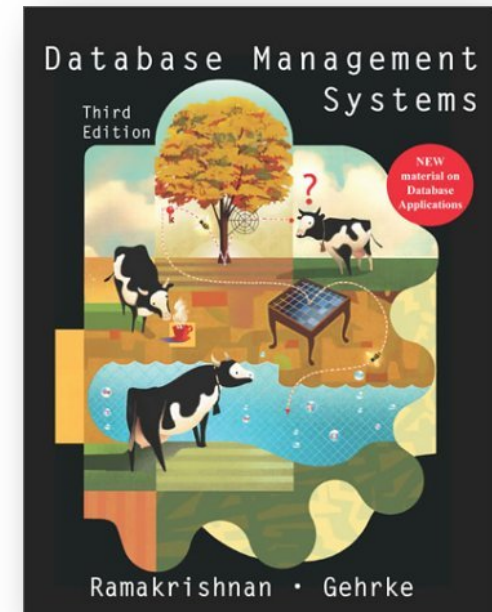
Prerequisites

- The following skills are **mandatory** prerequisites to attend and successfully complete this course

- **Foundations of database systems** (INF-12040 or equivalent)
  - E/R model and conceptual design, relational model, relational algebra and calculus, query languages, database application programming, etc.

- **Computer systems** (INF-11740, INF-11880, or equivalent)
  - computer architecture, operating systems, compilers, networks, etc.

- **System programming** (INF-11930 or equivalent)
  - some of the exercises are based on a (somewhat) complex Java project
  - students **must** have the ability to program in Java (read, understand, design, and write **high-quality** Java code)

- **Key competences** (INF-10175 or equivalent)
  - Subversion, LaTeX, etc.

Rooms and Dates

- Lecture
    - Monday   3:15 pm – 4:45 pm   Room P 602
    - Tuesday   3:15 pm – 4:45 pm   Room P 1138
- Exercise
    - Wednesday   5:00 pm – 5:45 pm   Room P 1138

Exercises

- Assignments will be made available on Ilias

  – solved in pairs of two students

- Five two-week programming projects

  – based on Minibase for Java

  – opportunity to implement core components of a DBMS yourself

- Grading

  – one-week assignments give 20 points

  – two-week assignments give 40 points

  – 50% of total course grade (if exam is passed)

Assignments and Exam Grading

- Same grading scale used for assignments and exam
- Exam will consist of four exercises with 25 points each
  1. disk and file storage
  2. hash and tree-based indexes
  3. query evaluation
  4. query optimization
- Overflow bonus points to exam points conversion

$$P_{exam} = \left\lceil \frac{1}{2} \cdot \frac{100}{280} \cdot P_{bonus} \right\rceil$$

| Percentage of Points	German Grade	Letter Grade
100-91	1.0	A
90-86	1.3	A-
85-81	1.7	B+
80-76	2.0	B
75-71	2.3	B-
70-66	2.7	C+
65-61	3.0	C
60-56	3.3	C-
55-51	3.7	D+
50-45	4.0	D
44-0	5.0	F

Exam

- Written exam
  - two-hour exam
  - closed-book exam, but one hand-written double-sided piece of A4 paper with notes is permitted

- Content
  - lecture and lecture slides
  - (written) exercises
  - relevant chapters from textbook

- Scheduling
  - first date   February 26, 2019   (C 353)
  - second date   April 9, 2019   (C 353)

- Grading
 - 50% of total course grade (if exercises are passed)

Minibase!

- Complete single-user database management system
  - originally developed in C/C++ by Ramakrishnan/Gehrke at Wisconsin
  - ported to Java at Purdue and Portland State
  - extended and improved at Konstanz
- **New features**
  - new data types
  - different buffer replacement policies
  - additional indexes and operators
  - more compliance to SQL standard
  - cascades-style query optimizer
  - simple user interface
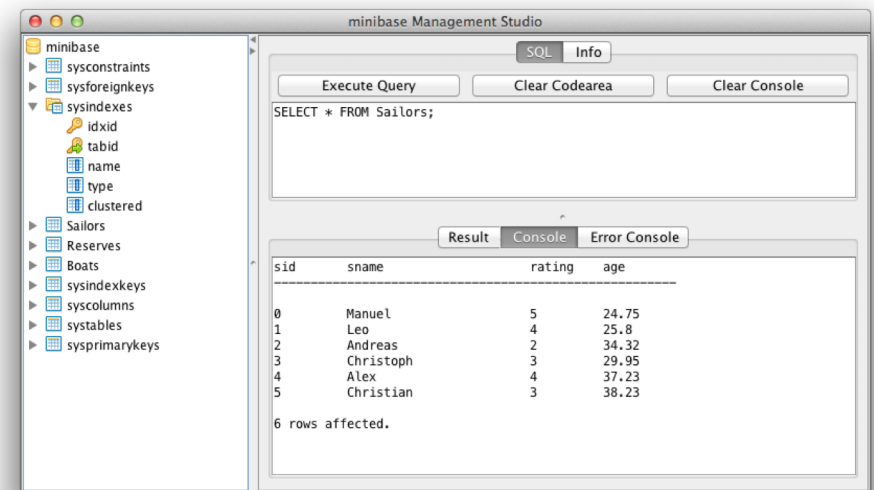
- https://github.com/DBIS-UniKN/minibase (private, obviously)
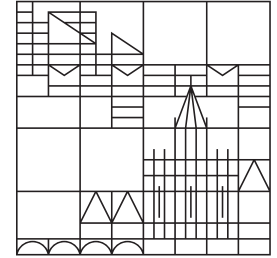
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TO BE CONTINUED...