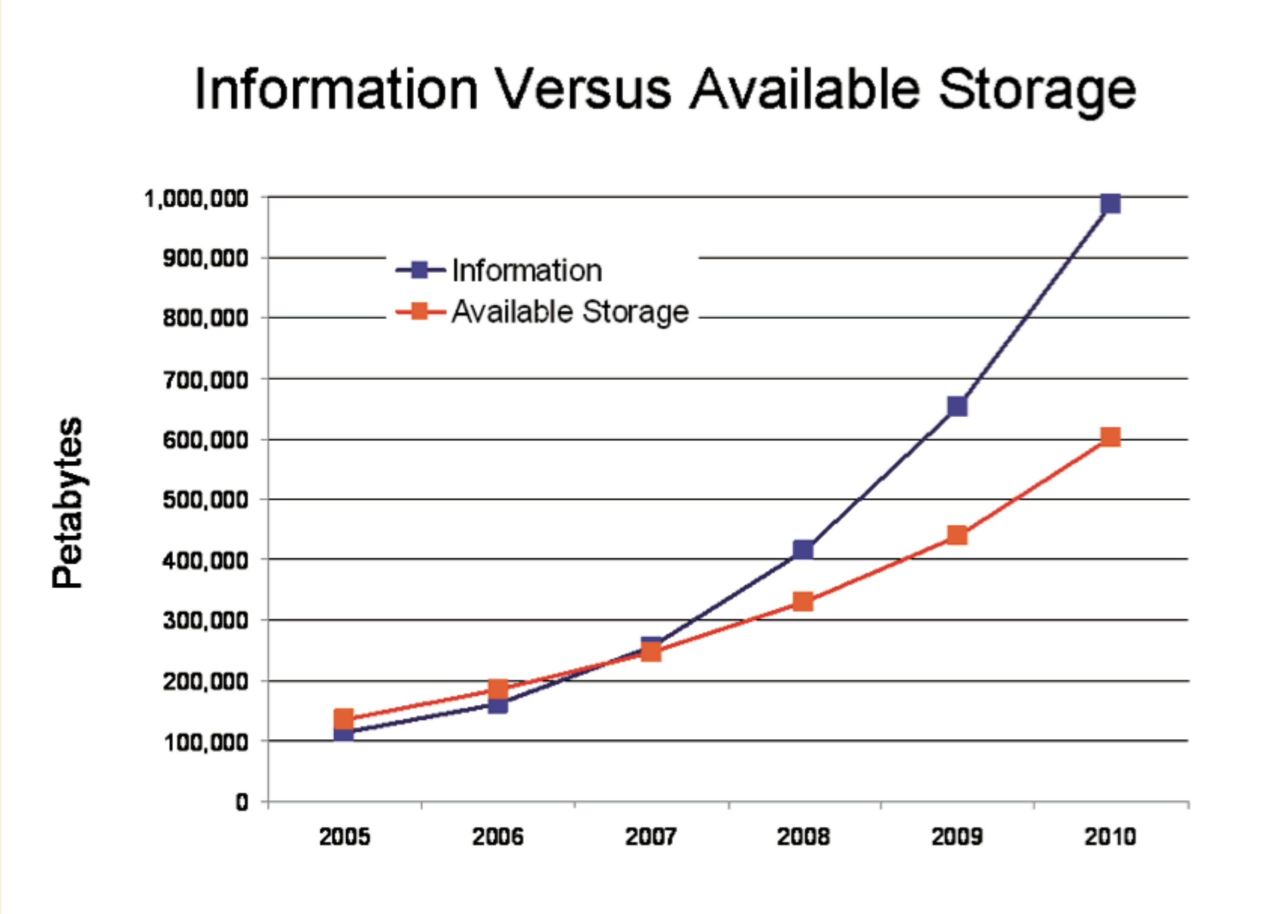
Supplementary slides for introduction

Rasmus Pagh

Information explosion

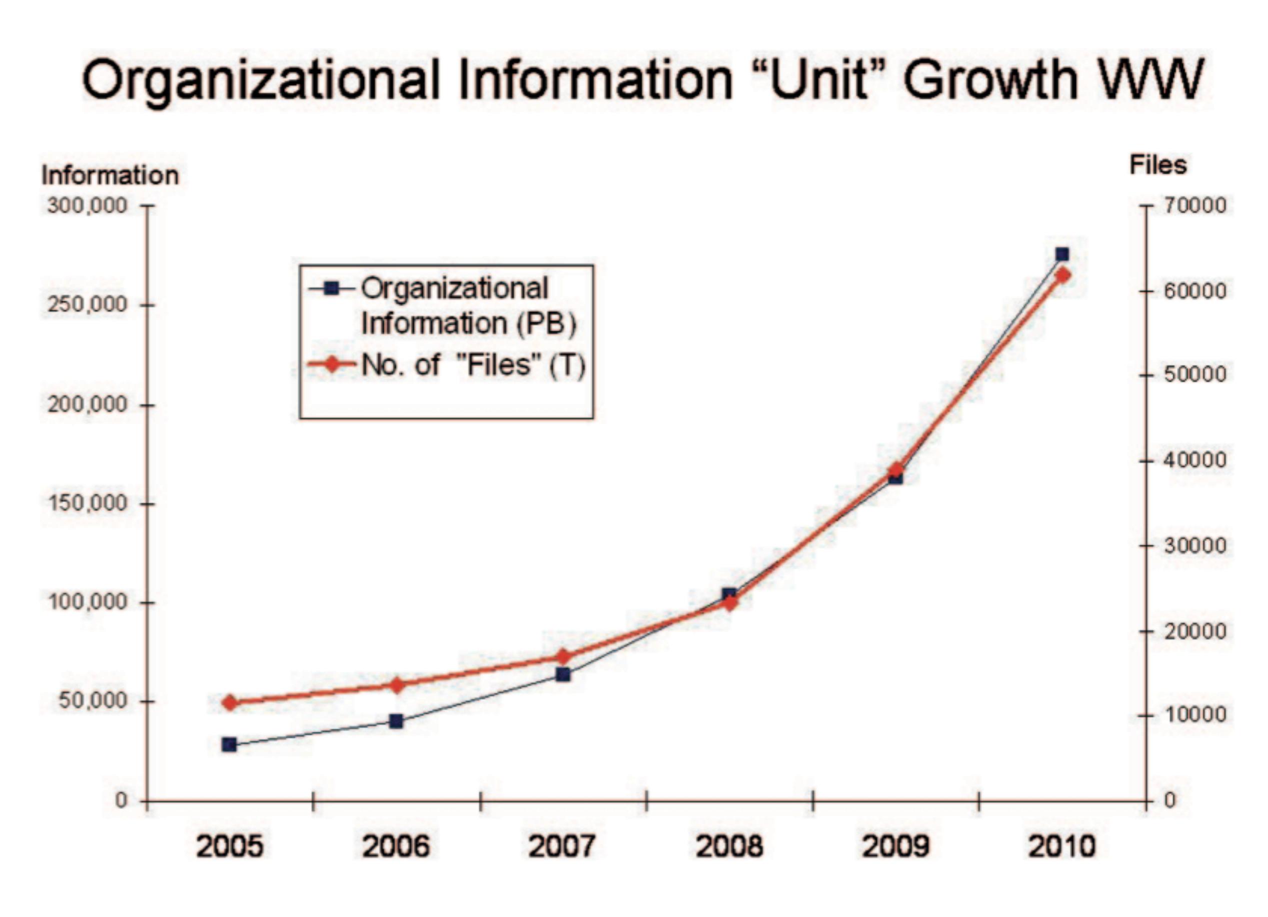
Figure 2



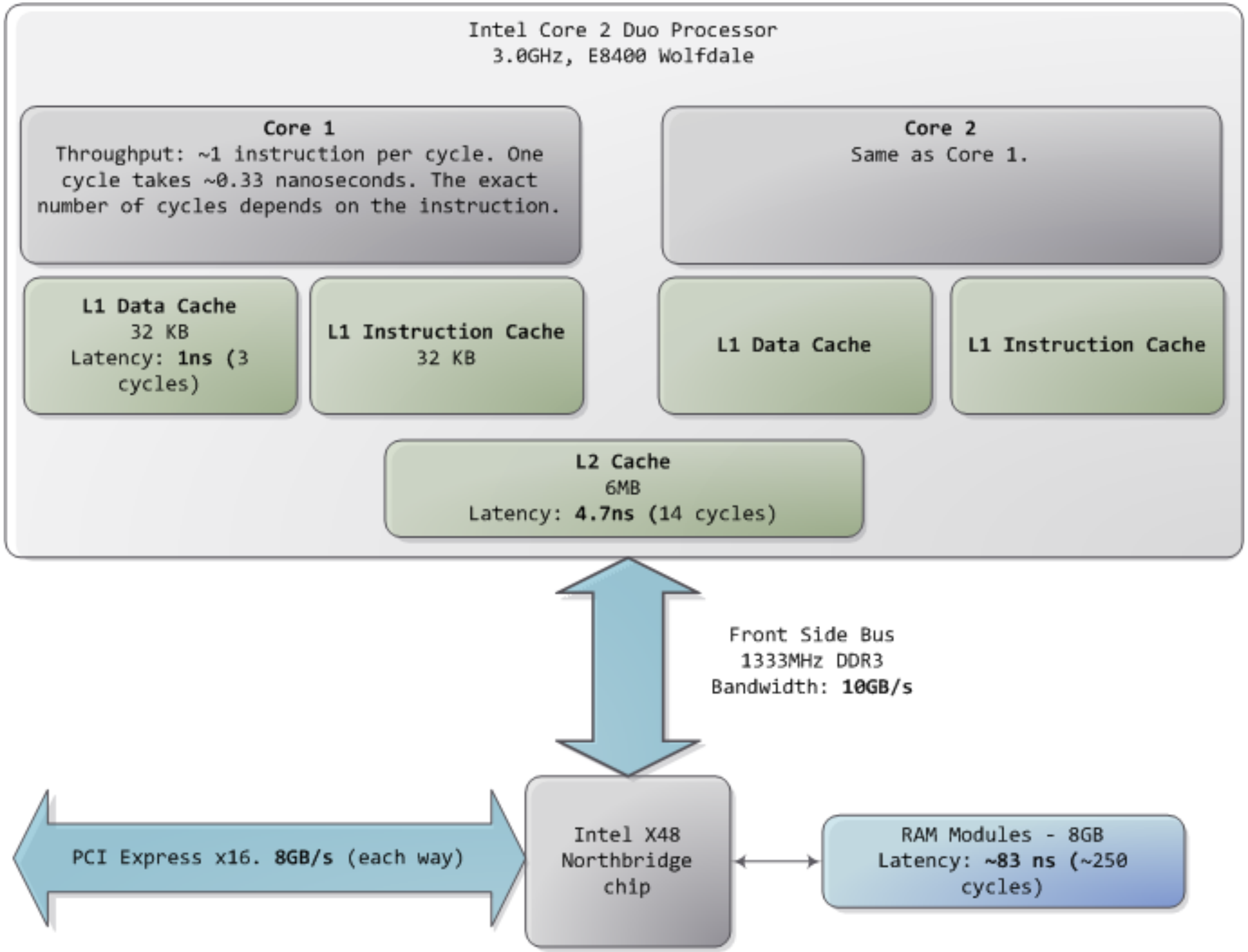
Source: IDC, 2007

Information explosion, cont.

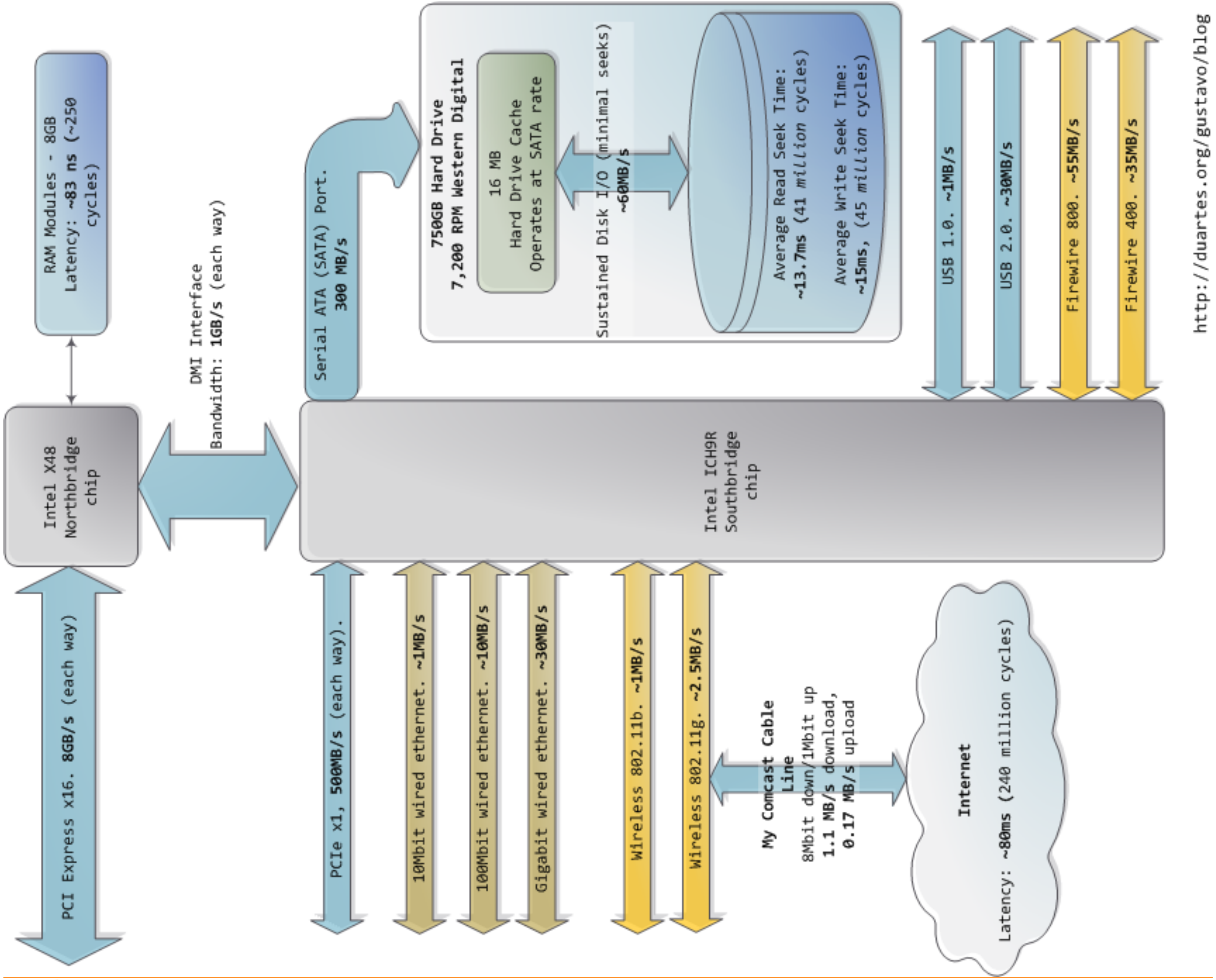
Figure 3



Source: IDC, 2007



http://duartes.org/gustavo/blog


RAM Modules - 8GB
Latency: ~83 ns (~250 cycles)
Intel X48 Northbridge chip
DMI Interface
Bandwidth: 1GB/s (each way)
Serial ATA (SATA) Port.
300 MB/s
750GB Hard Drive
7,200 RPM Western Digital
16 MB
Hard Drive Cache
Operates at SATA rate
Sustained Disk I/O (minimal seeks)
~60MB/s
Average Read Seek Time:
~13.7ms (41 million cycles)
Average Write Seek Time:
~15ms, (45 million cycles)
USB 1.0. ~1MB/s
USB 2.0. ~30MB/s
Firewire 800. ~55MB/s
Firewire 400. ~35MB/s
http://duartes.org/gustavo/blog
Intel ICH9R Southbridge chip
PCI Express x16. 8GB/s (each way)
PCIe x1, 500MB/s (each way).
10Mbit wired ethernet. ~1MB/s
100Mbit wired ethernet. ~10MB/s
Gigabit wired ethernet. ~30MB/s
Wireless 802.11b. ~1MB/s
Wireless 802.11g. ~2.5MB/s
My Comcast Cable Line
8Mbit down/1Mbit up
1.1 MB/s download,
0.17 MB/s upload
Internet
Latency: ~80ms (240 million cycles)

Sequential vs random access

- My laptop can, in 1 second:
  - Perform up to 20 billion CPU instructions
  - Read 0.8 billion 4-byte words, sequentially
  - Read 0.034 billion words, random access

```
Rasmus-Paghs-computer-2:~/papers/sse/src pagh$ ./linear Generating 8388608 pointer-value pairs
100 linear probing sequences begin
End: 838860700
1.000000 seconds

100 double hashing sequences begin
End: 1677721400
24.320000 seconds
```

Lecture overview

Rasmus Pagh

The lectures at a glance

- Data storage, tree indexes.
- Hash indexes, index tuning
- Impl. of relational operations, external sorting
- Query optimization, query tuning
- Concurrency control

- Decision support, OLAP
- Data mining
- Temporal databases
- Text indexing
- Spatial databases
- ITU research in databases

Exciting invited lectures are mixed in!

Tree indexes

- **B-trees**, a generalization of binary search trees, is the most important index type in DBMSs.
- You will get an understanding of what functionality B-trees offer, and how they are updated when the data changes.
- **Buffered B-trees**, a new B-tree variant that has exceptionally good update performance, is presented.

Hash indexes, index tuning

- External memory hash tables generalize hash tables as you know them.
- Faster than B-trees in some situations.
- Need to understand to choose!

- We will discuss general issues about how to choose the right indexes, and good physical organization of data in general (sparse vs dense, partitioning).

Relational algebra operations

- The building blocks in DBMS query evaluation are algorithms that implement relational algebra operations.
- May be based on:
  - sorting (quicksort is bad!),
  - hashing, or
  - using existing indexes
- The DBMS knows the characteristics of each approach, and attempts to use the best one in a given setting.

Query optimization, query tuning

- Query optimization is the process where the DBMS tries to find the ”best possible” way of evaluating a given query.
- Standard approach builds on finding a ”good” relational algebra expression and then choosing how and in what order the operations are to be executed.
- Query tuning is a ”manual” effort to make query execution faster.

Concurrency control

- For databases with many users, the concurrency control mechanisms of a DBMS can cause performance problems.
- DBMSs are distinguished by their design of concurrency control system
  - Pessimistic (locking based) vs optimistic
  - Granularity
- To handle concurrency control problems, an understanding of the system in use is often required.

Second part

- First part is ”classical DBMS” topics.
- Rest of course:
  - Extensions of capability in various settings...
  - Main tool: Efficient indexing

Decision support (OLAP)

- OLAP systems are specialized databases for decision support applications.
- Idea: Read-only (or write-rarely), optimized for fast answers to queries.
- Special indexing techniques for read-only data are used (bitmap indexing).
- Precomputation of aggregates important for performance.

Data mining

- Normal database operations follow a query-answer pattern:
  - To analyze data you may perform a sequence of queries.
- *Data mining* is another paradigm:
  - *"Let the software find the interesting properties of the data"*
- We will look at *corellation mining*, and see how it can be implemented in a scalable way.

Temporal databases

- It is increasingly feasible to never delete data (i.e., keep old versions)
- $\Rightarrow$ Demand for capability to query old data.
- Need indexing capability also for old data!
- You will see surprisingly efficient ways of doing this.

Spatial databases

- Many large databases contain geographical data.
- In general, many data sets can be viewed as points in a multi-dimensional space. **Example**: (salary, age) pairs.
- Need for efficient indexes that allow the DBMS to find part of the space. **Example**: ”Find all tuples with age below 30 and salary above 500,000”.

Text indexing

- Many database applications contain lots of text
- But in the relational model it is complicated to represent and query the structure of text.
- In practice, a text datatype that may contain long strings that have to be handled in queries.
- We look at two topics:
  - B-trees optimized for strings
  - Full-text indexing

ITU research in databases

- An overview of some results by ITU researchers on (or related to) performance aspects of databases.
- Mainly theoretical work - chance to be the first in the world to implement and test!
- Especially meant to serve as inspiration for formulating possible thesis projects.

Invited lectures

- Philippe Bonnet, DIKU (author of ”Database Tuning”). Topic: TBA.
- Someone from LECTOR: Data partitioning in Oracle.
- Rasmus Resen Amossen, ITU (to be confirmed): The H-store database system.
- Jesper Larsson, Apptus Technologies (to be confirmed): Relational text indexing.
- …
- As part of the project, each group will have to write a summary of one of the invited lectures.

The project

- Database development project (in groups of 4).
- Use of the database will be simulated by a java program supplied to you.
- Your task:
  - Make a good database design.
  - Implement various query and update ops.
  - Tune for performance.
  - Have fun!
- More information next week. Project kick-off on Tuesday February 10.