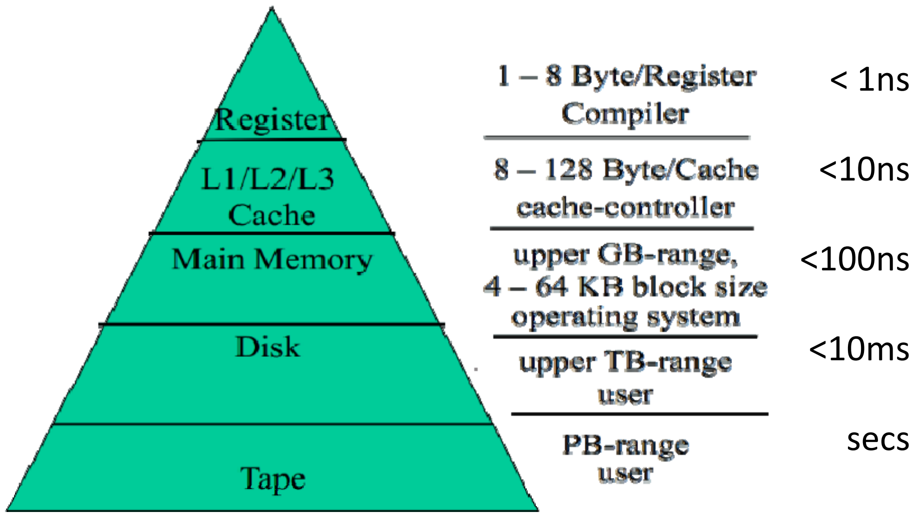
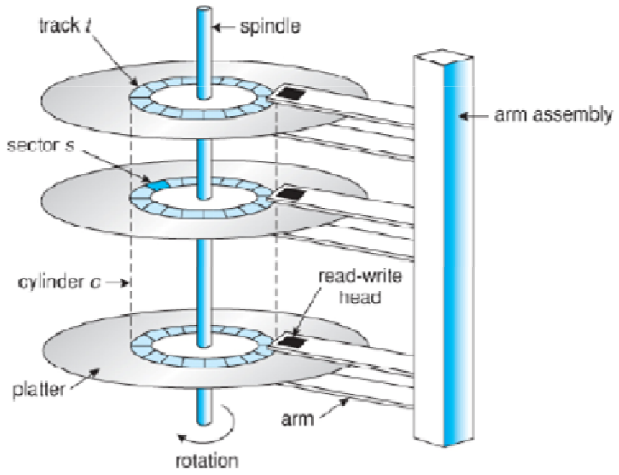
Indexes

Storage Hierarchy, ISAM, B-Trees and Hashing

Storage Hierarchy

- Storage hierarchy is important for run-time
    - keep as much as possible in main memory
- Read data from disk:
    - Store things you do not need outside on disk
    - **Seek time:** time until track is found
    - **Latency:** Rotation until head starts to write sector
    - **Transfer time:** time to transfer full sector





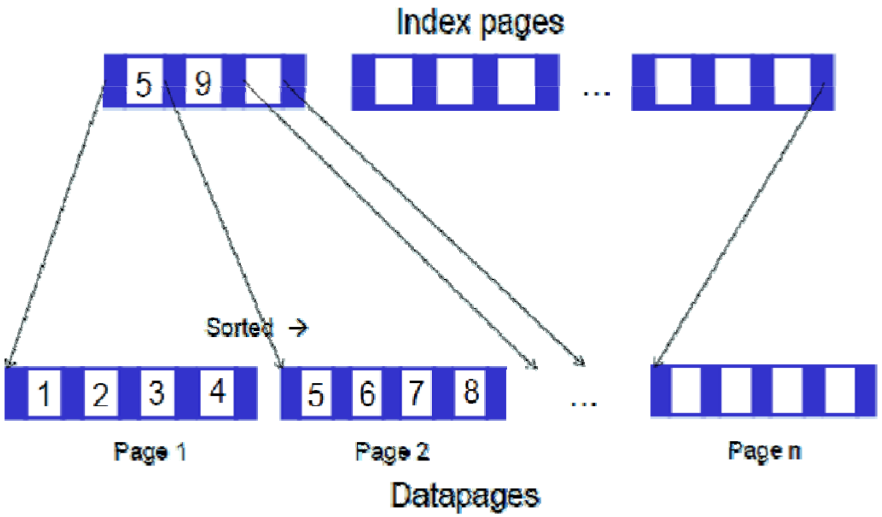
Sector:
Unit to read or write, 1-8 KB

Track:
Formed of sectors of equal size

Hierarchical Indexes: ISAM and B-Trees

- Data transfer can be very time-expensive → keep it as little as possible
- Use index structures: only needed parts are transferred
- **ISAM**: Index Sequential Access Method
  - Predecessor of B-Trees
  - Main Idea: sort tuples on indexes attribute
  - Similar to thumb index in a book
  - Problem: Maintenance of index is expensive

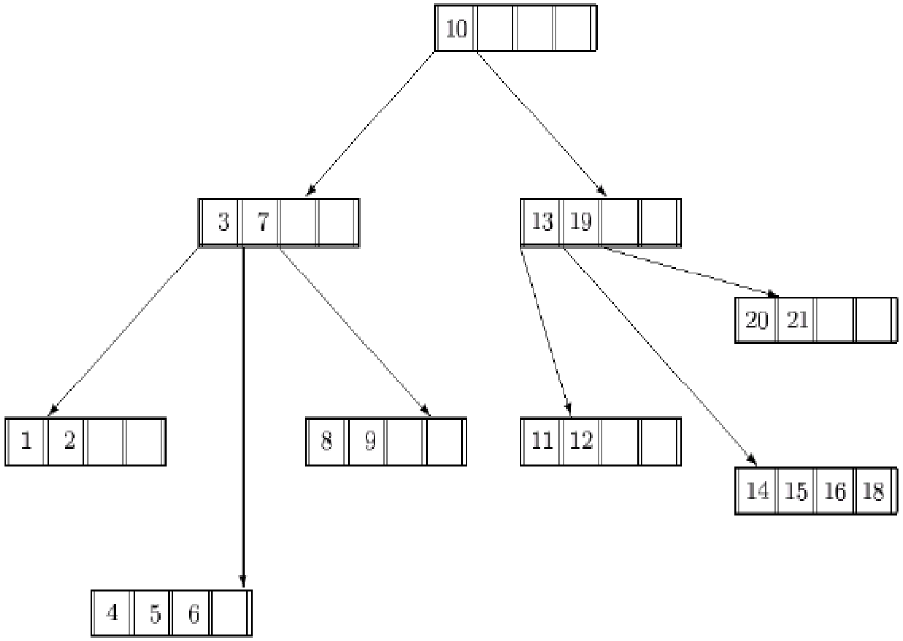
  → Index pages for index pages (B-Trees)



B-Tree

Properties

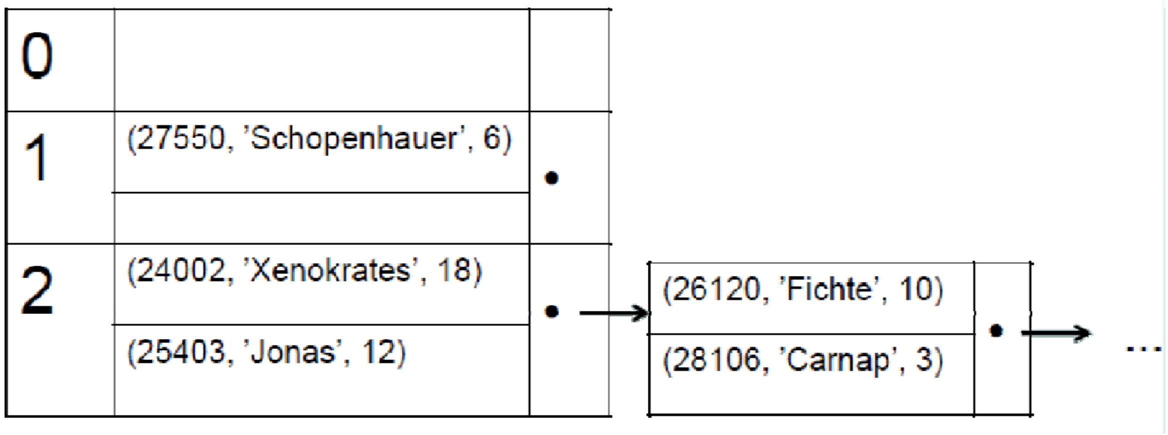
- Balanced and sorted
- Degree i: between i and 2i entries (exception: root)
- Every node with n entries has n+1 children (exception: leaves)



Improvement: B+-Tree: reference keys in inner nodes, data in leaf nodes
→ better run-time

Hashing

- Storing tuples in a defined memory area
- Hash function: mapping tuples to a fixed set of function values
- Optimal hash function: injective and surjective
- Typical hash function h: h (x) = x mod N → set of function values thereby {0,..., N-1}



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1 (27550, 'Schopenhauer', 6)

2 (24002, 'Xenokrates', 18) (25403, 'Jonas', 12) → (26120, 'Fichte', 10) (28106, 'Carnap', 3) → ...

Hashing – advantages and disadvantages

Advantages	Disadvantages
• Few accesses to external storage	• Collision handling necessary
• Simple implementation	• Pre-allocation of memory area
	• Not dynamic,
	• no range queries

Exam Exercises

- Insert following numbers into an empty B-Tree (degree 2)

  7, 21, 5, 3, 17, 90, 4, 34, 24, 32, 13

- What does degree 2 mean for this tree?

Exam Exercises – Solution (1)

Exercise:
Insert 7, 21, 5, 3, 17, 90, 4, 34, 24, 32, 13

1) Insert 7, 21, 5 and 3 in order:

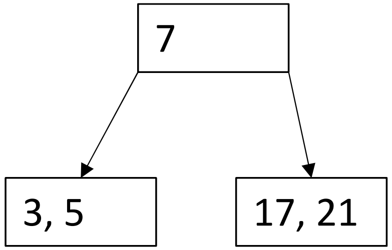
7

7, 21

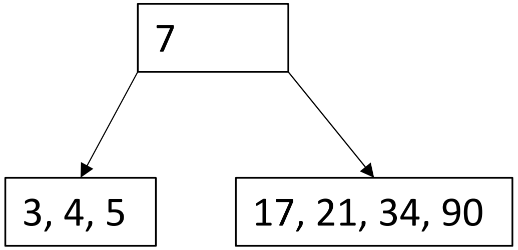
5, 7, 21

3, 5, 7, 21

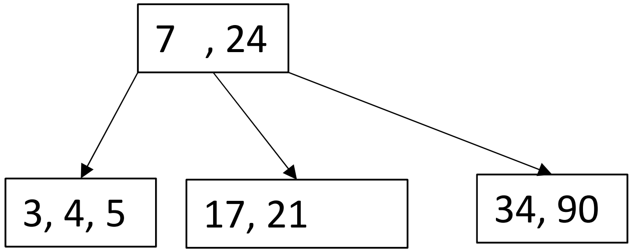
2) Insert 17: take median as root



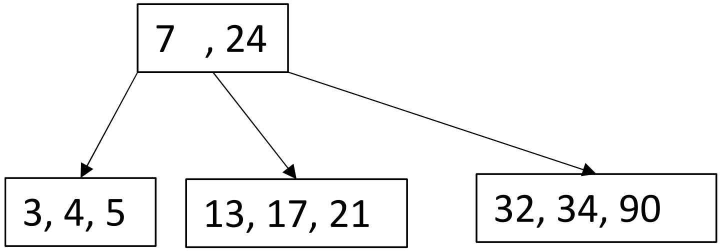
3) Insert 90, 4 and 34



4) Insert 24: take the median to root



5) Insert 32 and 13



Exam Exercises – Solution (2)

Exercise: What does degree 2 mean for this tree?

- B-Tree has at least 2 and at most 2x2 = 4 entries for every node (except the root)