These lecture notes include some material from Professors Bertossi, Ullman, Widom, Ramakrishnan, Gehrke

Multilevel Indexes Using B-Trees

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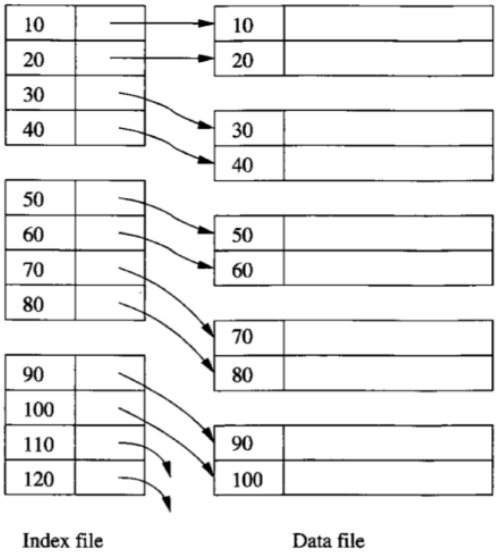
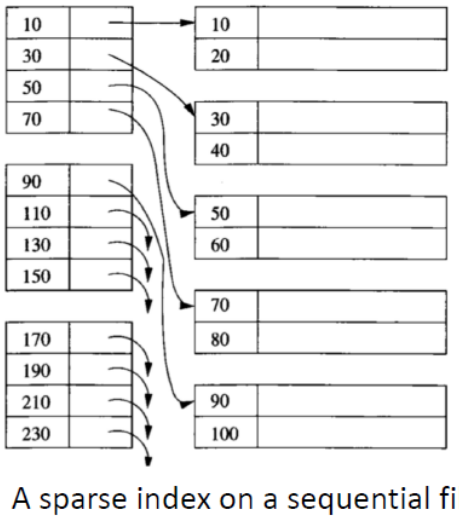
Dense vs. Sparse indices



A dense index has one lookup for each value of the search key



A sparse index on a sequential file

A sparse index has one lookup for each data block

Dynamic Multilevel Indexes Using B-Trees

The nodes are blocks, all leaf nodes are at the same level, each node has n search keys and n + 1 pointers

- Inner node: all pointers are to sub-nodes
- Leaf node: n data-pointers and 1 next-pointer, similar to the Index file
- All nodes must contain a certain amount of search keys / pointers

B-Trees example

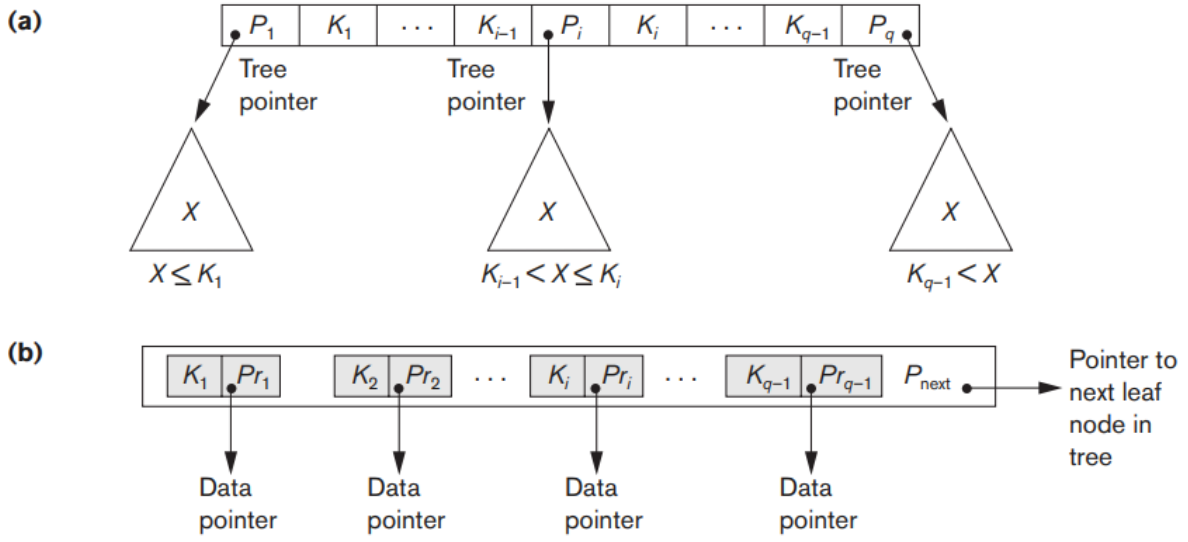
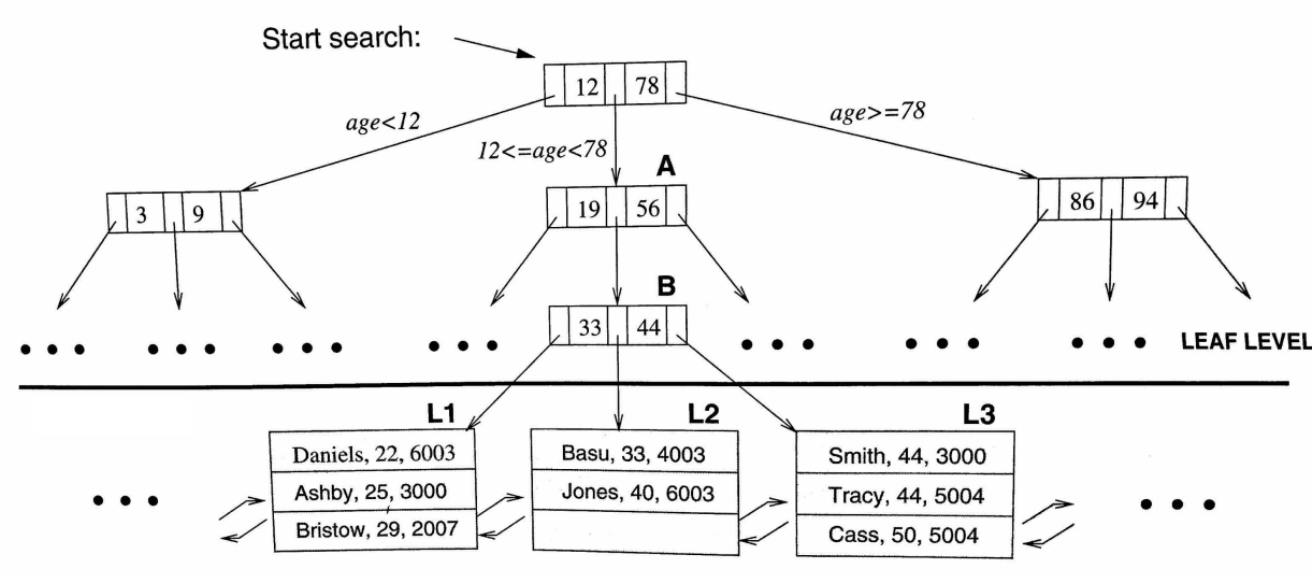


Figure 17.11
The nodes of a B^+-tree. (a) Internal node of a B^+-tree with $q-1$ search values. (b) Leaf node of a B^+-tree with $q-1$ search values and $q-1$ data pointers.

(From Fundamentals of Database Systems, 7th Edition. 4 Elmasri and Navathe)

B-Trees example with sparse index



(From Database Management Systems, 2002 by R. Ramakrishnan and J. Gehrke)

Example 1

Suppose blocks hold 33 keys and 34 pointers. Assume the B-tree node is 69 % full.
On average, each internal block will have 34 * 0.69 or approximately 23 pointers, and hence 22 keys.
Each leaf block, on average, will hold approximately 22 data record pointers plus 1 next-pointer.
A B-tree will have the following average number of entries at each level:

Root:	1 blocks	22 key entries	23 pointers
Level 1:	23 blocks	506 key entries	529 pointers
Level 2:	529 blocks	11,638 key entries	12,167 pointers
Leaf level:	12,167 blocks	267,674 data record pointers	

Example 2

Suppose blocks hold either three records, or 9 keys and 10 pointers. Assume the B-tree node is 100 % full. Given 100 records, how many blocks do we need to hold a data file and

- a dense index
  No. of blocks to hold the data file = 100/3=34
  No. of blocks to hold the index file on Leaf level= 100/9=12
  No. of blocks to hold the index file on Level 1= 12/10=2
  No. of blocks to hold the index file on root level= 2/10=1
  No. of total blocks = 34+12+2+1 = 49
- a sparse index
  No. of blocks to hold the data file = 100/3=34
  No. of blocks to hold the index file on Leaf level= 34/9=4
  No. of blocks to hold the index file on root level= 4/10=1
  No. of total blocks = 34+4+1 = 39