B-trees

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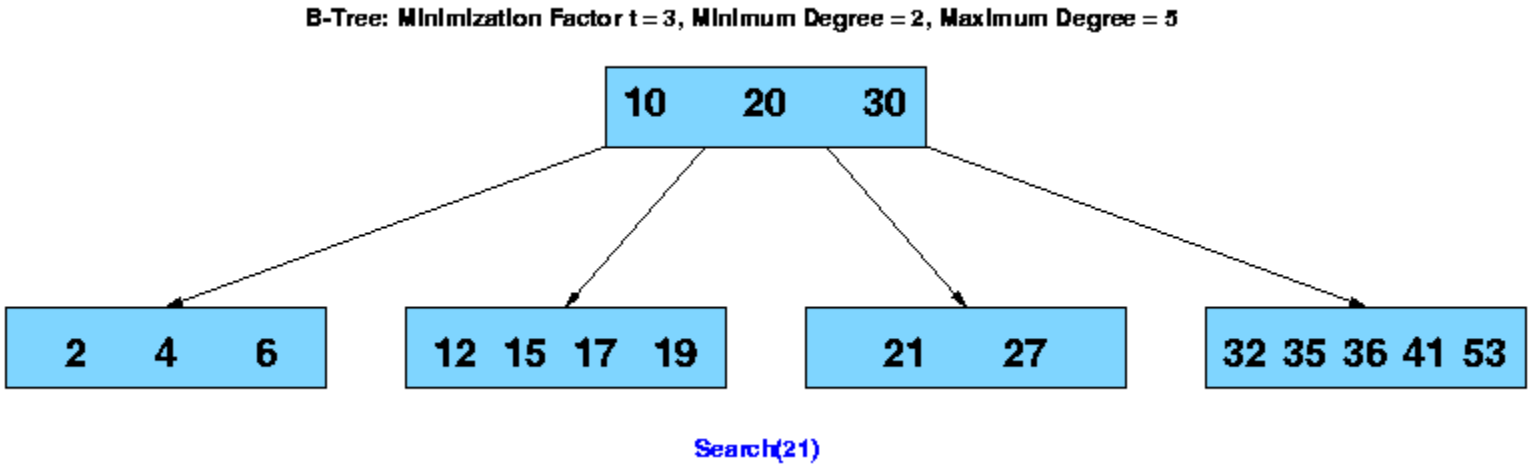
B-Tree

- Generalizes 2-3-4 trees by allowing up to M links per node.
- Main application: file systems.
  - Reading a page into memory from disk is expensive.
  - Accessing info on a page in memory is free.
  - Goal: minimize # page accesses.
  - Node size M = page size.
- Space-time tradeoff.
  - M large ! only a few levels in tree.
  - M small ! less wasted space.
  - Number of page accesses is $\log_M N$ per op.
  - Typical M = 1000, N < 1 trillion.

Search


B-Tree: Minimization Factor t = 3, Minimum Degree = 2, Maximum Degree = 5
10 20 30
2 4 6
12 15 17 19
21 27
32 35 36 41 53
Search(21)

Insert

B-Tree in the wild

- Red-black trees: widely used as system symbol tables
  - Java: java.util.TreeMap, java.util.TreeSet.
  - C++ STL: map, multimap, multiset.
  - Linux kernel: linux/rbtree.h.
- B-Trees: widely used for file systems and databases
  - Windows: HPFS.
  - Mac: HFS, HFS+.
  - Linux: ReiserFS, XFS, Ext3FS, JFS.
  - Databases: ORACLE, DB2, INGRES, SQL, PostgreSQL
- All nodes in B-Tree are assumed to be stored in secondary storage (disk) rather than primary storage (memory),
- There basic operations for accessing a page: *Disk-Read(), Disk-Write(), Allocate-Node()*

B-Tree Library

- Software and documentation is accessed at http://www.hydrus.org.uk/doc/bt/html/index.html

API

- Creating a B Tree File

BTA* btcrt(char* *fid*, int *nkeys*, int *shared*);

- Opening a B Tree File

BTA* btopn(char* *fid*, int *mode*, int *shared*);

- Closing a B Tree File

int btcls(BTA* *btact*);

API (cont.)

- Inserting a key and data

int btins(BTA* *btact*, char* *key*, char* *data*, int *dsize*);

- Updating data for an existing key

int btupd(BTA* *btact*, char* *key*, char* *data*, int *dsize*);

- Locating data for an existing key

int btsel(BTA* *btact*, char* *key*, char* *data*, int *dsize*, int* *rsize*);

- Deleting a key and associated data

int btdel(BTA* *btact*, char* *key*);

- Locating data for the next key in sequence

int btseln(BTA* *btact*, char* *key*, char* *data*, int *dsize*, int* *rsize*);

Building and installing the BT Library

- Unpack the tar file into a convenient directory.

$cd <bt library>

$make clean

$make

- Make built an UNIX static library **libbt.a**, a BT test harness **bt**, and a utility, **kcp**, which performs intelligent copies of BT index files.

Quiz 1

- Install and compile BT Library in your machine
- Run BT test harness to verify if successful installed
- See documentation at

http://www.hydrus.org.uk/doc/bt/html/ch05.htm

Quiz 2

- Use the BT library to write a phone book program that manipulates data on the secondary disk.

Another library for B-Tree

- Download at

http://www.mycplus.com/utilitiesdetail.asp?iPro=10

- This library allows specifying different comparison functions for keys.

Mini project 1

- Make a program to manage a computer dictionary
  - Add/Search/Delete a word (using B-Tree)
  - Auto complete search. Ex. When we enter “comput” and <tab>, the word “computer” should be auto completed (like in Bash Shell)
  - Suggestion search => Use soundex library
- Please test the performance of your program with a dictionary of millions words (the words can be randomly created)
  - Test for the two basic operations: search and insert
- Project in group of 3-4 persons