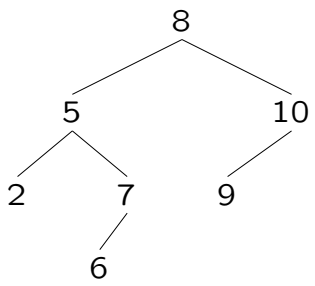
7: 2-3 Trees and B-Trees

CSE326 Spring 2002

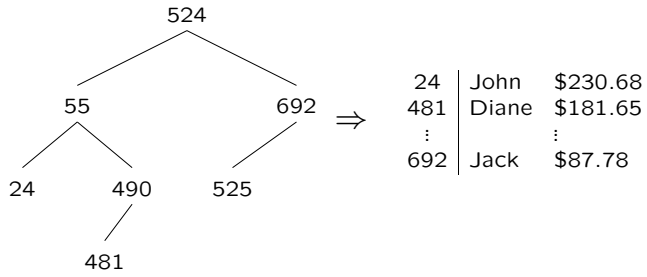
April 14, 2002

Trees in the Real World



Only 326 just stores numbers in a tree

Trees in the Real World



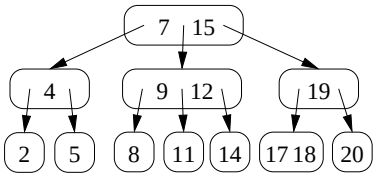
Use *key* to index *data*

Trees in the Real World

```
struct Node {
  int key;
  Data *data;
  Node *left, * right;
};
```

Store *pointer to data* in node with *key*

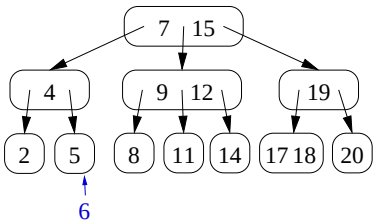
Achieving Perfect Balance



2-3 Trees

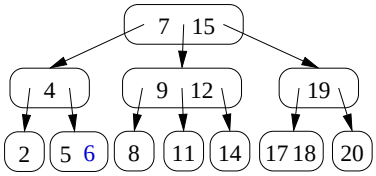
- 2-node: 2 children, 1 key
- 3-node: 3 children, 2 keys
- Any key k is *between* all keys in the subtrees adjacent to k
- All leaves are at the *same depth*
- What is depth with respect to size?
- How long to search?

Insertion



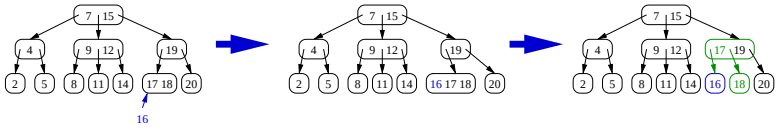
Search for leaf location

Insertion



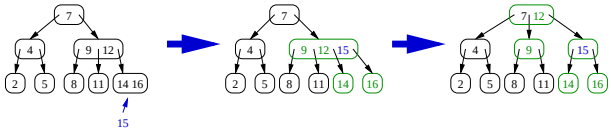
Squeeze new key into leaf

Insertion



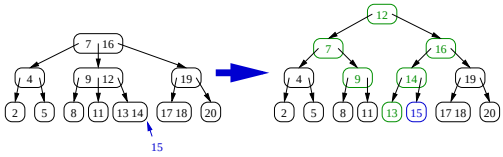
Split to make space

Insertion



Many need to split further up the tree

Insertion



If root is full, increase height

Total time to insert?

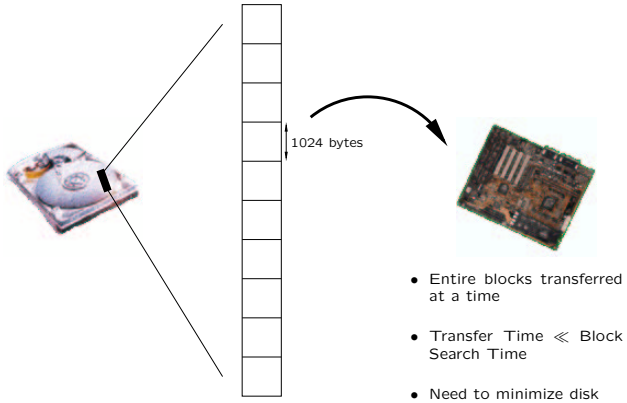
Deletion

(a, b)-Trees

Why Stop at 2-3?

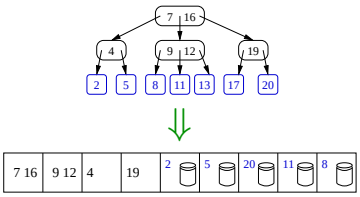
- Each node has between a and b children
  - $a \geq 2, b \geq 2a - 1$, root may be smaller
  - Why is b at least twice a?
- All leaves at same depth
- Advantages?
- Disadvantages?

Disks



- Entire blocks transferred at a time
- Transfer Time $\ll$ Block Search Time
- Need to minimize disk accesses

B-Trees



- # disk access to search = # levels in tree
- Each node may as well fill up disk block
  i.e. b = block size
- Only store *index* in node
- Store *data* in leaves

B-Trees

$a = 100, b = 199$:

- How many levels to store 10^6 items?
- Many variations, very practical