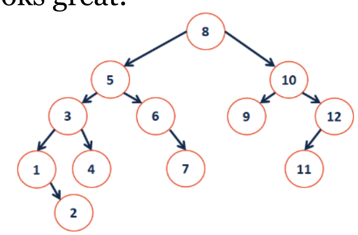
## #21: BTrees
March 7, 2022 · *G Carl Evans*

### BTree Motivation
Big-O assumes uniform time for all operations, but this isn't always true.

However, seeking data from the cloud may take 100ms+.
...an O(lg(n)) AVL tree no longer looks great:




### Consider Instagram profile data:

| | | |
|---|---|---|
| How many profiles? | | |
| How much data /profile? | | |
| | AVL Tree | BTree |
| Tree Height | | |

### BTree Motivations
Knowing that we have long seek times for data, we want to build a data structure with two (related) properties:

1.

2.

### BTree$_m$


**Goal:** Build a tree that uses ____________________ /node!
*...optimize the algorithm for your platform!*

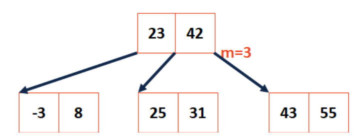
A **BTree of order m** is an m-way tree where:

**1.** All keys within a node are ordered.

### BTree Insert, using m=5

...when a BTree node reaches **m** keys:

### BTree Insert, m=3:




### Great interactive visualization of BTrees:
https://www.cs.usfca.edu/~galles/visualization/BTree.html

## BTree Properties

For a BTree of order **m**:

1. All keys within a node are ordered.
2. All leaves contain no more than **m-1** nodes.

3. All internal nodes have exactly **one more key than children**.
4. Root nodes can be a leaf or have **[2, m]** children.
5. All non-root, internal nodes have **[ceil(m/2), m]** children.

6. All leaves are on the same level.

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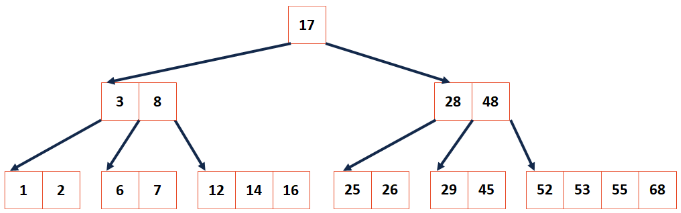
## Example BTree




What properties do we know about this BTree?

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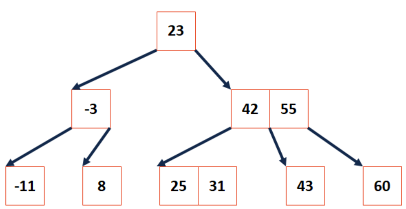
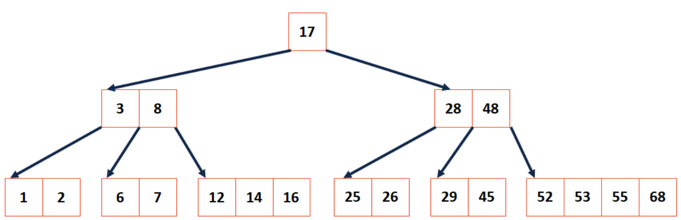
## BTree Search




**BTree.hpp**

```
bool Btree<K, V>::_exists(BTreeNode & node, const K & key) {
  unsigned i;
  for (i=0; i<node.keys_ct_ && key<node.keys_[i]; i++) { }

  if ( i < node.keys_ct_ && key == node.keys_[i] ) {
    return true;
  }

  if ( node.isLeaf() ) {
    return false;
  } else {
    BTreeNode nextChild = node._fetchChild(i);
    return _exists(nextChild, key);
  }
}
```

## BTree Analysis

The height of the BTree determines maximum number of ______________ possible in search data.

...and the height of our structure:

**Therefore,** the number of seeks is no more than: ______________.

*...suppose we want to prove this!*

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## BTree Analysis

In our AVL Analysis, we saw finding an upper bound on the height (given **n**) is the same as finding a lower bound on the nodes (given **h**).

**Goal:** We want to find a relationship for BTrees between the number of keys (**n**) and the height (**h**).

### CS 225 – Things To Be Doing:

1. mp_mosaic due today!
2. Final Project groups due Friday.
3. Daily POTDs are ongoing!