CS 225

#24: BTree Analysis + Hashing Intro
October 21, 2019 · *G Carl Evans*

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 children than keys**.
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.

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!

BTree Proof #1

In our AVL Analysis, we saw finding an **upper bound** on the height (**h** given **n,** aka **h = f(n)**) is the same as finding a **lower bound** on the keys (**n** given **h,** aka $\mathbf{f^{-1}(h)}$).

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

BTree Strategy:

1. Define a function that counts the minimum number of nodes in a BTree of a given order.
    a. Account for the minimum number of keys per node.
2. Proving a minimum number of nodes provides us with an upper-bound for the maximum possible height.

Proof:

1a. The minimum number of <u>nodes</u> for a BTree of order **m** at each level is as follows:

root:

level 1:

level 2:

level 3:

...

level h:

1b. The minimum total number of <u>nodes</u> is the sum of all levels:

2. The minimum number of keys:

3. Finally, we show an upper-bound on height:

So, how good are BTrees?

Given a BTree of order 101, how much can we store in a tree of height=4?

Minimum:

Maximum:

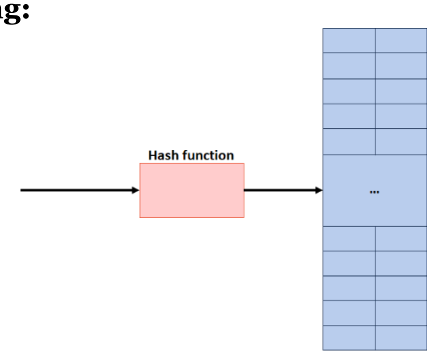
Hashing

Locker Number	Name
103	
92	
330	
46	
124	

...how might we create this today?

Goals for Understanding Hashing:

1. We will define a **keyspace**, a (mathematical) description of the keys for a set of data.



2. We will define a function used to map the **keyspace** into a small set of integers.

All hash tables consists of three things:

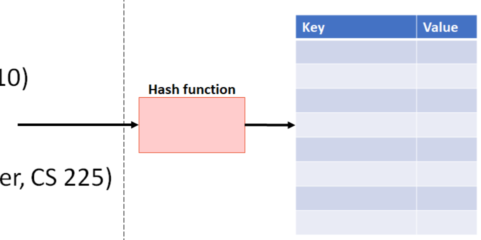
1.

2.

3.

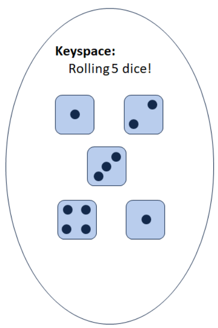
A Perfect Hash Function

(Angrave, CS 241)
(Beckman, CS 421)
(Cunningham, CS 210)
(Davis, CS 101)
(Evans, CS 126)
(Fagen-Ulmschneider, CS 225)
(Gunter, CS 422)
(Herman, CS 233)



...characteristics of this function?

A Second Hash Function



0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

...characteristics of this function?

CS 225 – Things To Be Doing:

1. Programming Exam B starts Thursday
2. MP4 is due tonight by 11:59pm; MP5 released Tuesday
3. lab_btree released on Wednesday
4. Daily POTDs are ongoing!