Name: _____

Today's Date: _____

Today's Goals

- Name three open addressing strategies
- Describe how each open addressing strategy works
- Identify the problems that can arise with open addressing

Today's Question(s)

What three components do you need to have a hash table?

Hash Table = + +

Lingering Questions

Evaluating Separate Chaining

What is the expected number of items in one bucket?

Where `M` is the table size and `N` is the number of elements in table.

- P(bucket 0 contains the first item)
- P(bucket 0 does not contain the first item)
- P(bucket 0 contains the first k items but no others)
- P(bucket 0 contains exactly k items)
- P(bucket i contains exactly k items)

Class Exercise

What's the performance of separate chaining?

- Lookup
  - Unsuccessful search:
  - Successful search:
- Insert
  - Don't search for duplicates?
  - Search for duplicates:

Successful Search (Anak Yadpinyanee's Method)

- What is the probability that an element is in the chain of the searched-for element and appears before the searched-for element (rather than after it)?
- How many such elements should we consider?
- Any other costs?

Open Addressing

"Find another bucket" - but which one?

Instead of putting all items that hash to the same bin in that bin, find different bin

Linear Probing

- Insertion:
- Lookup: ?
- Deletion: ?

Naive Analysis

Fact: If we succeed with probability p, the expected number of trials until success is $1/p$.

Maybe unsuccessful search checks $1/(1\text{-}\lambda)$ buckets?

E.g. if λ=0.75, then

- $1/4$ of buckets are empty
- Expect to examine 4 buckets before stopping?

Primary Clustering

Quadratic Probing

Try to "leap out" of a cluster

- Lookup
  - Successful: 1-ln(1-λ)-$\lambda/2$
  - Unsuccessful: $1/(1\text{-}\lambda)$ - λ - ln(1-λ)
- Deletion?

A Glitch

Suppose we have 16 buckets, and we have five items that hash to bucket 0. Where will they end up?

More Clustering!

We're still prone to clustering (secondary clustering), just less of it and it's harder to spot.

Double Hashing

- Lookup
  - Successful: $1/\lambda$ ln$(1/(1\text{-}\lambda))$
  - Unsuccessful: $\lambda/(1\text{-}\lambda) + 1 = 1/(1\text{-}\lambda)$
- Deletion: ?