CS 225

Data Structures

Oct. 30 – Hashing 2

A Hash Table based Dictionary

Client Code:

```
1  Dictionary<KeyType, ValueType> d;
2  d[k] = v;
```

A **Hash Table** consists of three things:

1.

2.

3.

Exam Updates

Current: Exam 8 (Programming)

- Topics: MP4-like (eg: iterators), AVL

Next Week: Exam 9 (Theory)

- Topics: AVL trees
  BTrees
  *k*D Trees

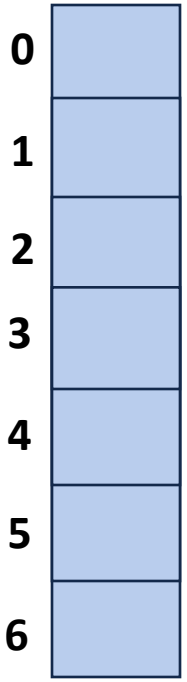
MP5

(Example of open hashing)

Collision Handling: Separate Chaining

S = { 16, 8, 4, 13, 29, 11, 22 } **|S| = n**

h(k) = k % 7 **|Array| = N**



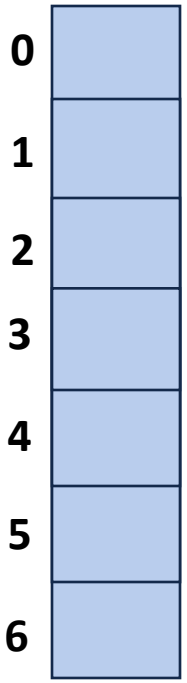
	Worst Case	SUHA
Insert		
Remove/Find		

(Example of closed hashing)

Collision Handling: Probe-based Hashing

S = { 16, 8, 4, 13, 29, 11, 22 } **|S| = n**

h(k) = k % 7 **|Array| = N**



Try h(k) = (k + 0) % 7, if full…

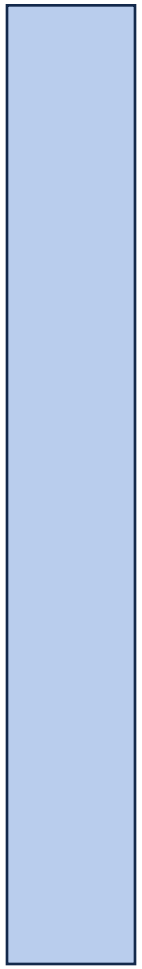
Try h(k) = (k + 1) % 7, if full…

Try h(k) = (k + 2) % 7, if full…

Try …

A Problem w/ Linear Probing

Primary clustering:



Description:

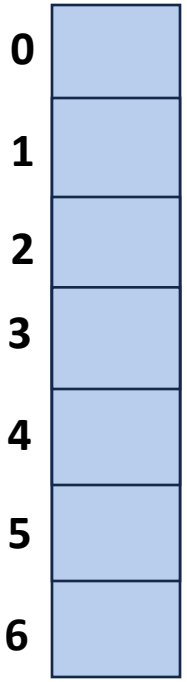
Remedy:

(Example of closed hashing)

Collision Handling: Double hashing

S = { 16, 8, 4, 13, 29, 11, 22 } **|S| = n**

h(k) = k % 7 **|Array| = N**



Try h(k) = (k + 0*h_2(k)) % 7, if full…

Try h(k) = (k + 1*h_2(k)) % 7, if full…

Try h(k) = (k + 2*h_2(k)) % 7, if full…

Try …

h(k, i) = (h_1(k) + i*h_2(k)) % 7

Running Times

The expected number of probes for find(key) under SUHA

Linear Probing:

- Successful: **$\frac{1}{2}(1 + 1/(1-\alpha))$**
- Unsuccessful: **$\frac{1}{2}(1 + 1/(1-\alpha))^2$**

Double Hashing:

- Successful: **$1/\alpha * \ln(1/(1-\alpha))$**
- Unsuccessful: **$1/(1-\alpha)$**

Separate Chaining:

- Successful: **$1 + \alpha/2$**
- Unsuccessful: **$1 + \alpha$**

(Don't memorize these equations, no need.)

Instead, observe:

- As α increases:

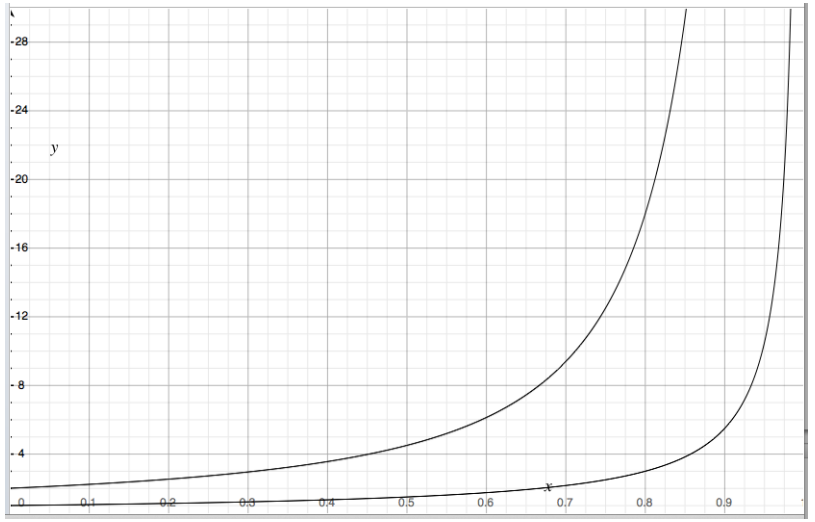
- If α is constant:

Running Times

The expected number of probes for find(key) under SUHA

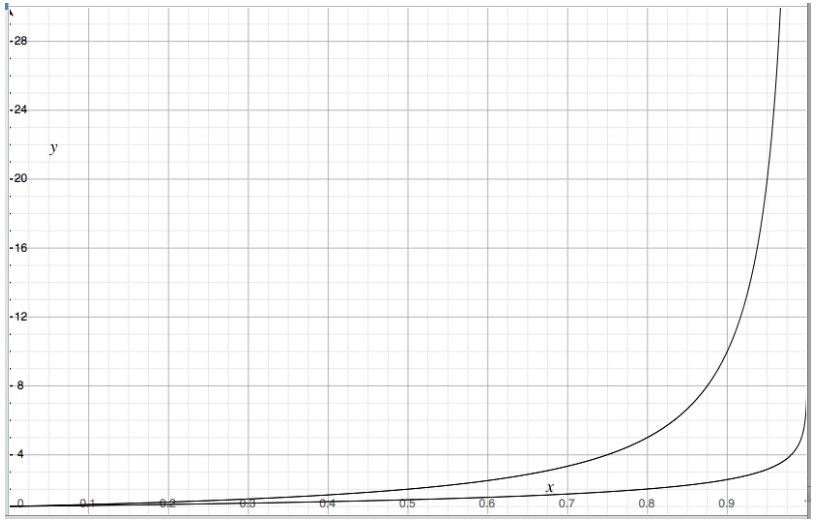
Linear Probing:

- Successful: **½(1 + 1/(1-α))**
- Unsuccessful: **½(1 + 1/(1-α))²**



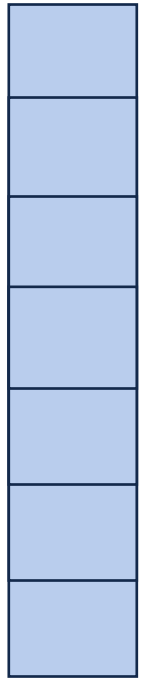
Double Hashing:

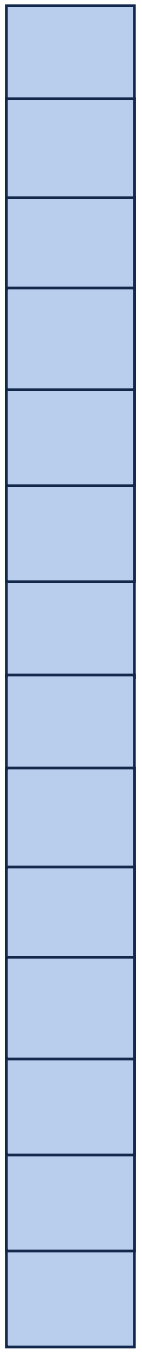
- Successful: **1/α * ln(1/(1-α))**
- Unsuccessful: **1/(1-α)**



ReHashing

What if the array fills?





Which collision resolution strategy is better?

- Big Records:

- Structure Speed:

What structure do hash tables replace?

What constraint exists on hashing that doesn't exist with BSTs?

Why talk about BSTs at all?

CS 225 – Things To Be Doing

Exam 8 (programming exam, MP4-like and AVL) is live!

More Info: https://courses.engr.illinois.edu/cs225/fa2017/exams/

MP5: EC due tonight!

Extra Credit +7 deadline: Monday, Oct. 30

Lab: lab_hash is released Wednesday

Due Sunday, Dec. 5 at 11:59pm

POTD

Every Monday-Friday – *Worth +1 Extra Credit /problem (up to +40 total)*