

Announcements — Exam 2: 03/11, PA2: 03/01, HW3: 03/04.

Collision resolution —

Separate Chaining: (an example of open hashing)

$S = \{16, 8, 4, 13, 29, 11, 22\}$

$|S| = n$ $h(k) = k \% 7$

0	
1	
2	
3	
4	
5	
6	

	Worst case	Under SUHA
Insert		
Remove/find		

Collision Handling - Probe based hashing: (example of closed hashing)

$S = \{16, 8, 4, 13, 29, 11, 22\}$

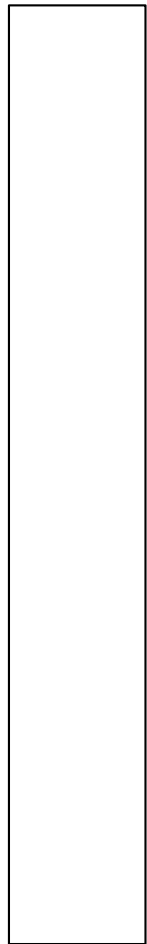
$|S| = n$ $h(k) = k \% 7$

0	
1	
2	
3	
4	
5	
6	

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...

Linear Probing – 2 problems...

Primary clustering:



Description:

Remedy:

Removal:



Description:

Remedy:

Probe based hashing: double hashing

$S = \{16, 8, 4, 13, 29, 11, 22\}$ $|S| = n$ $H(k,i) = h_1(k) + ih_2(k)$

0	
1	
2	
3	
4	
5	
6	

Try $h(k) = (k + 0 \cdot h_2(k)) \% 7$. If full...
try $h(k) = (k + 1 \cdot h_2(k)) \% 7$. If full...
try $h(k) = (k + 2 \cdot h_2(k)) \% 7$. If full...
try...

Hash table performance: expected # 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: $1 + \alpha$

Do not memorize these!

Observe:

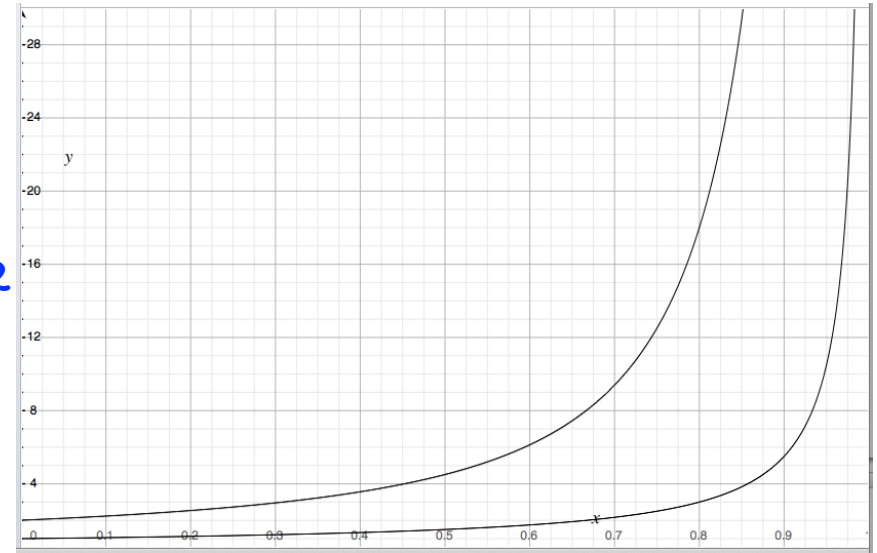
- As α increases, running times increase!
- If α is held constant then running times are constant!

Hash table performance: expected # of probes for Find(key) under SUHA

Linear probing -

successful: $\frac{1}{2} (1 + 1/(1-\alpha))$

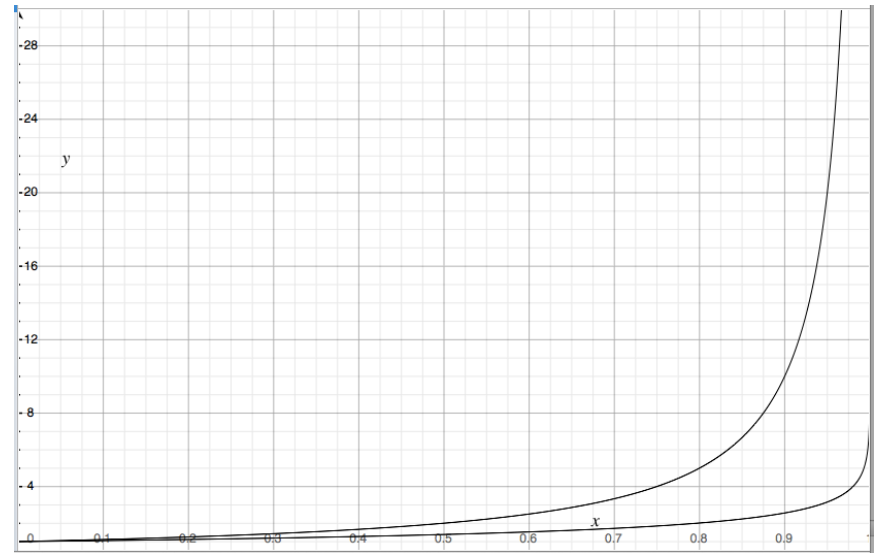
unsuccessful: $\frac{1}{2} (1 + 1/(1-\alpha))^2$



Double hashing -

successful: $1/\alpha \ln 1/(1-\alpha)$

unsuccessful: $1/(1-\alpha)$



ReHashing:

What if the array fills?



Hashing Miscellaneous Discussion —

Which collision resolution strategy is better?

- Big records —
- Structure speed —

What structures do hash tables replace for us?

There is a constraint on Keyspaces for BST that does not affect hashing...

Why do we talk about balanced BST if hashing is so great?

More resources:

<http://jeffe.cs.illinois.edu/teaching/algorithms/notes/05-hashing.pdf>

http://en.wikipedia.org/wiki/Hash_function

Applications of hashing?

Area of active research in mathematics to develop general purpose hash functions.