Skip Lists

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Randomized Ordered Set Data Structure

What other randomized data structures have you heard of?

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High level usage of the skip list

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High level usage of the skip list

- Sorted Dictionary

Skip List

Randomized Ordered Set Data Structure

What other randomized data structures have you heard of?

High level usage of the skip list

- Sorted Dictionary (BBSTs already can do this!)

Skip List

Randomized Ordered Set Data Structure

What other randomized data structures have you heard of?

High level usage of the skip list

Paralleled Sorted Dictionary

Linked List-Like

What runtime would it be to insert a value into a sorted linked list?

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- Every node with the skip pointers could be a pain to update.
- Nodes will have a number of pointers with some probability

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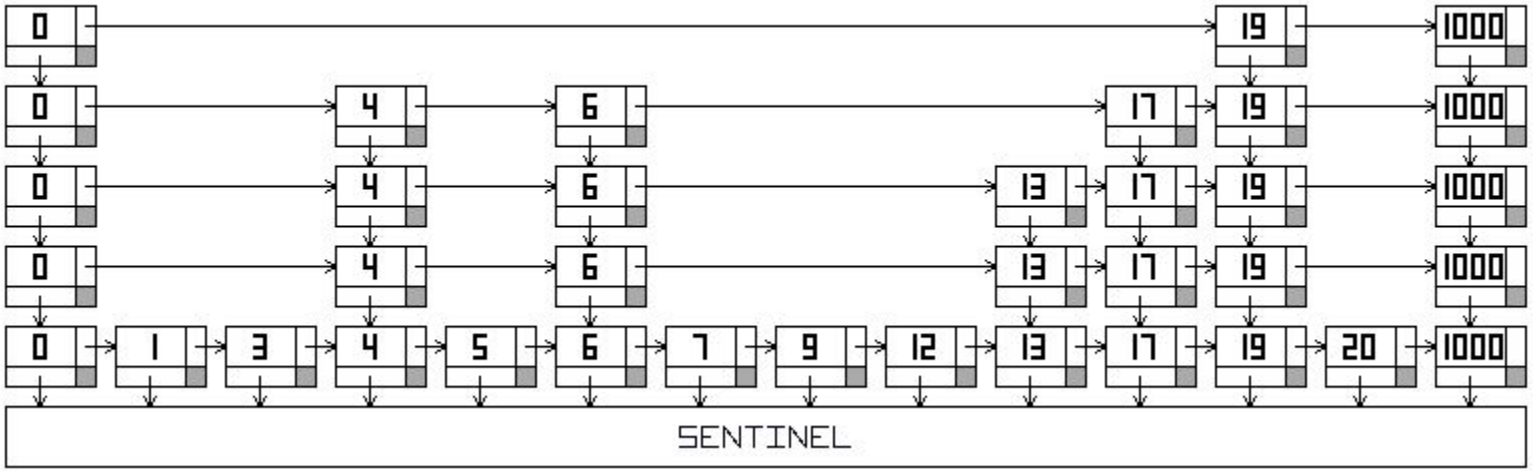
A height will determine the number of pointers, and which nodes can point to them

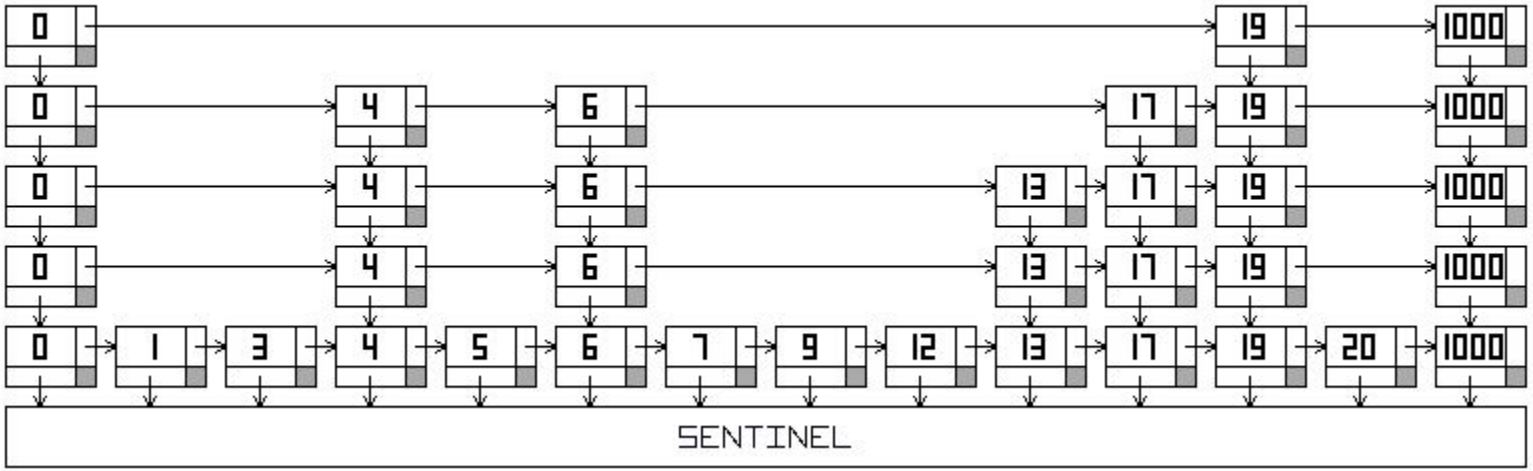
- The skip list becomes a series of lists stacked on top of each other
- If a jump is too big we move down a list

Picture


0
19
1000
0
4
6
17
19
1000
0
4
6
13
17
19
1000
0
4
6
13
17
19
1000
0
1
3
4
5
6
7
9
12
13
17
19
20
1000
SENTINEL

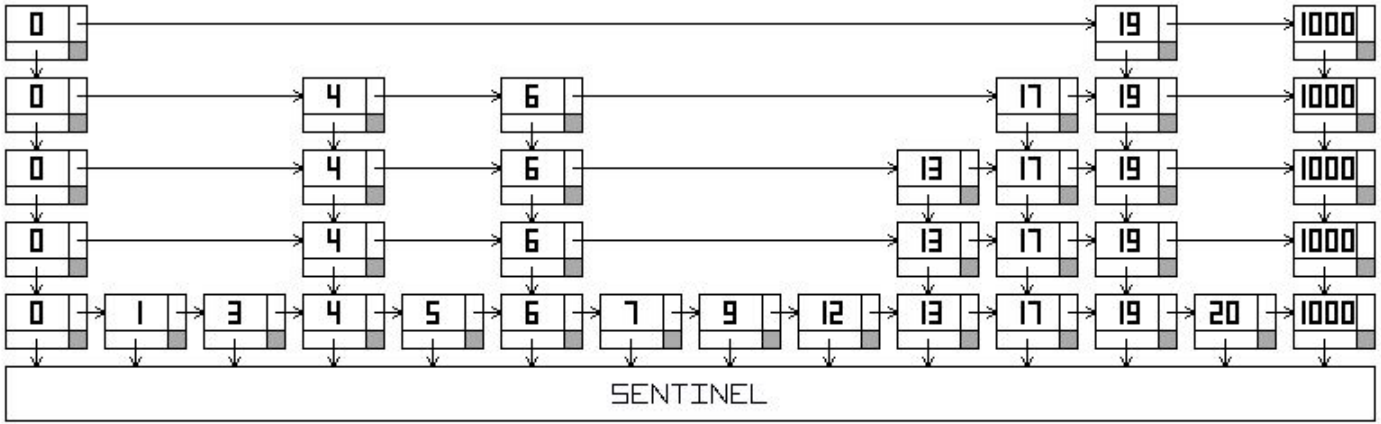
Picture

How would we know if 14 exists or not?



Containment

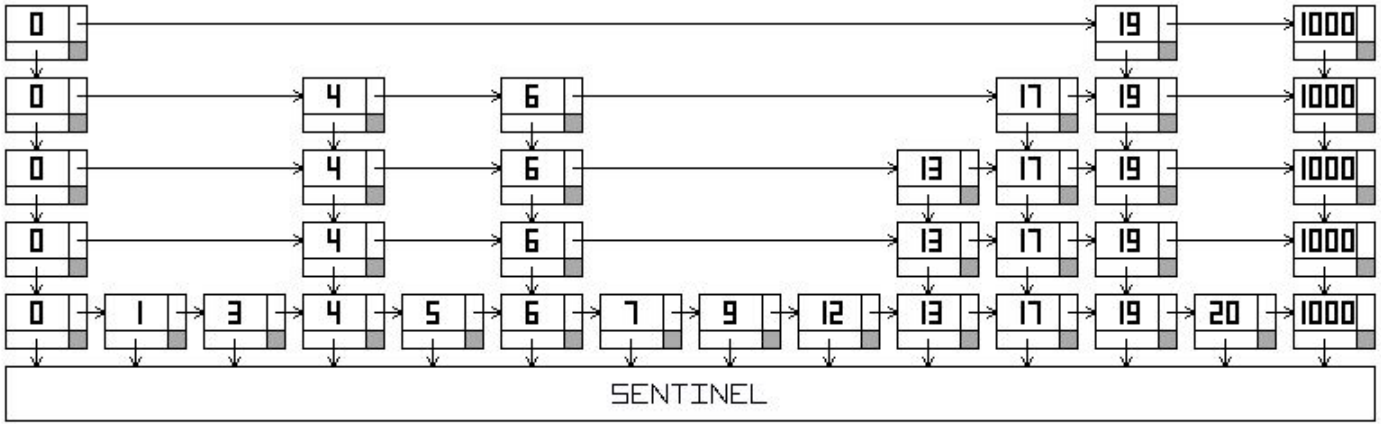
Start current node at the first node



Containment

Start current node at the first node

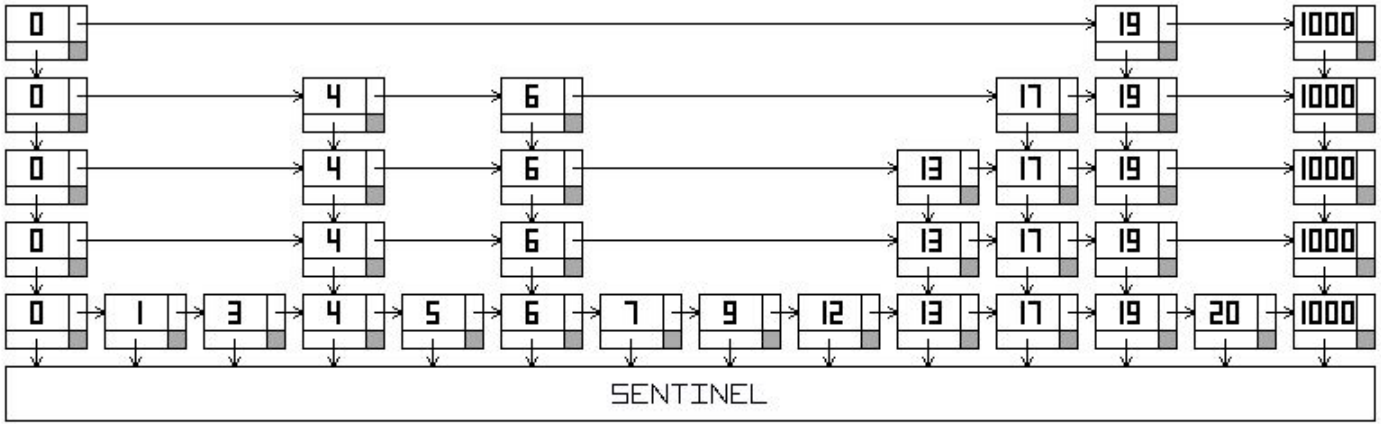
- If the next value is too big step down and retry



Containment

Start current node at the first node

- If the next value is too big step down and retry
- If the next value is too small step to the next node and retry



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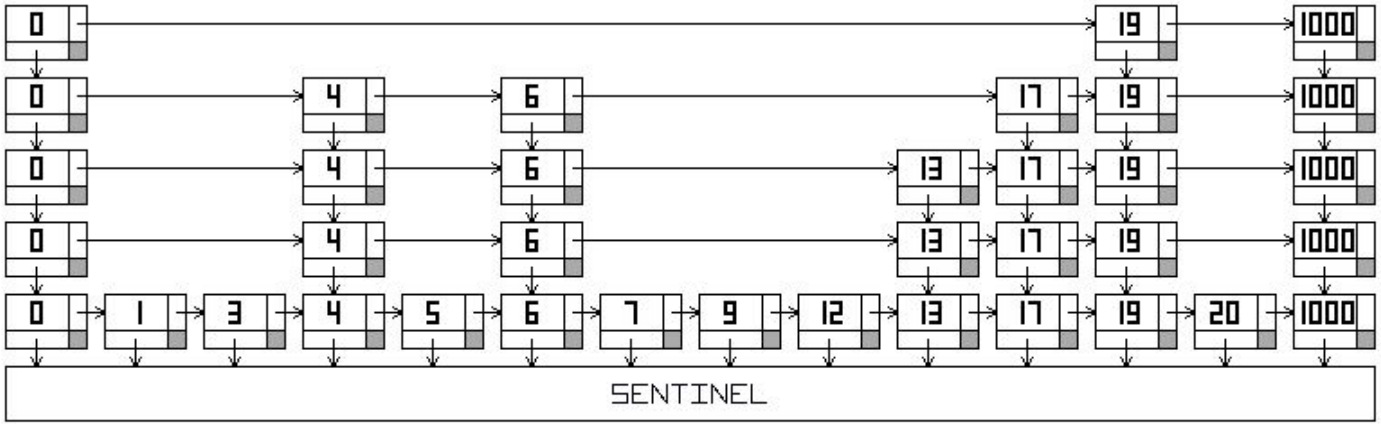
Start current node at the first node

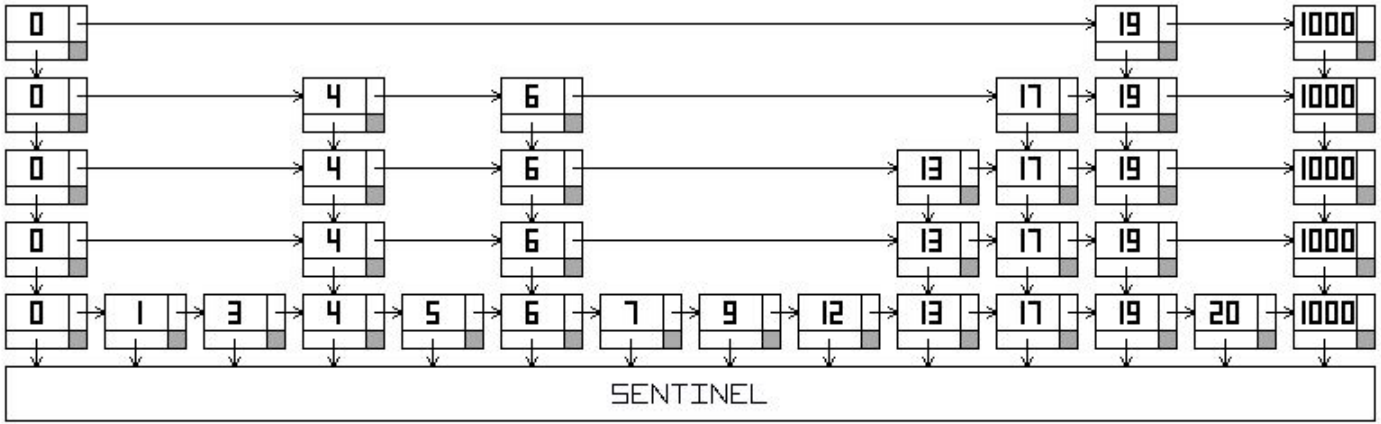
- If the next value is too big step down and retry
- If the next value is too small step to the next node
- If the next value is just right return that the value exists



Containment

Start current node at the first node

- If the next value is too big step down and retry
- If the next value is too small step to the next node
- If the next value is just right return that the value exists
- If the node we are at is the bottom sentinel, the value is not contained



Creating Nodes

Determine the height

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- Deterministically

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Creating Nodes

Determine the height

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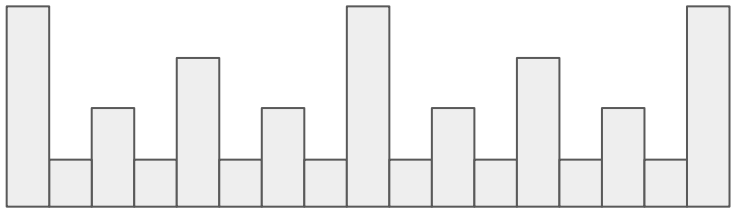
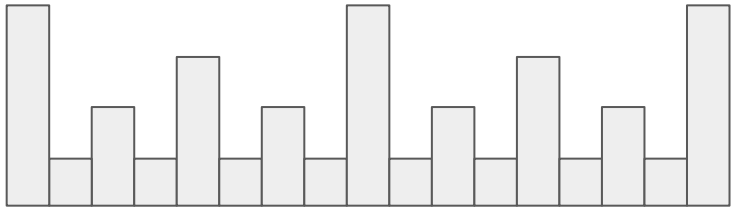


Creating Nodes

Determine the height

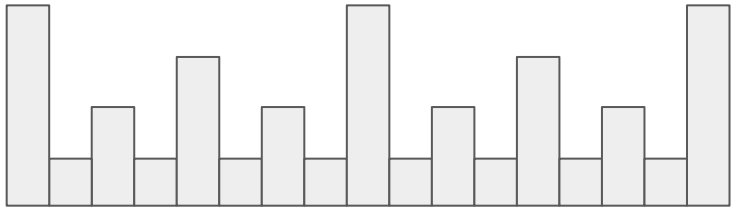
- Deterministically
- Randomly
  - ½ have height 1



Creating Nodes

Determine the height

- Deterministically
- Randomly
  - ½ have height 1
  - ¼ have height 2
  - ⅛ have height 3
  - …



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Determine the height

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  - ½ have height 1
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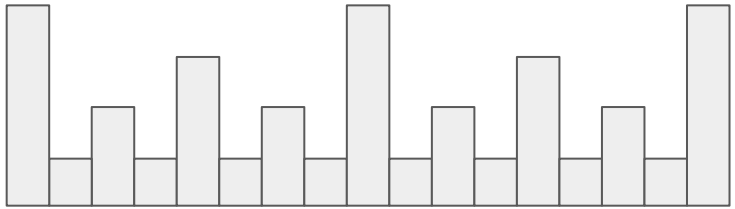
  - “Flip a 50/50 coin” to determine if height should be 1 higher and repeat



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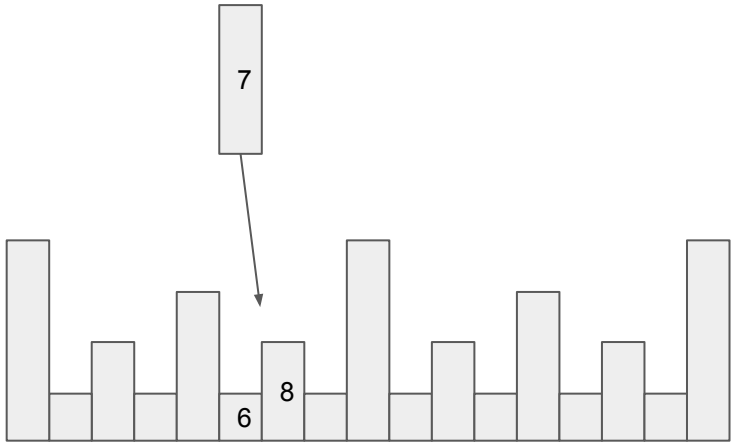

Find the links in which the new node needs to be inserted.

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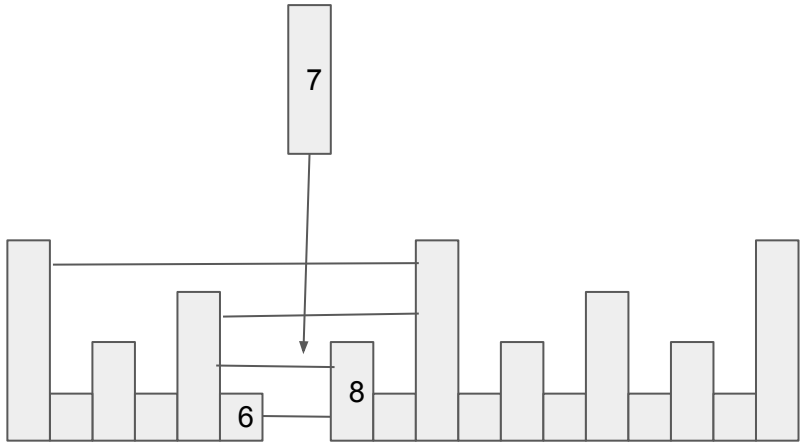

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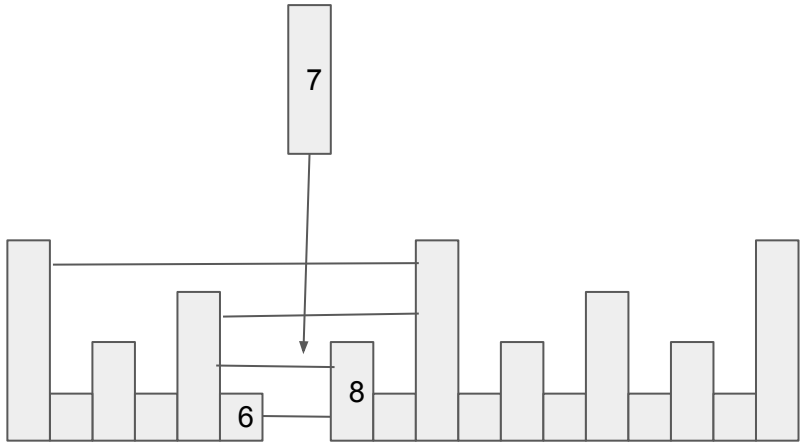

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Update necessary links (based on height)

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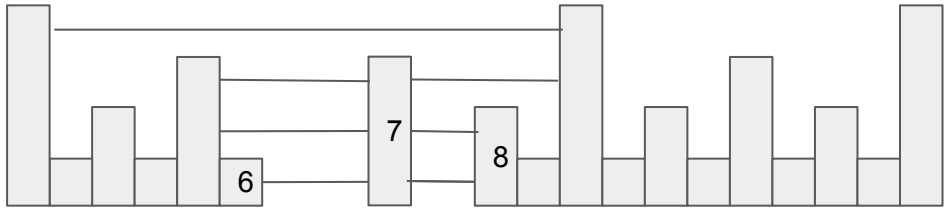

Find the links in which the new node needs to be inserted.

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Removing Nodes

Find all the links that point to said node

Removing Nodes

Find all the links that point to said node

Modify the pointer to the pointer after

Removing Nodes

Find all the links that point to said node

Modify the pointer to the pointer after

- respect the height for each pointer

Too Many Tall Nodes?

If too many nodes are at the maximum height, the height can be increased

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For all nodes at the max height

Too Many Tall Nodes?

If too many nodes are at the maximum height, the height can be increased

For all nodes at the max height
    determine if their height should increase by 1

Runtimes

Average case?

Runtimes

Average case?

Worst Case?

Runtimes

Average case?

Worst Case?

Deterministic height example

Runtimes

Average case?

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Deterministic height example

Height = to the highest power of 2 that divides it

Runtimes

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Worst Case?

Deterministic height example

Height = to the highest power of 2 that divides it

- Values not divisible by 2 are height 1
- Values divisible by 2 but not 4 are height 2
- Values divisible by 4 but not 8 are height 3

Runtimes

Average case?

Worst Case?

Deterministic height example

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Worst case?

Memory

Average Case?

Memory

Average Case?

Worst Case?