leftist heaps


LEFTIST HEAPS!
imgflip.com

data structure

```
(deftem 'node 'r nil 'x nil 'a nil 'b nil)

(def rank (h)
  (if h h!r 0))

(def maket (x a b)
  (if (>= rank.a rank.b) ; enforce leftist property. swap children if rank.b > rank.a
    (inst 'node 'r (+ 1 rank.b) 'x x 'a a 'b b)
    (inst 'node 'r (+ 1 rank.a) 'x x 'a b 'b a)))

(def isempty (h)
  (if (is (type h) 'tem) nil t))

(def merge (h1 h2)
  (if (no (and h1 h2)) (or h1 h2) ; if both aren't there, return whichever is
      (<= h1!x h2!x)   (maket h1!x h1!a (merge h1!b h2)) ; smaller value moves to new root
                       (maket h2!x h2!a (merge h1 h2!b))))

(def insert (x h)
  (merge h (inst 'node 'r 1 'x x)))

(def findmin (h)
  (if (isempty h) (err "EMPTY") h!x))

(def deletemin (h)
  (if (isempty h) (err "EMPTY") (merge h!a h!b)))
```

implemented as an immutable binary tree

invariants

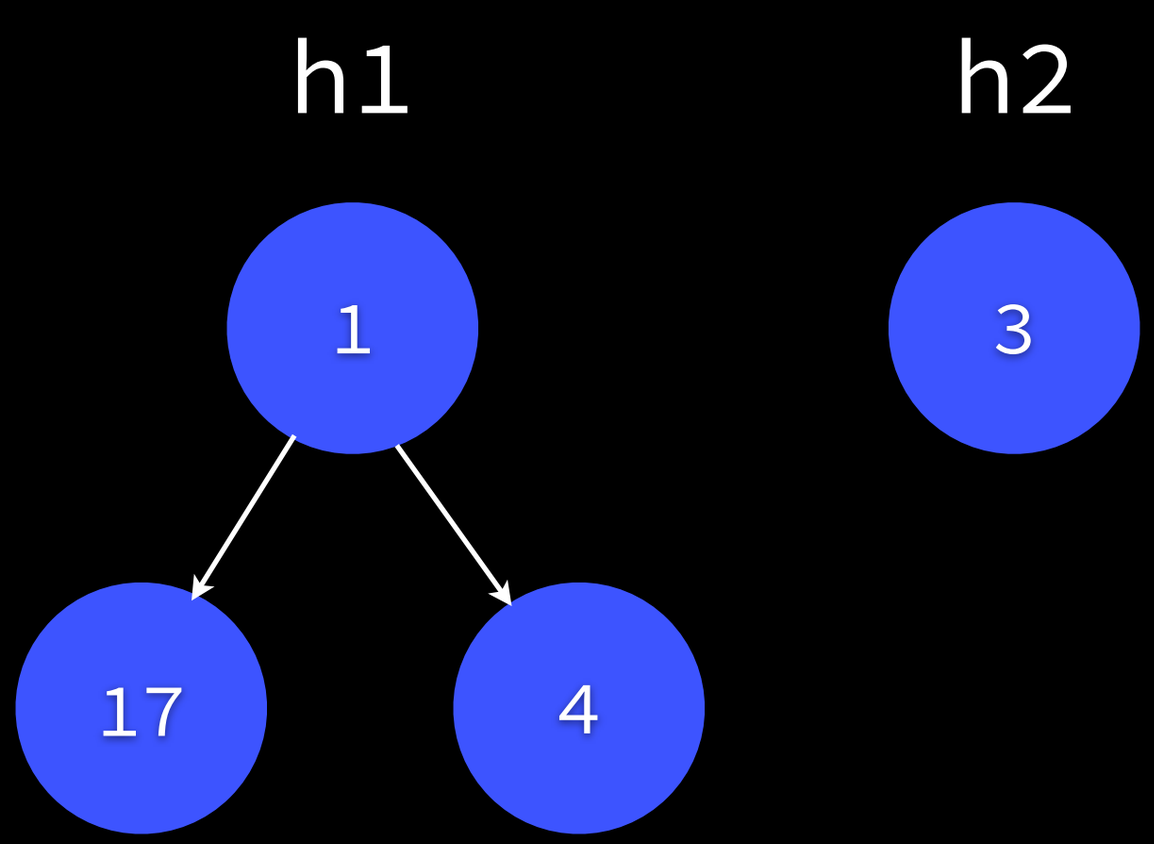
- each node <= 2 children (binary tree)
- the root is the minimum of the tree
- leftist property:
  - (rank left) >= (rank right)
    - rank is the distance
      to the nearest leaf
- every subtree is a leftist heap

why?
O(log n) merging

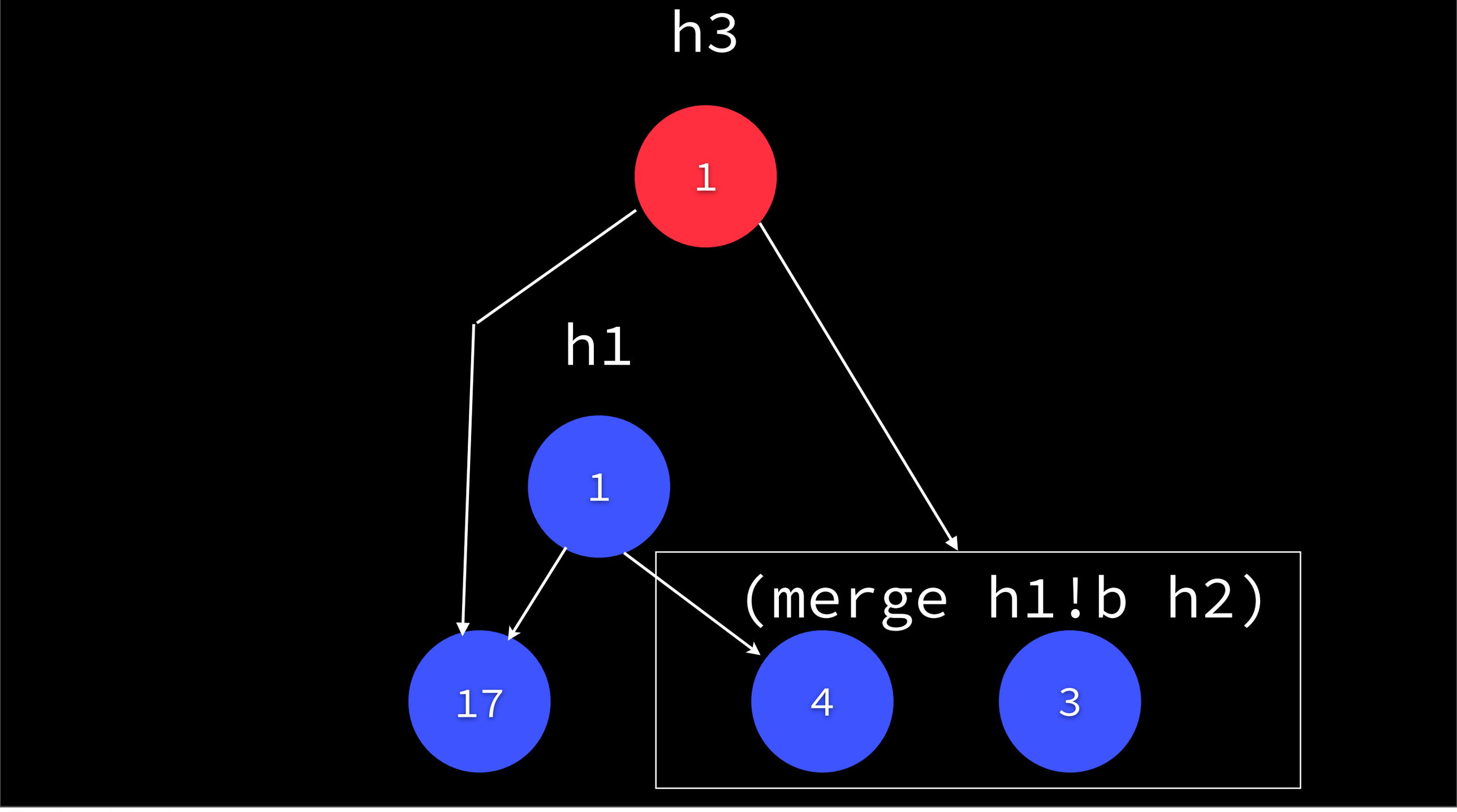
- cost? lose O(log n) search
- benefit? O(log n) merge
  O(1) findmin
- use case: priority queues

```
(= h3 (merge h1 h2)
```

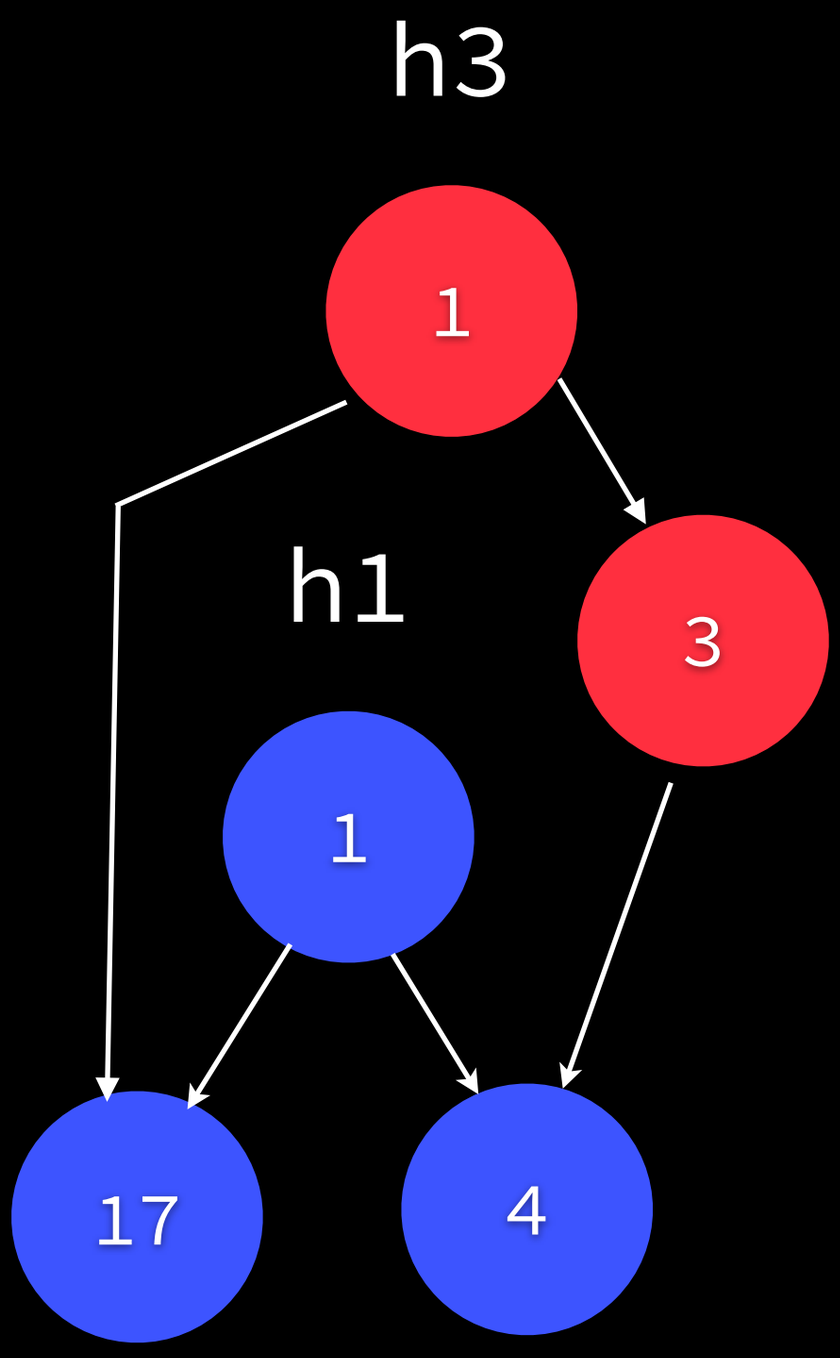
```
(maket h1!x h1!a (merge h1!b h2))
```



(maket h1!x h1!a (merge h1!b h2))

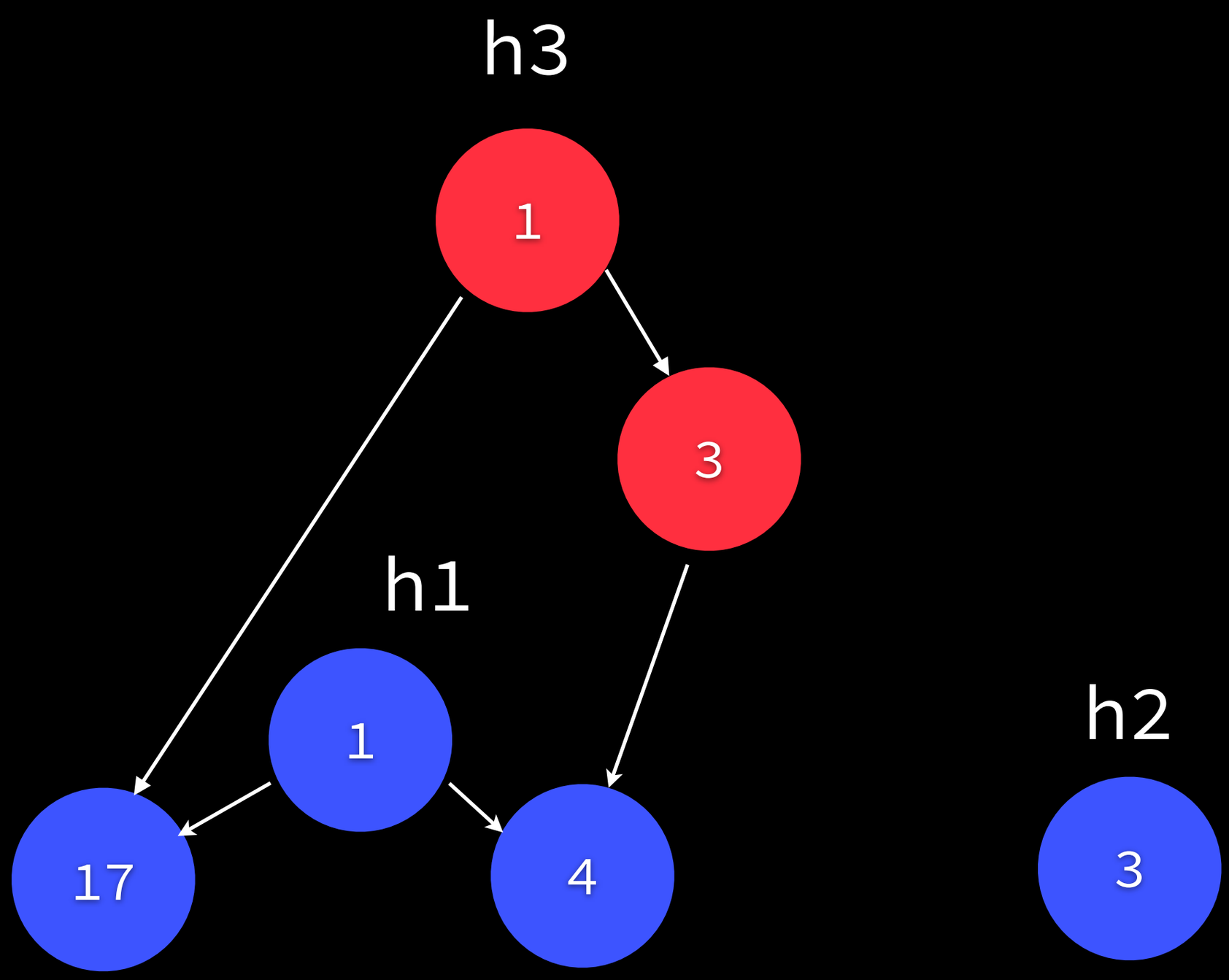


(merge h1!b h2)



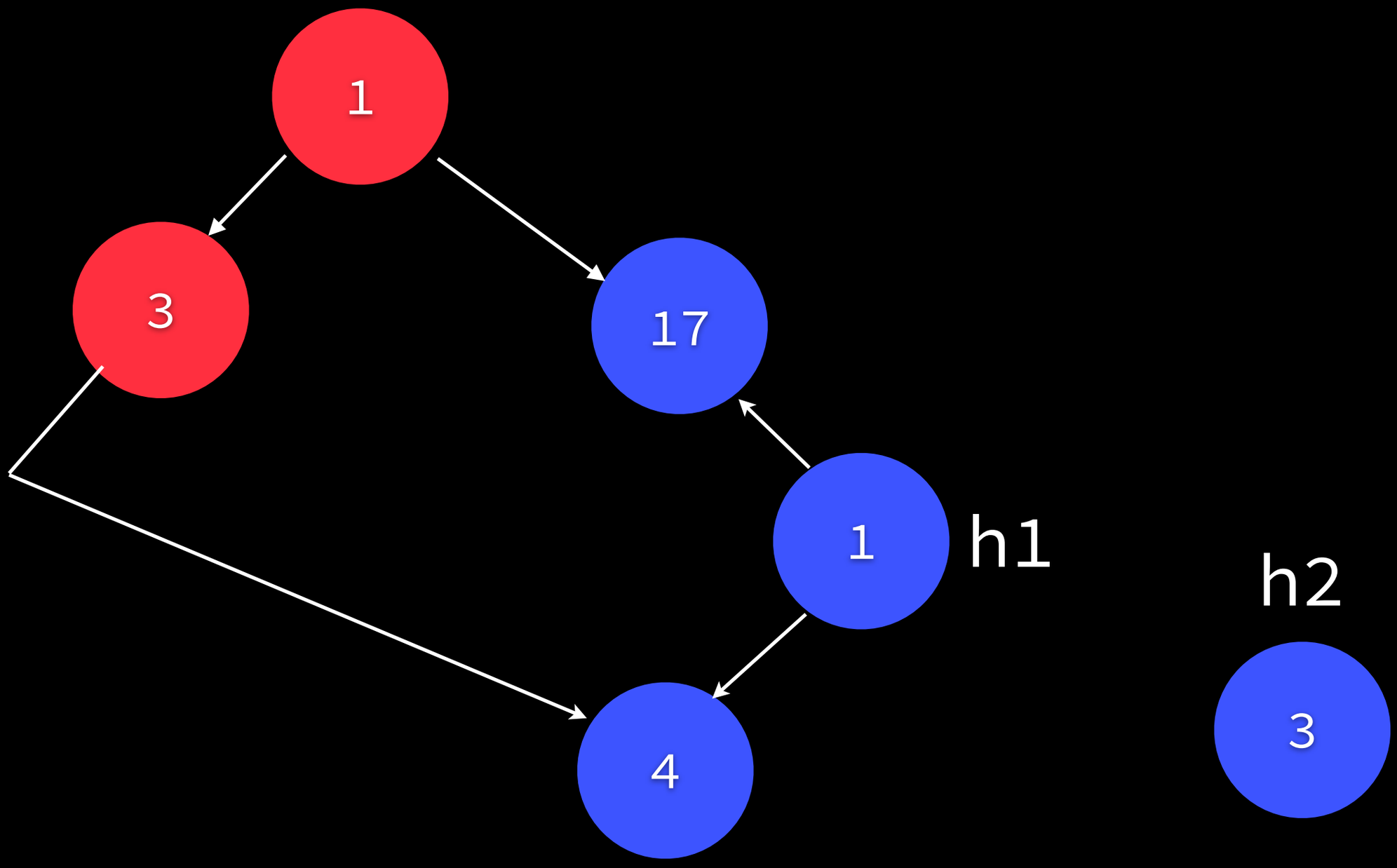

```
(maket h2!x h2!a (merge h1!b h2!b))

(maket h2!x nil (merge h1!b nil))

(maket h2!x nil h1!b)
```

are we done? no.



enforce leftist property (flip it)

h3



Purely Functional Data Structures
by Chris Okasaki

my solutions
github.com/brianru/pfds-arc